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WP8 – Monitoring & Evaluation – D8.2

Core and site specific data collection protocols

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Responsible Organisation: Imperial College London **Contributing Organisation(s):** Instituto Superior Technico Politecnico di MIlano - Departmento of Energy Ricerca sul Sistema Energetico - RSE SpA	**Principal Author(s):** Konstantinos Zavitsas John Polak Francesco Causone Sonia Cunha Anita Tatti Pierpaolo Girardi Andre Pina Andrea Temporelli **Contributing Author(s):**

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1 INTRODUCTION

1.1 Background

1.1.1 Sharing Cities

The SHARING CITIES project brings together city authorities, business and research organisations to develop a vision of a more agile and more collaborative smart cities market. The aim is to dramatically increase the speed and scale, smart solutions are implemented across Europe by engaging citizens in new ways that enable them to play an active role in the transformation of their communities – delivering more vibrant, liveable, economically active and resource efficient cities. Underpinning this are shared solutions that apply a "digital first" approach and that provide "building blocks" incorporating European and worldwide leading practices that can be deployed at scale, yet tailored to cities of different size and stage of development. The vision and objectives are delivered through implementation of a number of measures which are categorised into three core subjects of the project: People, Place, Platform.

People concerns tools to develop a deep understanding of society, and the means by which citizens can actively participate in making their districts better places, through sharing services, delivering better outcomes. Place comprises of four main streams of work that address city infrastructure and services that support low energy districts, electrification of mobility, and integration of infrastructures and processes. These include: Building Retrofit; Sustainable Energy Management System; Shared eMobility; and Smart Lampposts. Platform concerns the development of an urban sharing platform (USP) that manages data from a wide range of sources including sensors as well as more traditional data sources. The USP is built using open technologies and standards, building on London's DataStore expertise, Milan's work on an API marketplace and Lisbon's work on sensor data and gateways.

More information on the Sharing Cities project and news on the demonstrators can be found at www.sharingcities.eu.

1.1.2 Monitoring & Evaluation

Monitoring and evaluation forms a key element of SHARING CITIES, since it provides the means by which the work undertaken in the project becomes relevant to the wider policy and innovation community. The overall aim of the "monitoring and evaluation" work stream is to deliver a comprehensive assessment of the effects of the People/Place/Platform (PPP) measures developed and deployed as part of the SHARING CITIES project. The scope of WP8 is not about populating urban scale indicators sets, but rather it is about monitoring and evaluation specific local demonstrators. 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:

- Common framework: A common monitoring and evaluation framework defines the evaluation targets to be addressed and the evaluation methods to be used including processes covering data collection, data standards, data quality, data stewardship and the definition of key evaluation indicators.
- Local implementation: Although the overall evaluation framework will be developed centrally, responsibility for the implementation of the framework will reside locally with relevant research and delivery partners in each city. This is because the successful implementation of complex data collection protocols depends on detailed local knowledge

which is only available in the local partners. Moreover, local knowledge is critical for the design of proper control.

- Target salience: Each PPP measure will entail a set of technical developments and will have a range of direct and indirect effects on people, business and the public sector. Since it is impractical to monitor and evaluate every possible technical and impact dimension, the selection of relevant evaluation targets will be a critical part of the common framework. This selection will be based on consideration of the salience of each potential evaluation target 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.
- Control for covariates: Each PPP measure will be introduced into a complex environment in which many different factors can influence a particular outcome or evaluation target. For example, when considering the impact of a building retrofit measure on energy use and expenditure, we need to recognise that energy expenditure will be affected by energy prices, weather conditions, appliance ownership and use and patterns of building occupancy as well as the retrofit measure itself. It is vital that the monitoring and evaluation activities collect sufficient information on these covariates to enable proper statistical control for their effect. An important element of this is to ensure that a sufficient time series of data are collected not only after but also before the implementation of the PPP measures.
- Common core: A key element of the common evaluation framework is the development of a common core of evaluation targets and associated KPIs and data and measurement processes that will be implemented in a consistent manner across all three cities. This common core will provide the fundamental mechanism by which the SHARING CITIES will be able to aggregate experience and learning across the participating cities and indeed more widely. This common core will be selectively augmented by additional evaluation targets that are specific to a particular city and/or a particular PPP measure.
- Dimensions of impact: It is recognised that the PPP measures implemented by SHARING CITIES 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. Our experience suggests that it is useful to structure consideration of these impacts under five broad headings:
    - technical performance
    - institutional and business consequences
    - impacts on attitudes and behaviours
    - wider systemic impacts including environmental, security, safety and sustainability
    - economic and social implications including those affected by efficiency, equity and social inclusion

  This structuring provides a useful simplification of what might otherwise be an overly complex domain and additionally assists the task of designing data collection protocols.

1.1.3 D8.1: Common monitoring and evaluation framework (CMEF)

Deliverable 8.1 (D8.1) describes the CMEF that defines the following key elements for each SHARING CITIES demonstrator:

- The specific evaluation targets: These are the research questions of relevance and interest to SHARING CITIES. For example, in the case of PPP measures in the transport domain such questions relate to the adoption and use of shared mobility services and the impact of such services on car ownership, energy use and emission. Likewise, for the platform technologies developed in the project, interest focuses on the quality of the data attracted to the platform and the use made of it by individuals and business. Developing an agreed set of evaluation targets was a key early activity in the project. These were divided between core targets that are addressed.
- Measurable indicators: Corresponding to each evaluation target one or more measurable indicators are defined. For instance, in the case of the shared mobility example considered above, adoption and use can be measured using indicators such as mode share and trip frequency. In general, the evaluation indicators will be quantitative but in some instances,

such as in understanding the impact of a new disruptive service on existing business relationships and regulatory framework, it may be more appropriate for indicators to include both quantitative and qualitative elements.

- Data standards: Standards are necessary both in the definition of underlying data and indicators (e.g., what exactly do we mean by a trip?) and in the manner in which relevant information is stored, pre-processed and stewarded through the lifetime of the project, and beyond. D8.1 draws on relevant industry and academic standards wherever possible, to ensure that the data are as transparent and transferable as possible.
- Data collection methods: The broad types of data collection methods that will be used to obtain the information required for the development of the evaluation indicators are identified and agreed in D8.1. A wide range of different methods of data collection is available including the harvesting of information from operation data streams, the undertaking of polls and questionnaires, panel surveys, the administration of structured and unstructured interviews, hypothetical choice experiments, case studies and narratives. Consideration is also given to the duration over which data should be collected including identify those case where a before-and-after approach is required. The types of methods used is matched to the nature of the research targets and indicators.

1.2 This deliverable

1.2.1 Scope

Based on the CMEF described in D8.1, specific data collection methods and instruments ("protocols") for the core and site specific research targets in each city are developed. These specific protocols take into account considerations of local context and language (including relevant local covariates) and are presented in a form that can be deployed directly in the relevant cities. Deliverable 8.2 describes the specific data collection protocols to be used to implement the CMEF in each city.

1.2.2 Process of developing core and site specific data collection protocols (DCPs)

To ensure that the principles described in section 1.1.2 are satisfied across all leader cities, a standardised approach for developing the DCPs is outlined.

Although the evaluation framework is developed centrally, local knowledge is essential for establishing feasible and realistic DCPs. Therefore, local monitoring and evaluation (M&E) partners are involved in the design processes to ensure its successful implementation. Taking into account the common evaluation targets defined in D8.1, DCPs are initially designed as site specific documents by local partners. The involvement of local partners both in the CMEF development process and the design of local DCPs, ensures the establishment of a common core of measures that accounts for local implementation constraints.

To apply salience to the evaluation targets considered in the DCPs, input from local authorities of the lead cities is requested, as the monitoring and evaluation is associated to demonstrator features and local policy aspirations. As DCPs do not only capture local uniqueness, but also consider the common urban context, a standardized table population approach has been adopted by local M & E partners across all cities. The form and function of the data collection tables that capture the demonstrator actions to direct effects to final benefits is discussed in more detail in the following section.

The close collaboration with local authorities is also important as the DCPs are anticipated to function as guideline documents to be deployed directly in the relevant cities. Demonstrator's procurement processes are in practice the mean for communicating the monitoring and evaluation requirements to the appropriate stakeholders. Therefore, establishing DCPs prior to demonstrator reaching the procurement stage is essential. The information that require to be captured as best as possible on the features of every PPP demonstrator from each local authority are:

- Aim(s) and relevant local policy aspirations
- Scale (area affected, number of units)
- Timeline of implementation
- Components (types of units)

- Existing monitoring equipment & data
- Other changes occurring in the demonstrator area over the same period of time

Once that information on each demonstrator have been gathered, it is possible to identify the optimal set of evaluation targets to saliently monitor and evaluate the performance of the specific demonstrator within the SHARING CITIES project context. To undertake this task, the most relevant evaluation targets from the ones described in D8.1 are identified using the demonstrator actions to direct effects to final benefits tables, that ensure that the monitoring is sufficiently exhaustive to capture performance with respect to the primal demonstrator aim, while ensuring sufficient covariates control, and reasonable data collection requirements. The mutual agreement on the detail of the data collection process with the local authorities is vital for successfully deploying the M & E program in each city.
Once a set of evaluation targets is identified for each demonstrator in each city, the common core can also be established, leading to the development of common and site specific DCPs. The local implementation of each DCP requires to be managed as a coherent programme of work, with clear responsibilities and solid processes of quality control. The detailed description of the data collection program, is beyond the context of this report and is addressed in Deliverable 8.3 of the SHARING CITIES project that focuses on the design of the overall monitoring programme activities in each city and the local evaluation programme delivery.

In summary, the DCP development process can be outlined as follows:

Part A) Local implementation parameters (per local demonstrator):

Step 1: What is the aim of the scheme/ demonstrator?
Step 2: What are the relevant local policy aspirations? Populate final benefits table.
Step 3: What is the demonstrator size, and at what scale is the demonstrator anticipated to have an impact (e.g. benefits from a small scale scheme won't be measurable at a borough level, instead the impact per individual user requires to be monitored).
Step 4: What is the demonstrator implementation timeline, e.g. procurement date?
Step 5: What components and features does the demonstrator involve? Populate demonstrator actions column.
Step 6: What monitoring is in place and what data are available that can be used for establishing a baseline or for covariates control.
Step 7: What other changes occur over the implementation period on the demonstrator area?

Part B) Local set of evaluation targets identification (per local demonstrator):

Step 1: Identify relevant evaluation targets from the CMEF, described in D8.1. Populate demonstrator actions to direct effects to final benefits tables.
Step 2: Check if demonstrator aims are evaluated accurately
Step 3: Check for sufficient covariates control.
Step 4: Local authorities agree on reasonable data collection detail.

Plan C) Common & site specific DCPs (per common demonstrator):

Step 1: Establish common ground with other cities w.r.t. monitoring data and evaluation processes.
Step 2: Develop demonstrator specific data collection protocol covering core and site specific evaluation. Describe monitoring devices required. Discuss the timeline of data collection in particular w.r.t. establishing a baseline. Describe surveys that require to be undertaken and their timeline in particular w.r.t. establishing a baseline.

Part A of the DCP development process is primarily concerned with collecting the information on the demonstrator actions to direct effects to final benefits tables for each SHARING CITIES demonstrator that are discussed into more detail in the following section. In Part B, the information collected are processed aiming to establish site specific data collection requirements, and in Part C, the information from all cities are consolidated into a unified DCP.

1.2.3 Demonstrator data collection tables

A tabular approach is introduced to establish a transparent link between the demonstrator actions and final benefits and to ensure all demonstrator impacts are captured and evaluated. The aim is to set a common scheme for analysing all demonstrator features in terms of their anticipated benefits, applicable to all leader cities of the project and beyond. The tabular approach provides a holistic view of the actions and benefits for each demonstrator, enabling the identification of specific data streams and the associated evaluation target each one captures. By linking, demonstrator actions and benefits, to specific evaluation targets and data sources, it is possible to identify overlapping data streams and data voids. This is an essential step for ensuring that:

1. there is at least one data stream for evaluating all demonstrator benefits and impacts,
2. while at the same time there is data collection salience, and
3. sufficient covariates' control.

This tabular approach originates from the "Smartainability" [1] methodology (Girardi & Temporelli, 2017). Smartainability method links every action of a project or project's asset with direct effects or functionality; with a similar scheme, every direct effect (functionality) is then linked with the project's benefits generated. These benefits, at last, are evaluated with adequate quantitative or qualitative indicators.

Taking inspiration from Smartainability methodology, the Sharing Cities tabular approach is realized. To better understand the main features of every demonstrator, the "actions to effects" and "effects to benefits" tables were populated for each demonstrator. For the "actions to effects" table each demonstrator implementation partner of the SHARING CITIES project was asked to explain what are the main components to be deployed for a demonstrator. For example, for the private building case, some actions are facade/wall insulation, floor insulation, roof, thermostatic valves and solar screens. Every deployed component has a direct effect within the project, and therefore the table captures how various effects are activated by specific demonstrator features.

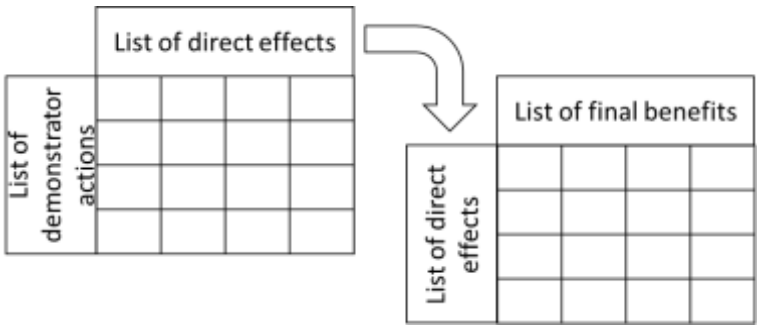

Figure 1.1: Actions to effects to benefits tables

For the "effects to benefits" table the direct effects list pivots and how demonstrator final benefits are activated for various direct effects is captured. The two tables together, map the links between demonstrator components, functions and impacts, making easy to track which effects and benefits a data collection stream captures. A correlation with evaluation targets is then made to ensure a sufficient and salient data collection protocol is established.

1.2.4 Fitting DCPs to be compliant and replicable

As described in Section 1.2.2, a bottom-up approach has been adopted in developing the Data Collection Protocols (DCPs), to ensure that the local monitoring and evaluation constraints are overcome and the proposed DCPs are compliant, feasible and realistic. However, monitoring and evaluation of SHARING CITIES demonstrators is required to be highly replicable, as a fundamental aim of the project is to develop widely applicable solutions in particular across Follower and Scale-Up cities.

[1] Girardi, Pierpaolo, and Andrea Temporelli. "Smartainability: A Methodology for Assessing the Sustainability of the Smart City." Energy Procedia 111 (2017): 810-816.

To build-in replicability into the monitoring and evaluation of the SHARING CITIES demonstrators, the Common Monitoring and Evaluation Framework (CMEF) presented in Deliverable 8.1 (D8.1), outlines standardized quantification means for various relevant evaluation targets, aiming to make similar data comparable across all demonstrators and cities and increase their utilization. In the context of this deliverable (D8.2), it is essential to establish the common Key Performance Indicators, evaluation targets and data sources associated to site specific DCPs. The "common ground" across site specific DCPs (referred hereafter as common DCPs) corresponds to the minimum monitoring and evaluation requirements and features each city and each demonstrator within and beyond SHARING CITIES should accommodate, to saliently assess performance and impact.

Within SHARING CITIES, a discussion with local authorities and replication partners is undertaken to establish the "common DCPs". A salient balance requires to be established between a small core that offers easier local compliance and light-touch data replicability; or a larger core that is more difficult to replicable but provides higher data value. As data are expensive to acquire, it is essential to make aware local authorities of the value that can be extracted by various types of data sources and analysis, and establish how much is worth investing (further to the 'specific DCPs') to establish a 'common DCPs' core that represents and optimal and salient minimum data requirement.

In recent years there have emerged tens of different overlapping and mutually contradictory indicators sets from different national and international bodies and projects, and there are no agreed or globally applicable standards. In the context of the CITYKeys[2] and CIVITAS[3] projects, smart cities monitoring frameworks have also been developed by shortlisting indicators in terms of availability, indicating that data for the indicators should be easily available. As the inventory for gathering the data for the indicators should be kept limited in time and effort, the indicators should be based on data that either:

- are available from the project leader or others involved in the innovation case that is being evaluated,
- or can easily be compiled from public sources,
- or can easily be gathered from interviews, maps, or terrain observations.

It is also noted that, indicators that require, for instance, interviews of users or dwellers are not suited as the large amounts of data needed are too expensive to gather. The same holds for indicators that require extensive recalculations and additional data, such as footprint indicators, and some financial indicators. The current selection contains, however, a few footprint type indicators that might be expected to become common in the near future (e.g. reduction in indirect CO2 emissions). Also, a few indicators have been added that score very high on relevance, as they touch upon topics that are high on the political agenda, but for which data availability at the moment is low (e.g urban food production). They are on the list as 'aspirational' indicators, for which it is expected that the data situation may change soon.

In the context of Sharing Cities, some of the indicators proposed in CITYKeys and CIVITAS projects adequately capture city level and demonstrator performance, and are adopted. However, there is little consideration of the value of replicability of indicators, and no consensus on when cities should invest to amend their monitoring strategies to 'common KPIs'.

1.2.5 Deliverable structure & contents

The deliverable presents DCPs into four chapters that discuss retrofit, SEMS, mobility and lamppost demonstrators respectively. In each chapter, a description of the demonstrator features and aims is undertaken for each city and where relevant a city-wide ambitions description is provided. The tables connecting the demonstrator features to benefits and evaluation targets are presented and discussed per demonstrator, and finally the core and site specific DCP is presented.

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[2] Peter Bosch, P., Jongeneel, S., Vera Rovers, V., Hans-Martin Neumann, H.M., Airaksinen, M. and A. Huovila, 2017. CITYkeys indicators for smart city projects and smart cities. CITYkeys project.

[3] Rooijen, T., Nesterova, N. & Guikink, D., 2013. Applied framework for evaluation in CIVITAS PLUS II. Deliverable 4.10 of CIVITAS WIKI of CIVITAS initiative. Cleaner and better transport in cities (CIVITAS WIKI)

The methodology for developing the DCPs is highly dependent on the maturity of a demonstrator, as described in sections 1.2.2 and 1.2.3. This deliverable is therefore considered to be a live document that is updated as more detailed information on demonstrator features become available. Depending on the finality of information on demonstrator features and actions, the DCPs described in this report can be considered either as “complete” for procured demonstrators or as “work-in-progress” for non-procured ones. The stage of each demonstrator considered in the Sharing Cities project is described in Table 1-1. The “work-in-progress” DCPs are based to on the most up-to-date demonstrator features available and are meant to be considered as indicative rather than binding.

Table 1-1: Sharing Cities demonstrator procurement stage

	Demonstrator Types	Lisbon	London	Milan
T3.1	Public residential	Project is procured – not works	First procurement done – more to follow	
	Private residential	Project and works procured – more buildings to be selected		Not procured – it is waiting for condominiums approval
	Public service	Not procured – they are currently negotiating the PV installation approval.		N/A
T3.2	SEMS	RFP sent to contenders		Not to be procured
	SEPS		N/A	
T3.3	e-bike	Procured	Procured	Based on an existing procurement
	e-car	First procurement done – more to follow	Procurement imminent	Based on an existing procurement
	e-vehicle charging	RFP is being finished		Based on an existing procurement
	e-bus		N/A	N/A
	e-logistics	First procurement done – more to follow	Procurement imminent	Based on an existing procurement
	Smart parking			
T3.4	Smart lamppost		Not procured – currently examining AQ sensors options	Procured

2 DCPS FOR T3.1 – BUILDINGS RETROFIT

2.1 Nomenclature

The terminology used in this chapter is in accordance with the standard EN 15603. The terms used in the chapter are defined below.

ENERGY NEED

- **Energy need for heating or cooling:** heat to be delivered to, or extracted from, a conditioned space to maintain the intended temperature conditions during a given period of time.
- **Energy need for domestic hot water (DHW):** heat to be delivered to the needed amount of domestic hot water to raise its temperature from the cold network temperature to the prefixed delivery temperature at the delivery point.
- **Energy need for humidification and dehumidification:** latent heat in the water vapor to be delivered to or extracted from a conditioned space by a technical building system to maintain a specified minimum or maximum humidity within the space.

ENERGY USE

- **Energy use for space heating or cooling or domestic hot water:** energy input to the heating, cooling or hot water system to satisfy the energy need for heating, cooling (including dehumidification) or hot water respectively.
- **Energy use for ventilation:** electrical energy input to the ventilation system for air transport and heat recovery (not including the energy input for preheating the air) and energy input to the humidification systems to satisfy the need for humidification.
- **Energy use for lighting:** electrical energy input to the lighting system.
- **Energy use for plug load*:** electrical energy input to the plug load system.
- **Energy use for thermal aux*:** electrical energy used for the thermal auxiliaries (e.g. circulating pumps).
- **Energy use for BMS/Control*:** electrical energy input to the Building Management System and for the other control equipment.

DELIVERED ENERGY

- **Delivered energy**: energy, expressed per energy carrier, supplied to the technical building systems through the system boundary, to satisfy the uses taken into account (heating, cooling, ventilation, domestic hot water, lighting, appliances etc.) or to produce electricity.
- **Technical building system**: technical equipment for heating, cooling, ventilation, domestic hot water, lighting and electricity production.
- **System boundary:** boundary that includes within it all areas associated with the building (both inside and outside the building) where energy is consumed or produced.

RENEWABLE AND EXPORTED ENERGY

- **Renewable energy**: energy from sources that are not depleted by extraction, such as solar energy (thermal and photovoltaic), wind, water power, renewed biomass.
- **Renewable energy produced on the building site:** energy produced by technical building systems directly connected to the building using renewable energy sources.
- **Exported energy:** energy, expressed per energy carrier, delivered by the technical building systems through the system boundary and used outside the system boundary.
- **Renewable energy produced and exported from site***: renewable energy produced on the building site (by Photovoltaic System, Biomass, Geothermal, Solar Thermal, Wind Energy, etc.) and exported from site.
- **Renewable energy used and produced on site*:** renewable energy produced on the building site (by Photovoltaic System, Biomass, Geothermal, Solar Thermal, Wind Energy, etc.) and used on site.

EFFICIENCY

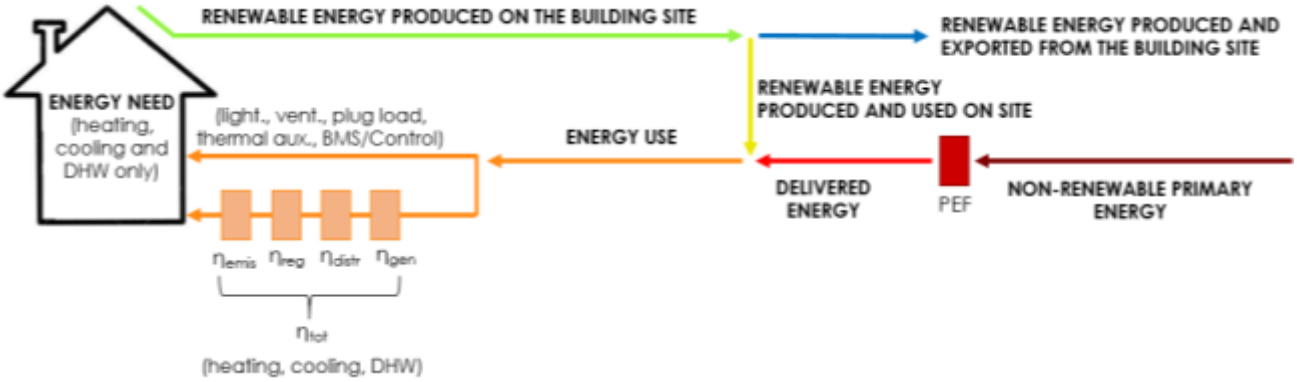
- **Efficiency η_{tot}***: total efficiency of each technical building systems (including emission efficiency η_{emis}, regulation efficiency η_{reg}, distribution efficiency η_{distr} and generation efficiency η_{gen}).

PRIMARY ENERGY

- **Primary energy:** energy that has not been subjected to any conversion or transformation process. Primary energy includes non-renewable energy and renewable energy. If both are taken into account it can be called total primary energy. For a building, it is the energy used to produce the energy delivered to the building. It is calculated from the delivered and exported amounts of energy carriers, using conversion factors.
- **Total primary energy factor (PEF):** for a given energy carrier, non-renewable and renewable primary energy divided by delivered energy, where the primary energy is that required to supply one unit of delivered energy, taking account of the energy required for extraction, processing, storage, transport, generation, transformation, transmission, distribution, and any other operations necessary for delivery to the building in which the delivered energy will be used.
- **Non-renewable primary energy factor:** for a given energy carrier, non-renewable primary energy divided by delivered energy, where the non-renewable energy is that required to supply one unit of delivered energy, taking account of the non-renewable energy required for extraction, processing, storage, transport, generation, transformation, transmission, distribution, and any other operations necessary for delivery to the building in which the delivered energy will be used.
- **CO_2 emission coefficient:** for a given energy carrier, quantity of CO_2 emitted to the atmosphere per unit of delivered energy.

***** The definitions marked with the star (*), are not derived from the standard EN 15603 but are provided by the authors.

Figure 2.1 Scheme of building energy levels



2.2 Overview of leader cities actions

2.2.1 Milan

In Milan the main aim of building retrofit is to reduce the energy consumption while maintaining or increasing comfort for the occupants. Before describing in detail the retrofit actions planned for public and private buildings, summarized respectively in the following Table 2-3 and Table 2-13, the entire amount of retrofit actions foreseen in the city of Milan, including both public and private interventions are described. In the following sections, these actions will be detailed for the specific public and private estates.
The retrofit actions, divided per subsystem, i.e. envelope, and technical systems are gathered in Table 2-1.

Table 2-1: Summary of retrofit actions foreseen in the city of Milan

Subsystem	Retrofit actions
Envelope	Façade insulation
	Floor insulation
	Roof insulation
	Windows substitution
	Solar shadings installation
Technical systems	Heat generator substitution
	Distribution system insulation
	Replacement of circulation pumps for the heating and domestic hot water systems
	Generation system remote management
	Thermostatic valves installation
	Voltage regulation
	LED lamps installation (only for common area)
	Photovoltaic panels installation
	Electrical storage battery
	Solar thermal panels installation
	Mechanical ventilation system installation

In Milan the improvement of the building envelope is a core action of the retrofit, and it includes the façade, floor, and roof insulation, windows substitution and solar shadings installation. These actions contribute both to the energy saving and to the occupants' thermal and visual comfort improvement.
The actions on the heating and domestic hot water (DHW) systems include the substitution of the heat generator, the distribution system insulation, the remote control of the generation system, the installation of thermostatic valves and the replacement of circulation pumps. These actions will improve the generation, distribution and regulation efficiencies of the systems. Moreover, the generation system remote management will enable the occupants, according to their feedbacks, to manage and control some environmental parameters, such as the indoor air temperature.
The substitution of the existing lighting system with more energy-efficient LED lamps in common areas, will reduce lighting energy consumptions, whereas the voltage regulation by processing different electrical parameters such as voltage peaks and reactive energy, will stabilise the voltage over a wide range of equipment.
Moreover, to contrast energy consumptions, renewable energy sources will be exploited by installing photovoltaic (PV) and solar thermal systems. Electrical storage batteries may eventually contribute to maximize the use on site of the energy produced by photovoltaic panels. This technical solution has the highest impact when electrical heat pumps are adopted as generation system.
Finally, the installation of a mechanical ventilation system, will allow to the reduce ventilation heating loss and at the same time to provide an adequate level of indoor air quality (IAQ).
Not all of the action summarised in Table 2-1 are implemented in the public or private buildings. Thus, when a retrofit action is not implemented, a "not applicable" label is reported in the following sessions and Tables.

2.2.2 Lisbon

The goal of the retrofitting actions taking place in Lisbon were the reduction of primary energy consumption, the increase of comfort levels for the occupants as well as the increase of the use of renewables. In Lisbon there are demonstrators for retrofitting in public residential buildings, private residential buildings and public service buildings. The retrofitting actions taking place depend on buildings as each have different needs and restrictions. These actions are described in detail in the following sections. The retrofit actions taking place divided per subsystem, i.e. envelope, and technical systems are gathered in Table 2-2.

Table 2-2 - Summary of retrofit actions foreseen in the city of Lisbon.

Subsystem	Retrofit actions
Envelope	Façade insulation
	Roof insulation

	Windows replacement
	Glazing replacement
Technical systems	LED lamps installation
	LED lamps installation in common areas
	Heat Pump installation for air conditioning
	HVAC system replacement
	Heat Pump installation for DHW
	Electric water heater installation
	Photovoltaic panels installation

The improvement of the building's performance is achieved by focusing on the enhancement of the envelope of the building and its systems. The improvement of the building envelope is one of the core actions of retrofitting as it improves the building's performance, regardless of the system's operation. For the Lisbon demonstrator the envelopes will be improved by adding insulation in the façade and roof and by using better windows (glazing plus framing) or by using better glazing solutions for a building for which the framing of the windows cannot be changed.
The replacement of the existing lighting systems by more efficient LED light bulbs will reduce the electricity consumption for lighting without compromising the visual comfort of the occupants of the buildings.
Heat and cooling supply energy efficiency improvement will be achieved either by the replacement of the HVAC system or by the installation of heat pumps. The use of heat pumps for domestic hot water will also contribute for a decrease in energy consumption for water heating. The electric water heater is a less efficient alternative but still an improvement when compared with the original equipment in the building.
Renewable energy sources available on site will be explored by installing PV panels.

2.3 Public residential buildings

2.3.1 Milan demonstrator actions

As part of the Sharing Cities project, the Municipality of Milan has decided to promote a deep energy renovation, of a social housing unit built in the 1980's, consisting of two blocks with four stories each. The retrofit is meant to improve energy and comfort conditions of this building and the wellbeing of the inhabitants.
The gross surface area of the buildings is 4633 m^2, accounting for 66 residential units. The building envelope is made of prefabricated concrete elements, presenting almost no thermal insulation, and of low performance windows with no solar shading. The exiting centralized heating system uses fuel oil as energy carrier, whereas each apartment is equipped with a local boiler for DHW generation, using natural gas as energy carrier. Natural gas is used also for cooking, while all the other energy uses rely on electrical energy, supplied by the national grid.
The blocks are located in the proximity of a few other social housing units, undergoing similar, although less ambitious, energy retrofits. The area may therefore be considered as the inception of a smart energy district, where deep energy retrofits are complemented by advanced monitoring plans, aiming at assessing the actual buildings' performance.
Monitoring and evaluation forms, in fact, a key element of the project, since it provides the means by which the work undertaken in the project will become a source of information for future local policies on energy retrofit.
The retrofit strategy is based on many actions focused on the substantial reduction of building's energy needs, providing, at the same time, adequate thermal comfort conditions for occupants. The improvement of the building envelope is therefore the core action of the retrofit, and it includes:

- Exterior insulation of the opaque elements including walls, roof and exposed ground floor slab;
- Low-e double glazing windows and frame with thermal break;
- Exterior solar shading (louvres manually operated by occupants).

In order to control heat loss due to ventilation, allowing at the same time for an adequate level of IAQ, a centralized mechanical ventilation system with heat recovery and by-pass (to allow for free cooling in summer and mid seasons) will be installed. The additional actions on building systems, complementing the deep intervention on the envelope include:

- Installation of a high-performance centralized heating systems based on heat pumps;
- Installation of a high-performance centralized DHW generation system based on heat pumps;
- Mechanical ventilation (as described above);
- Substitution of lighting systems lamps in common areas with LED lamps;
- Distribution system's insulation in the boiler room.

The delivered energy will be partially complemented exploiting renewable energy source by installing:

- A PV system for the production of electrical energy;
- A solar thermal system integrating the DHW system.

An energy management system, in combination with electric storage batteries, will contribute to maximize the building self-use of the PV generated energy, to contrast common uses such as elevators and lighting, and perhaps also heat pumps and mechanical ventilation.
The retrofit actions described above may have different direct effects, affecting and improving building performance by reducing heat losses, controlling heat gains, exploiting renewable energy sources, improving systems' efficiency, and ensuring adequate ventilation in the environments.
In the different retrofit actions undertaken for the public building are connected to the direct effects experienced in the building. The matrix shows the link existing between a retrofit action and one or more direct effects. The "X" shows the retrofit actions implemented in the public social housing in Milan and to what direct effect they are contributing to.
The following Table 2-3 reports all the possible retrofit actions pursue in the Milan area, when a retrofit action is not implemented, a "not applicable" label is reported.

Table 2-3 Summary of retrofit actions in relation to the direct effects for the public building in Milan

Direct effects / **Retrofit actions**	Winter heat loss control	Summer heat gains control	Indoor temperature improvement	Generation efficiency improvement	Distribution efficiency improvement	Regulation efficiency improvement	Renewable energy system penetration	Electric efficiency improvement	Solar radiation control	Ventilation heating loss reduction	Suitable ventilation
Façade insulation	X		X								
Floor insulation	X		X								
Roof insulation	X		X								
Windows substitution	X	X	X						X		
Solar shadings installation		X							X		
Heat generator substitution				X		X					
Distribution system insulation (only in the boiler room)					X						
Replacement of circulation pumps for the heating system					X	X					
Generation system remote management	Not applicable										

Thermostatic valves installation						X					
Voltage regulation	Not applicable										
LED lamps installation (only for common area)								X			
Photovoltaic panels installation							X				
Electrical storage battery							X				
Solar thermal panels installation							X				
Mechanical ventilation system installation										X	X

2.3.2 Milan demonstrator benefits and evaluation targets

Building energy retrofits may have different benefits depending on the actions undertaken and the consequent direct effects. In the contest of the Sharing Cities project, as consequence of the deep energy renovation of the social housing building, the expected benefits are:

- Energy savings;
- Thermal comfort improvement;
- Visual comfort improvement;
- Indoor air quality (IAQ);
- Emissions reduction.

Better thermal comfort conditions affect directly the quality of life of occupants, physiologically and psychologically. Most of the occupants of social housing often experience low levels of thermal comfort due mostly to an inadequate temperature and to cold air draughts. By improving envelope (both opaque and transparent) insulation, and by increasing the buildings' airtightness, the major reasons of discomfort complaints should be solved. Providing an adequate level of natural light ensures, on the other hand, building occupants' visual comfort. Moreover, daylight can increase occupants' satisfaction if glare can be controlled. By installing exterior solar shading (louvres manually operated by occupants), the occupants will be empowered to control the amount of light coming from outside, and so to control both the natural light level and the glare. Improved mechanical ventilation and education on how and when to properly operate windows, should moreover guarantee adequate levels of IAQ and energy savings.

After the energy retrofit, the energy delivered to the buildings for space heating and other energy uses is expected to substantially decrease, with energy and economic savings, and pollutants and greenhouse gas emissions reduction. Due to the limited size of the intervention the reduction of emissions cannot be measured, nevertheless it might represent, in the long run, one of the most important effects of energy retrofits, if similar interventions will be replicated on a large part of the city's buildings stock.

In Table 2-4 the direct effects of energy retrofit are linked to the benefits pursue by the tenants and the society. Each benefit is resulting from the combination of the many direct effects that altogether contribute to it; e.g., energy saving is the results of the complex combination of: winter heat loss control, summer heat gains control, generation efficiency improvement, distribution efficiency improvement, regulation efficiency improvement, electric efficiency improvement and ventilation heat loss reduction.

The "X" shows the contribution of direct effects foreseen in the public social housing to the final benefits.

Table 2-4 Summary of direct effects in relation to the benefits for public buildings in Milan

Benefits / **Direct effects**	Energy saving	Thermal comfort improvement	Visual comfort improvement	Indoor air quality improvement	Emissions reduction
Winter heat loss control	X	X			X
Summer heat gains control	X	X			X

Indoor temperature improvement		X			
Generation efficiency	X				X
Distribution efficiency	X				X
Regulation efficiency	X	X			X
Renewable energy system penetration	X				X
Electric efficiency improvement	X				X
Solar radiation control		X	X		
Ventilation heating loss reduction	X	X			X
Suitable ventilation				X	

Assessing specific evaluation targets is a suitable way to prove apartment or building performance, and the consequent benefits obtained. Some benefits, as energy saving, can be assessed through several targets, corresponding to the different levels of energy (e.g. energy savings for heating, energy savings for ventilation etc.).
Tenants' satisfaction, thermal comfort, visual comfort, acoustic comfort and IAQ, have been defined as key evaluation targets to check for improvements in the quality of building's indoor environments.
In Table 2-5 benefits are linked to the possible evaluation targets that will allow, once expressed in terms of performance indicators, to measure the building performance.
Highlighted in bold in the Table, the core-benefits and their relative evaluation targets, that are related to the retrofit actions foreseen by the Sharing Cities project in the public buildings in Milan. In Italics, we report further benefits that may results as indirect consequence of the retrofit actions. Since they are not basic for the Sharing Cities project, they may not be evaluated by means of evaluation targets and related performance indicators. It means that the retrofit actions may have indirect positive benefits, that will improve further the building performance, but they will not be evaluated within the project, because they are not core-benefits.
The "X" in the right column, indicates what evaluation targets is applied to the project.

Table 2-5 Benefits and evaluation targets for the public building in Milan

Benefits	Evaluation targets	Applied in the project
Energy saving	Energy savings for heating	X
	Energy savings for cooling	no
	Energy savings for ventilation	X
	Energy savings for lighting	Together with other electrical uses
	Energy savings for domestic hot water	X
	Energy savings for cooking	X
	Energy savings for plug load/ appliances	Together with lighting
	Energy from renewable sources	X
Indoor thermal comfort improvement	Indoor thermal comfort level	X
	Tenants satisfaction	X
Indoor visual comfort improvement	Indoor visual comfort level	no
Indoor acoustic comfort	Indoor acoustic comfort level	no
Indoor air quality improvement	Indoor air quality level	X
Emissions reduction	Air pollution level	no
Building resilience	Performance reliability	no
City resilience	Building energy supply reliability	no

	City energy generation relief	no
	City electricity networks infrastructure relief	no
Attitudinal - Operator	Operator perception of system functionality	no
	Operators perception of system control	no
Attitudinal – User	Stakeholder willingness to retrofit	no

2.3.3 Milan specific data collection protocol

In this section, the list of possible measurable indicators that can be used to assess the proposed evaluation targets for public building retrofit are listed and characterized in terms of their units, possible data collection methods, critical issues, measurement frequency, etc. It is worth noting that there is a pending request to the national privacy authority that will provide us a final decision on the possibility of monitoring energy and environmental data at the apartment level. Until we will receive the authorization, the monitoring activities will not be put into practice. If the decision will be negative, only the aggregate building data will be analysed.

To properly assess the impacts on energy and thermal comfort, the energy and comfort monitoring plan has been designed in close relationship with the deep energy retrofit. This plan includes a two stage monitoring protocol, covering the pre-retrofit and post-retrofit. The pre-retrofit monitoring plans includes:

- Delivered energy for space heating;
- Delivered energy for electrical household and common uses;
- Detailed thermal and visual comfort monitoring in 19 reference apartments;
- Outdoor weather conditions;
- Questionnaire surveys on comfort perception, indoor air quality sensation, appliances use, etc.

The pre-retrofit activities are under development; however, the data privacy issue could hinder the monitoring of some indicators on energy savings at the apartment level, the detailed thermal comfort monitoring in 19 reference apartments, and the questionnaire surveys. In general, for the data referring to individual users or apartments (including post-retrofit data), a privacy impact assessment (PIA) document must be produced, in order to reduce the risks of breach of privacy data.

The post-retrofit monitoring plan includes:

- Delivered energy for space heating;
- Delivered energy for DHW;
- Delivered energy for cooking (apartment level);
- Delivered energy for electrical household and common uses;
- Delivered energy for centralized mechanical ventilation;
- Electrical energy generated by the PV system;
- Thermal energy generated by the solar thermal system;
- Detailed thermal and visual comfort monitoring, in 19 reference apartments;
- Basic thermal comfort monitoring in each apartment;
- Outdoor weather conditions;
- Questionnaire survey on comfort perception, indoor air quality sensation, appliances use, etc.

Table 2-6 shows the specific indicators monitored during the project, it specifies in detail what indicators will be monitored during pre- and/or post-retrofit intervention. In addition to units, data collection methods, critical issues and actions necessary to achieve the measure, also the frequency of measure or sampling, the frequency of data recording, and the frequency of data sending are reported.

In the following Table 2-6 (and in the later Table 2-16) some changes have been applied, with reference to Deliverable 8.1; in particular:

- The order (column “N.”) has been changed to group together evaluation targets that refers to the same area of interest, e.g. all the energy targets, or all the comfort targets, etc.
- Some evaluation targets name has been updated in order not to contrast with definitions provided by standards in the nomenclature session, and to be more clear to the final users.
- Some indicators which refer to the apartment energy consumption not reported in Deliverable 8.1, have been introduced to complete the actual data monitoring protocol applied at the apartment level.
- The evaluation targets “Energy from renewable sources” and “Energy savings for cooking” with their indicators, and the indicator “Air temperature and relative humidity as proxy for thermal comfort” not reported in Deliverable 8.1, have been introduced to complete the actual data monitoring protocol.

All the measurable indicators listed in Table 2-6 do refer to the building level, unless specifically stated. For example, *primary energy, delivered energy,* and *energy delivered by the generation system* are different levels of the energy consumed by the entire building, whereas *apartment energy use* refers only to the apartment energy consumption.

Table 2-6: List of evaluation targets and indicators for the public building in Milan (measurable indicators refers to the building level unless specifically stated)

N.	Evaluation target	Measurable indicator(s)	Unit	Applied in the pre-retrofit intervention	Applied in the post-retrofit intervention	Data collection method(s)	Measure frequency	Data recording frequency	Data sending frequency	Critical issues?	Necessary actions to achieve the measure?
1	Energy savings for heating	Primary energy	kWh	No	Yes	Delivered energy + primary energy factor	Continuously	15'	Hourly		
		Delivered energy	kWh, m^3, kg	No	Yes	Gas meter, flow meter + temperature sensors, barrels delivered, pellets delivered, electrical energy meters	Continuously	15'	Hourly		
		Energy delivered by the generation system	kWh	Yes	Yes	Temperature sensors + flow meters	Continuously	15'	Seasonal (pre-retrofit), hourly (post-retrofit)		
		Apartment energy use	kWh	No	Yes	Temperature sensors + Flow meters	Continuously	15'	Hourly	Privacy	PIA
2	Energy savings for cooling	Primary energy	kWh	No	No						
		Delivered energy	kWh, m^3, kg	No	No						
		Energy delivered by the generation system	kWh	No	No						
		Apartment energy use	kWh	No	No						
3	Energy savings for ventilation	Primary energy	kWh	No	Yes	Delivered energy + primary energy factor	Continuously	15'	Hourly		
		Delivered energy	kWh	No	Yes	Electrical energy meter	Continuously	15'	Hourly		
4	Energy use for lighting	Primary energy	kWh	Together with other common electrical uses	Together with other common electrical uses	Delivered energy + primary energy factor	Continuously	15'	Monthly		
		Delivered energy	kWh	Together with other common electrical uses	Together with other common electrical uses	Electrical energy meter	Continuously	15'	Monthly		
		Apartment energy use (delivered and primary)	kWh	Together with plug load/ appliances	Together with plug load/ appliances	Electrical energy meter	Continuously	15'	Monthly	Privacy	PIA

N.	Evaluation target	Measurable indicator(s)	Unit	Applied in the pre-retrofit intervention	Applied in the post-retrofit intervention	Data collection method(s)	Measure frequency	Data recording frequency	Data sending frequency	Critical issues?	Necessary actions to achieve the measure?
5	Energy savings for domestic hot water	Primary energy	kWh	No	Yes	Delivered energy + primary energy factor	Continuously	15'	Hourly		
		Delivered energy	kWh, m^3, kg	No	Yes	Gas meter, flow meter + temperature sensors, barrels delivered, pellets delivered, electrical energy meters	Continuously	15'	Hourly		
		Energy delivered by the generation system	kWh	No	Yes	Temperature sensors + Flow meters	Continuously	15'	Hourly		
		Apartment energy use	kWh	No	Yes	Temperature sensors + Flow meters	Continuously	15'	Hourly	Privacy	PIA
6	Energy savings for cooking	Apartment energy use	m^3	No	Yes	Gas meter	Continuously	15'	Monthly	Privacy, Smart meter deployment	PIA, A2A deployment program
7	Energy savings for plug load/ appliances	Apartment energy use (delivered and primary)	kWh	Together with lighting	Together with lighting	Electrical energy meter	Continuously	15'	Monthly	Privacy	PIA
8	Energy from renewable sources	Renewable energy produced on the building site	kWh	No	Yes	Flow meter + temperature sensors, electrical energy meter	Continuously	15'	Hourly		
		Renewable energy produced and exported from the building site	kWh	No	Yes	Electrical energy meter	Continuously	15'	Hourly		
		Renewable energy produced and used on site	kWh	No	Yes	Flow meter + temperature sensors, electrical energy meter	Continuously	15'	Hourly		
		Renewable energy stored in and released by the storage battery	kWh	No	Yes	Electrical energy meter	Continuously	15'	Hourly		

N.	Evaluation target	Measurable indicator(s)	Unit	Applied in the pre-retrofit intervention	Applied in the post-retrofit intervention	Data collection method(s)	Measure frequency	Data recording frequency	Data sending frequency	Critical issues?	Necessary actions to achieve the measure?
9	Indoor thermal comfort level	Air temperature and relative humidity as proxy for thermal comfort	°C, %	Yes (19 flats only)	Yes	Air temperature and RH sensors	Continuously	10'	10'	Privacy	PIA
		Operative temperature	°C	Yes (19 flats only)	Yes (19 flats only)	Air temperature and globe temperature sensors, anemometer	Continuously	10'	10'	Privacy	PIA
		PMV	-	Yes (19 flats only)	Yes (19 flats only)	Air temperature, globe temperature and RH sensors, anemometer	Continuously	10'	10'	Privacy	PIA
		PPD	%	Yes (19 flats only)	Yes (19 flats only)	Air temperature, globe temperature and RH sensors, anemometer	Continuously	10'	10'	Privacy	PIA
10	Indoor visual comfort level	Illuminance	Lux	Yes (19 flats only)	Yes (19 flats only)	Illuminance sensor	Continuously	10'	10'	Privacy	PIA
11	Indoor acoustic comfort level	Sound Pressure Level	dB(A)	No	No						
12	Indoor air quality level	CO_2	ppm	Yes (19 flats only)	Yes	CO_2 sensor	Continuously	60'	60'	Privacy	PIA
13	Tenants satisfaction	-	Grade 1-5	Yes	Yes	Tenants surveys	one time pre- and one time post-retrofit	one time pre- and one time post-retrofit	one time pre- and one time post-retrofit	Privacy	PIA
14	Air pollution level	Pollutants emitted (NO_x, PM)	kg	No	No						
15	Performance reliability	Minor repair	per year	No	No						
		Major repair	per year	No	No						
16	Building energy supply reliability	Frequency of blackouts	-	No	No						
17	City energy	Generation	%	No	No						

N.	Evaluation target	Measurable indicator(s)	Unit	Applied in the pre-retrofit intervention	Applied in the post-retrofit intervention	Data collection method(s)	Measure frequency	Data recording frequency	Data sending frequency	Critical issues?	Necessary actions to achieve the measure?
	generation relief	capacity factor									
18	City electricity networks infrastructure relief	Distribution network capacity	%	No	No						
		Transition network capacity	%	No	No						
19	Operator perception of system functionality	-	Grade 1-5	No	No						
20	Operators perception of system control	-	Grade 1-5	No	No						
21	Stakeholder willingness to retrofit	-	Grade 1-5	No	No						

2.3.4 Lisbon demonstrator actions

One of the retrofitting actions being led by the Lisbon municipality is the retrofit of a social housing unit in the Sharing Cities demonstrator area built in 1998. This unit includes two housing blocks made up by 10 buildings with a total of 248 dwellings and a build area of 20 609 m^2.

As is, the building as a façade of concrete blocks with a thickness of 20 cm and uses extruded polystyrene with a thickness of 4 cm in the interior side of the wall for thermal insulation. The roof is a 15 cm concrete slab and has 3 cm of extruded polystyrene insulation on the exterior and asbestos tiles. The windows have 4 mm simple glazing glass, aluminium frames and shutters. There are no central heating or cooling systems in any of the buildings. Domestic hot water is provided by a non-condensing boilers. Natural gas is the main energy carrier for domestic hot water and cooking appliances and electricity is used by small portable heaters, lighting and plug-in equipment.

The main goals of the retrofitting actions in social housing for the Lisbon municipality are the increase of thermal comfort for the occupants and the improvement of overall energy efficiency of the building. The main actions are:

- Façade and roof insulation;
- Window replacement;
- Replacement of lighting systems in common areas for LEDs lamps;
- Installation of PV panels.

The actions on the envelope will include the improvement of the insulation on the walls and the roof as well as the replacement of the windows. Regarding wall insulation, an external 6 cm thermal insulation composite system (ETICS) cork aggregate will be installed. It is particularly recommended in retrofit since, besides improving the overall energy performance of the building, it may reduce existent thermal bridges, and in terms of civil works it is not necessary to get inside the apartments. The roof will be renovated by replacing the roof insulation material with a 6 cm cork aggregate thick and removing the asbestos tiles. The existing windows, which have a very low thermal performance, will be replaced by double-glazing windows (4+16+4) with an air gap and PVC framing. It is expected that these actions will contribute for a decrease in the thermal needs of the building, which in this case can result in a decrease in energy consumption and/or improvement of thermal comfort for the occupants. It is expected that the improvements on the buildings' envelope will decrease the winter heat losses and summer heat gains, resulting in indoor temperature improvement. The improvement of the glazing will also result in a better solar radiation control.

The lamps in the common areas of the building will be replaced by more energy efficient LED lamps. This action will decrease the electricity needs of the building without compromising the lighting levels in the common areas. As the common areas are open air galleries, there will be no impact in the decrease of summer heat gains.

The roof of the building will be covered with PV panels. This action will contribute for the realisation of the renewable energy production potential of the building, resulting in the improvement of the overall energy performance of the building.

Table 2-7 presents a summary of the retrofitting actions taking place in the social housing retrofit demonstrator in Lisbon and evidences its expected benefits.

Table 2-7: Summary of retrofit actions in relation to the direct effects for the public residential buildings in Lisbon

Direct effects / Retrofit actions	Winter heat loss control	Summer heat gains control	Indoor temperature improvement	Generation efficiency improvement	Distribution efficiency improvement	Regulation efficiency improvement	Renewable energy system penetration	Electric efficiency improvement	Solar radiation control	Ventilation heating loss reduction	Suitable ventilation
Façade insulation	X		X								
Roof insulation	X		X								
Windows replacement	X	X	X						X		
Glazing replacement	Not applicable										
LED lamps installation	Not applicable										
LED lamps installation in common areas								X			
Heat Pump installation for air conditioning	Not applicable										
HVAC system replacement	Not applicable										
Heat Pump installation for DHW	Not applicable										
Electric water heater installation	Not applicable										
Photovoltaic panels installation							X				

2.3.5 Lisbon demonstrator benefits and evaluation targets

The benefits of building retrofit are dependent on the actions taking place the direct effects of such actions. For the Lisbon social housing retrofitted buildings the expected benefits are:

- Decrease of energy consumption;
- Improvement of thermal comfort;
- Improvement of visual comfort;
- Emissions reduction.

It is expected that the improvements to the envelope of the building result in a substantial improvement of indoor thermal comfort. Most of the occupants of social housing experience low levels of thermal comfort due mostly to an inadequate mean radiant temperature, i.e. inadequate temperatures of surrounding walls, and to cold air draughts. By improving envelope (both opaque and transparent) insulation and by increasing the buildings' airtightness, the major reasons of discomfort complaints should be solved. Better thermal comfort conditions affect directly the quality of life of occupants, physiologically and psychologically. Moreover, they may reduce, in the long run, the health issues related to a poor thermal environment. The removal of asbestos will result also in an improvement in health for occupants. A secondary benefit for tenants may result in the form of economic benefits. If, after the energy retrofit, the energy delivered to the buildings for space heating and other energy uses decreases, then the energy bills should decrease as well. However, due to the social-economic characteristics of the inhabitants, it may occur that some of the economic benefits will not be obtained, as people tend to not heat or cool their homes to the necessary comfort levels.

An expected indirect benefit for the government is the reduction of maintenance costs. It is also expected that the local government experiences economic benefits from the energy savings from the replacement of the lighting system in the common areas and the sale of energy to the grid from PV production.

Table 2-8 displays the expected benefits from each direct effect of the retrofitting of the social housing buildings in Lisbon.

Table 2-8 - Summary of direct effects in relation to the benefits for public buildings in Lisbon

Benefits / Direct effects	Energy saving	Thermal comfort improvement	Visual comfort improvement	Indoor air quality improvement	Emissions reduction
Winter heat loss control	X	X			X
Summer heat gains control	X	X			X
Indoor temperature improvement		X			
Generation efficiency					
Distribution efficiency					
Regulation efficiency					
Renewable energy system penetration	X				X
Electric efficiency improvement	X				X
Solar radiation control		X	X		
Ventilation heating loss reduction					
Suitable ventilation					

In order to assess the actual results of the retrofitting actions, several evaluation targets were established. The application of the evaluation targets is then dependent on the expected benefits and consequently the deployed actions. Table 2-9 relates the expected benefits with the evaluation targets that will allow the assessment of the success of the demonstrator. In Lisbon, due to privacy restrictions, the evaluation of the benefits is limited by the available data sources to assess the evaluation targets. For example, it will be possible to evaluate overall energy savings, just not disaggregated by the different uses.

Table 2-9 - Benefits and evaluation targets for the public buildings in Lisbon

Benefits	Evaluation targets	Applied in the project
Energy saving	Energy savings for heating	Included in total electricity consumption of tenants
	Energy savings for cooling	Included in total electricity consumption of tenants
	Energy savings for ventilation	no
	Energy savings for lighting	Included in common areas electricity consumption
	Energy savings for domestic hot water	no
	Energy savings for cooking	no
	Energy savings for plug load/ appliances	no
	Energy from renewable sources	X
Indoor thermal comfort improvement	Indoor thermal comfort level	no
	Tenants satisfaction	X
Indoor visual comfort improvement	Indoor visual comfort level	no
Indoor acoustic comfort	Indoor acoustic comfort level	no
Indoor air quality improvement	Indoor air quality level	no
Emissions reduction	Air pollution level	no
Building resilience	Performance reliability	no

Benefits	Evaluation targets	Applied in the project
City resilience	Building energy supply reliability	no
	City energy generation relief	no
	City electricity networks infrastructure relief	no
?	Operator perception of system functionality	no
	Operators perception of system control	no
?	Stakeholder willingness to retrofit	no

2.3.6 Lisbon specific data collection protocol

The assessment of the expected benefits in Lisbon is conditioned by the available data sources which are the electrical meters that are aggregated for the tenants and disaggregated by meter for each building for the common areas. Table 2-10 lists the possible measurable indicators and if and how they will be evaluated.

The energy savings from the envelope retrofit (improvement on the thermal insulation of the building and window replacement) can be evaluated from the decrease of electricity consumption of the tenants. The improvements on the building envelope are the only actions that may affect the tenants' electricity consumption as there are no actions affecting the tenants' electricity consumption for lighting, cooking or plug-in appliances, and no gas supply for heating. Because, this is social housing and people may not be able to heat or cool their homes, it is also possible that the electricity consumption remains the same and the result of the retrofit of the envelope will be in the comfort level of the tenants. Due to local restrictions, it is not possible to use the necessary equipment to measure comfort level inside the tenants' homes. The improvement of indoor temperature will then be evaluated through a survey on tenants' satisfaction.

The energy savings from the LEDs lamps installation can be evaluated from the electricity meters of the common areas of the buildings which cover lighting and elevators. The energy production of the PV panels can also be easily measured.

Table 2-10 - List of evaluation targets and indicators for the public buildings in Lisbon (measurable indicators refers to the building level unless specifically stated)

N.	Evaluation target	Measurable indicator(s)	Unit	Applied in the pre-retrofit intervention	Applied in the post-retrofit intervention	Data collection method(s)	Measure frequency	Data recording frequency	Data sending frequency	Critical issues?	Necessary actions to achieve the measure?
1	Energy savings for heating	Primary energy	kWh	Included in total electricity consumption of tenants	Included in total electricity consumption of tenants	Delivered energy + primary energy factor	Continuously	15'			
		Delivered energy	kWh, m^3, kg	Included in total electricity consumption of tenants	Included in total electricity consumption of tenants	Electrical energy meters	Continuously	15'			
		Energy delivered by the generation system	kWh	No	No						
		Apartment energy use	kWh	No	No						
2	Energy savings for cooling	Primary energy	kWh	Included in total electricity consumption of tenants	Included in total electricity consumption of tenants	Delivered energy + primary energy factor	Continuously	15'			
		Delivered energy	kWh, m^3, kg	Included in total electricity consumption of tenants	Included in total electricity consumption of tenants	Electrical energy meters	Continuously	15'			
		Energy delivered by the generation system	kWh	No	No						
		Apartment energy use	kWh	No	No						
3	Energy savings for ventilation	Primary energy	kWh	No	No						
		Delivered energy	kWh	No	No						
4	Energy use for lighting	Primary energy	kWh	Included in common areas electricity consumption	Included in common areas electricity consumption	Delivered energy + primary energy factor	Continuously	15'			

N.	Evaluation target	Measurable indicator(s)	Unit	Applied in the pre-retrofit intervention	Applied in the post-retrofit intervention	Data collection method(s)	Measure frequency	Data recording frequency	Data sending frequency	Critical issues?	Necessary actions to achieve the measure?
		Delivered energy	kWh	Included in common areas electricity consumption	Included in common areas electricity consumption	Electrical energy meter	Continuously	15'			
		Apartment energy use (delivered and primary)	kWh	No	No						
5	Energy savings for domestic hot water	Primary energy	kWh	No	No						
		Delivered energy	kWh, m^3, kg	No	No						
		Energy delivered by the generation system	kWh	No	No						
		Apartment energy use	kWh	No	No						
6	Energy savings for cooking	Apartment energy use	m^3	No	No						
7	Energy savings for plug load/ appliances	Apartment energy use (delivered and primary)	kWh	No	No						
8	Energy from renewable sources	Renewable energy produced on the building site	kWh	No	Yes	Electrical energy meter	Continuously	15'			
		Renewable energy produced and exported from the building site	kWh	No	Yes	Electrical energy meter	Continuously	15'			
		Renewable energy produced and used on site	kWh	No	Yes	Electrical energy meter	Continuously	15'			

N.	Evaluation target	Measurable indicator(s)	Unit	Applied in the pre-retrofit intervention	Applied in the post-retrofit intervention	Data collection method(s)	Measure frequency	Data recording frequency	Data sending frequency	Critical issues?	Necessary actions to achieve the measure?
		Renewable energy stored in and released by the storage battery	kWh	No	No						
9	Indoor thermal comfort level	Air temperature and relative humidity as proxy for thermal comfort	°C, %	No	No						
		Operative temperature	°C	No	No						
		PMV	-	No	No						
		PPD	%	No	No						
10	Indoor visual comfort level	Illuminance	Lux	No	No						
11	Indoor acoustic comfort level	Sound Pressure Level	dB(A)	No	No						
12	Indoor air quality level	CO_2	ppm	No	No						
13	Tenants satisfaction	-	Grade 1-5	Yes	Yes	Tenants surveys	one time pre- and one time post-retrofit	one time pre- and one time post-retrofit	one time pre- and one time post-retrofit	Privacy	PIA
14	Air pollution level	Pollutants emitted (NO_x, PM)	kg	No	No						
15	Performance reliability	Minor repair	per year	No	No						
		Major repair	per year	No	No						

N.	Evaluation target	Measurable indicator(s)	Unit	Applied in the pre-retrofit intervention	Applied in the post-retrofit intervention	Data collection method(s)	Measure frequency	Data recording frequency	Data sending frequency	Critical issues?	Necessary actions to achieve the measure?
16	Building energy supply reliability	Frequency of blackouts	-	No	No						
17	City energy generation relief	Generation capacity factor	%	No	No						
18	City electricity networks infrastructure relief	Distribution network capacity	%	No	No						
		Transition network capacity	%	No	No						
19	Operator perception of system functionality	-	Grade 1-5	No	No						
20	Operators perception of system control	-	Grade 1-5	No	No						
21	Stakeholder willingness to retrofit	-	Grade 1-5	No	No						

2.4 Private residential buildings

2.4.1 Milan demonstrator actions

In the contest of the Sharing Cities project, 21000 m^2 of private flat will be retrofitted in multi property buildings (condominiums). The flat owners have proposed their own buildings for renovation, through a public call; the owners were engaged in the urban scale project and participated to energy efficiency measures selection through a co-design process. At the date, the 14 tailored energy measures packages have been defined, one for each building, through the co-design process. None of these owners' communities have formally approved the execution of these works.

The energy retrofit packages aim to increase energy performance of common parts of the buildings. Very few solutions on private property are defined. Most of the building have centralised heating system.

The following solutions are combined in the energy retrofit packages:

- Insulation of the building envelope:
  - ETHICS (External thermal wall insulation composite system);
  - Cavity wall insulation. Where the cavity is thicker than 10 cm, it's proposed blown mineral wool;
  - Thermal insulation of roof;
  - Thermal insulation of basement;
  - Windows replacement (in very few cases – windows of the stair case);
  - External solar shading of windows and balconies.

- Replacement or integration of the centralised heating system:
  - New condensation boiler;
  - Gas heat pump.

- Energy management components and systems:
  - Thermostatic valves;
  - Voltage regulation systems;
  - Generation system remote management.

- Electric installation:
  - LED lamps in common areas
  - Replacement of circulation pumps for the heating system[4].

- Renewable energy source (RES) integration:
  - PV panels;
  - Solar thermal panels for hot water generation.

The Table 2-11 below present the energy packages for each building under renovation.

[4] pumps replacement with higher efficiency engines; in case of variable flow systems (with thermostatic valves) will be installed variable speed pumps.

Table 2-11: Retrofit actions on each multi property building in Milan

Retrofit actions / Buildings	External walls thermal insulation	Cavity wool insulation	Solar shading installation	Roof thermal insulation	Basement thermal insulation	Windows replacement	Thermostatic valves + variable speed pumps	High efficiency generation system installation	Gas heat pump for heat generation	Replacement of pumps for the heating system with higher efficiency engines	Solar thermal panels	Central boiler remote management	LED in common areas	Voltage regulation	Photovoltaic panels	PV storage system
Piazzale Martini 14		X			X		X	X				X	X	X	X	
Via Oglio, 3	X	X		X	X		X						X		X	
Via Soave, 20	X	X		X	X	X						X	X	X	X	
Piazza Insubria 24	X			X	X				X	X		X	X	X	X	
Via Passeroni 6	X	X		X	X		X	X				X	X	X	X	
Via Quadronno 34	X	X		X	X	X							X	X	X	
Via B. d'Este 23	X	X		X	X	X			X	X		X	X	X	X	
Via Verro, 78	X			X	X		X	X				X	X		X	
Via Fiamma 15/b	X		X	X	X								X			X
Via Mercalli 7	X			X				X		X		X	X		X	
Via Ripamonti 142		X		X		X							X			
Viale Ortles, 15	X			X	X								X		X	
Via Pampuri, 6	X			X					X	X		X	X		X	
Via Tito Livio, 21	X				X								X		X	

Building retrofits focus on improving building in various aspects, and the energy efficiency actions described above directly affect many building performance. Each of these actions, alone or in combination with the others, may have direct effects, as the winter control of the heat losses, summer control of heat gains, improvement of indoor temperature etc.

Table 2-12 summarizes the retrofit actions for multi property buildings that are connected to the direct effects experienced in the building. The matrix shows the link existing between a retrofit action and one or more direct effects. As for public buildings, when a retrofit action or a direct effect is not implemented, a "not applicable" label is reported.

Table 2-12: Summary of retrofit actions in relation to the direct effects for multi property buildings in Milan

Direct effects / **Retrofit actions**	Winter heat loss control	Summer heat gains control	Indoor temperature improvement	Generation efficiency improvement	Distribution efficiency improvement	Regulation efficiency improvement	Renewable energy system penetration	Electric efficiency improvement	Solar radiation control	Ventilation heating loss reduction	Suitable ventilation
External walls thermal insulation	X		X							Not applicable	Not applicable
Cavity wool insulation	X		X								
Basement thermal insulation	X		X								
Windows substitution	X	X	X						X		
Solar shading installation		X							X		
High efficiency generation system installation				X		X					
Gas heat pump for heat generation				X							
Replacement of circulation pumps for the heating system with higher efficiency engines					X	X					
Generation system remote management				X		X					
Thermostatic valves + variable speed circulation pumps installation						X					
Voltage regulation						X					
LED lamp installation for common areas								X			
Photovoltaic panels installation							X				
Electrical storage battery							X				

Many of the detailed retrofit actions described for the multi property buildings, may be merged together, when their direct effect is evaluated, e.g. external walls thermal insulation and cavity wall insulation are two example of façade insulation, and may be merged under this generic label. To be coherent with the Table 2-3 shown in paragraph 2.3.1 for public buildings, Table 2-13 shows the retrofit actions and their direct effects, merging retrofit actions that showed the same effects, as previously described.

Table 2-13: Standardised retrofit actions in relation to the direct effects for multi property buildings in Milan

Direct effects / Retrofit actions	Winter heat loss control	Summer heat gains control	Indoor temperature improvement	Generation efficiency improvement	Distribution efficiency improvement	Regulation efficiency improvement	Renewable energy system penetration	Electric efficiency improvement	Solar radiation control	Ventilation heating loss reduction	Suitable ventilation
Façade insulation	X		X								
Floor insulation	X		X								
Roof insulation	X		X								
Windows substitution	X	X	X						X		
Solar shadings installation		X							X		
Heat generator substitution				X		X					
Distribution system insulation (only in the boiler room)	Not applicable										
Replacement of circulation pumps for the heating system					X	X					
Generation system remote management				X		X					
Thermostatic valves installation						X					
Voltage regulation								X			
LED lamps installation (only for common area)								X			
Photovoltaic panels installation							X				
Electrical storage battery							X				
Solar thermal panels installation							X				
Mechanical ventilation system installation	Not applicable										

2.4.2 Milan demonstrator benefits and evaluation targets

As a result of the retrofit actions undertaken, and the consequent direct effects on multi property buildings, the expected benefits are:

- Energy savings;
- Thermal comfort improvement;
- Visual comfort improvement;
- Emissions reduction.

Each benefit is related to specific retrofit actions undertaken on each building, for example, buildings that will not have improvement or substitution of the solar shadings, will not experience visual comfort improvement.

All the selected buildings will benefit from improved thermal comfort, energy savings and emission reduction, that are benefits directly linked to the improvement of the building envelope and of the generation, distribution and regulation systems efficiency.

Moreover, education and information on building retrofit can increase citizens' awareness and attitude to energy retrofit, and therefore to energy saving. In the multi property building this goal will be achieved also through the co-design process.
In Table 2-14 the direct effects are linked to the expected benefits, pursue by the tenants and the society. Each benefit is resulting from the combination of the many direct effects that altogether contribute to it. The "X" shows what real action is implemented in the complex of the several private buildings and to what benefit is contributing to.

Table 2-14: Summary of direct effects in relation to the benefits in the multi property buildings in Milan

Benefits / **Direct effects**	Energy saving	thermal comfort improvement	Visual comfort improvement	Indoor air quality improvement	Emissions reduction
Winter heat loss control	X	X			X
Summer heat gains control	X	X			X
Indoor temperature improvement		X			
Awareness increase	X				X
Generation efficiency increase	X				X
Distribution efficiency improvement	X				X
Regulation efficiency increase	X	X			X
Renewable energy system					X
Electric efficiency increase	X				X
Solar radiation control	X	X	X		
Ventilation heating loss reduction					
Suitable ventilation					

Table 2-15 shows the evaluation targets to be used for assessing performance at either building or apartment level. Highlighted in bold, the core-benefits and their relative evaluation targets, that are related to the retrofit actions foreseen by the Sharing Cities project in the private buildings in Milan. In Italics, the benefits that may results as indirect consequence of the retrofit actions or of the monitoring plan. In particular in the private buildings no retrofit action will affect the indoor air quality, nevertheless, the monitoring of the CO_2 level and the sharing of this information with the occupants, may affect positively their operation of windows, with an indirect effect on indoor air quality. So, it is the monitoring and communication that might influence indoor air quality not the retrofit intervention itself.
The "X" in the right column, indicates what evaluation targets is applied to the project.

Table 2-15: Benefits and evaluation targets for the multi property buildings in Milan

Benefits	Evaluation targets	Applied in the project
Energy savings	Energy savings for heating	X
	Energy savings for cooling	no
	Energy savings for ventilation	no
	Energy savings for lighting	no
	Energy savings for domestic hot water	no
	Energy savings for cooking	no
	Energy savings for plug load/ appliances	X
	Energy from renewable sources	X
Indoor thermal comfort improvement	Tenants thermal comfort level	X
	Tenants satisfaction	X
Indoor visual comfort improvement	Indoor visual comfort level	no
Indoor acoustic comfort improvement	Indoor acoustic comfort level	no
Indoor air quality improvement	Indoor air quality level	X

Benefits	Evaluation targets	Applied in the project
Emissions reduction	Air pollution level	no
Building resilience	Performance reliability	no
City resilience	Building energy supply reliability	no
	City energy generation relief	no
	City electricity networks infrastructure relief	no
Increase willingness to install	Operator perception of system functionality	no
	Operators perception of system control	no
	Stakeholder willingness to retrofit	no

2.4.3 Milan specific data collection protocol

In this section, the list of possible measurable indicators that can be used to assess the proposed evaluation targets for private residential building retrofit are listed and characterized in terms of units, possible data collection methods, critical issues, measurement frequency, etc. in Table 2-16 . Some of the indicators as thermal comfort and energy uses will be monitored during pre- and post-retrofit intervention according to a specific monitoring plan.

The pre-retrofit assessment monitoring plan includes:

- Delivered energy for space heating;
- Delivered energy for electrical household and common uses;
- Temperature and humidity monitoring in 80 reference apartments;
- Outdoor weather conditions;
- Questionnaire surveys on comfort perception, indoor air quality sensation, appliances use, etc.

As for public building, the pre-retrofit activities are under development, but the data privacy issue could hinder the monitoring of some energy and thermal comfort data.

The post-retrofit monitoring plan includes:

- Delivered energy for space heating;
- Delivered energy for electrical household and common uses;
- Electrical energy generated by the PV system (where installed);
- Thermal energy generated by the solar thermal system (where installed);
- Temperature and humidity monitoring in 80 reference apartments;
- Outdoor weather conditions.
- Questionnaire surveys on comfort perception, indoor air quality sensation, appliances use, etc.

Table 2-16 shows for each indicator: the units, the data collection methods, the critical issues, the actions necessary to achieve the measure, the frequency of measure, the frequency of data recording, and the frequency of data sending. Moreover, it shows what specific indicators will be monitored during pre- and/or post-retrofit intervention.

All the measurable indicators listed in Table 2-16 do refer to the building level, unless specifically stated. For example, *primary energy, delivered energy,* and *energy delivered by the generation system* are different levels of the energy consumed by the entire building, whereas *apartment energy use* refers only to the apartment energy consumption. There is a pending request to the national privacy authority that will provide us a final decision on the possibility of monitoring energy and environmental data at the apartment level. Until we will receive the authorization, the monitoring activities will not be put into practice. If the decision will be negative, only the aggregate building data will be analysed."

To be coherent with Table 2-6 for public building, in the following Table 2-16 the same changes have been applied, with reference to Deliverable 8.1; in particular:

- The order (column “N.”) has been changed to group together evaluation targets that refers to the same area of interest, e.g. all the energy targets, or all the comfort targets, etc.
- Some evaluation targets name has been updated in order not to contrast with definitions provided by standards in the nomenclature session, and to be clearer to the final users.
- Some indicators which refer to the apartment energy consumption not reported in Deliverable 8.1, have been introduced to complete the actual data monitoring protocol applied at the apartment level.
- The evaluation targets “Energy from renewable sources” and “Energy savings for cooking” with their indicators, and the indicator “Air temperature and relative humidity as proxy for thermal comfort” not reported in Deliverable 8.1, have been introduced to complete the actual data monitoring protocol.

All the measurable indicators listed in Table 2-16 do refer to the building level, unless specifically stated. For example, *primary energy, delivered energy,* and *energy delivered by the generation system* are different levels of the energy consumed by the entire building, whereas *apartment energy use* refers only to the apartment energy consumption.

Table 2-16: List of evaluation targets and indicators for private building (measurable indicators refers to the building level unless specifically stated**)**

N.	Evaluation target	Measurable indicator(s)	Unit	Applied in the pre-retrofit intervention	Applied in the post-retrofit intervention	Data collection method(s)	Measure frequency	Data recording frequency	Data sending frequency	Critical issues?	Necessary actions to achieve the measure?
1	Energy savings for heating	Primary energy	kWh	No	Yes	Delivered energy + primary energy factor	Continuously	60'	Weekly	Meter substitution	Get in touch with A2A (data owner)
		Delivered energy	kWh, m^3, kg	No	Yes	Gas meter, flow meter + temperature sensors, barrels delivered, pellets delivered, electrical energy meters	Continuously	60'	Weekly	Meter substitution	Get in touch with A2A (data owner)
		Energy delivered by the generation system	kWh	No	Yes	Temperature sensors + flow meters	Continuously	60'	Weekly	If the generator will not be substituted the sensor will not be installed	Consider in the budget project in case of generator substitution
		Apartment energy use	kWh	No	No						
2	Energy savings for cooling	Primary energy	kWh	No	No						
		Delivered energy	kWh, m^3, kg	No	No						
		Energy delivered by the generation system	kWh	No	No						
		Apartment energy use		No	No						
3	Energy savings for ventilation	Primary energy	kWh	No	No						
		Delivered energy	kWh	No	No						
4	Energy use for lighting	Primary energy Only in common spaces with a dedicated line	kWh	No	No						
		Delivered energy Only in common spaces with a dedicated line	kWh	No	No						

N.	Evaluation target	Measurable indicator(s)	Unit	Applied in the pre-retrofit intervention	Applied in the post-retrofit intervention	Data collection method(s)	Measure frequency	Data recording frequency	Data sending frequency	Critical issues?	Necessary actions to achieve the measure?
		Primary energy	kWh	No	No						
5	Energy savings for domestic hot water	Delivered energy	kWh, m^3, kg	No	No						
		Energy delivered by the generation system	kWh	No	No						
6	Energy savings for cooking	Apartment energy use	m^3	No	No						
7	Energy savings for plug load/ appliances	Apartment energy use (delivered and primary)	kWh	No	Yes	Electrical energy meter	Continuously	15'	Monthly	Budget	Cost benefit analysis
8	Energy from renewable sources	Renewable energy produced on the building site	kWh	No	Yes	Flow meter, electrical energy meter	Continuously	15'	Hourly		
		Renewable energy produced and exported from the building site	kWh	No	Yes	Electrical energy meter	Continuously	15'	Hourly		
		Renewable energy produced and used on site	kWh	No	Yes	Flow meter, electricity meters	Continuously	15'	Hourly		
		Renewable energy stored in and released by the storage battery	kWh	No	Yes	Electrical energy meter	Continuously	15'	Hourly		
9	Indoor thermal comfort level	Air temperature and relative humidity as a proxy of thermal comfort	°C, %	Yes	Yes	Air temperature and RH sensors	Continuously	10'	10'	Privacy	PIA
		Operative temperature	°C	No	No						
		PMV	-	No	No						
		PPD	%	No	No						

N.	Evaluation target	Measurable indicator(s)	Unit	Applied in the pre-retrofit intervention	Applied in the post-retrofit intervention	Data collection method(s)	Measure frequency	Data recording frequency	Data sending frequency	Critical issues?	Necessary actions to achieve the measure?
10	Indoor visual comfort level	Illuminance	Lux	No	No						
11	Indoor acoustic comfort level	Sound Pressure Level	dB(A)	No	No						
12	Indoor air quality level	CO_2, VOC concentration	ppm	Yes (reference apartments)	Yes	Air pollutant sensors	Continuously	60'	60'	Privacy	PIA
13	Tenants satisfaction	-	Grade 1-5	Yes	Yes	Tenants surveys	One time, at the end of the action	One time, at the end of the action	One time, at the end of the action	Privacy	PIA
14	Air pollution level	Pollutants emitted (NOx, PM)	kg	No	No						
15	Performance reliability	Minor repair	per year	No	No						
		Major repair	per year	No	No						
16	Building energy supply reliability	Frequency of blackouts		No	No						
17	City energy generation relief	Generation capacity factor	%	No	No						
18	City electricity networks infrastructure relief	Distribution network capacity	%	No	No						
		Transition network capacity	%	No	No						
19	Operator perception of system functionality		Grade 1-5	No	No						
20	Operators perception of system control		Grade 1-5	No	No						
21	Stakeholder willingness to retrofit		Grade 1-5	No	No						

2.4.4 Lisbon demonstrator actions

In Lisbon a private housing will be retrofitted by a private company – Reabilita. The retrofit of private residential buildings is based on a business model consisting on the purchase of buildings that are mostly vacant and in significant need of rehabilitation. The buildings are then rehabilitated in the common areas, and sometimes within the apartments, and sold to private consumers. Under the Sharing Cities project, Reabilita will improve the typical rehabilitation by taking specific actions to improve the energy efficiency of the buildings. So far 2 buildings have been selected for retrofitting and different actions will be taken for different buildings. More buildings may be added later on.

The first unoccupied building (EC) is in Rua Esperança do Cardal, has 424 m^2 and 6 apartments. The main retrofitting actions taking place in this building are:

- Roof exterior insulation with 8 cm XPS;
- New windows with PVC framing and double glazing (4+16 argon+4);
- Installation of a heat pump for domestic hot water;
- Installation of LED in all areas of the building;
- Installation of PV panels.

The second building (SB) is also unoccupied and is located in Rua de São Bento. It has 933 m^2 and 9 apartments. This building will undergo deep construction as the apartments will go from T6 to T2. Currently the apartments have several internal rooms and so the internal walls will change. The mains retrofitting actions aimed at the improvement of the thermal performance and energy efficiency of the building are:

- Roof exterior insulation with 8 cm XPS;
- New windows with PVC framing and double glazing (4+16 argon+4);
- Installation of a heat pump for air conditioning;
- Installation of an electric water heater;
- Installation of LED in all areas of the building;
- Installation of PV panels.

Table 2-17 relates the retrofitting action taking place in each of the buildings with the expected direct effects. If the table is filled with a “EC” that means that that action will be taking place in the building in Rua Esperança do Cardal. On the other hand, if the slot is filled with a “SB” then that action is taking place in the building in Rua de São Bento.

Table 2-17 - Summary of retrofit actions in relation to the direct effects for the private residential buildings in Lisbon

Direct effects / Retrofit actions	Winter heat loss control	Summer heat gains control	Indoor temperature improvement	Generation efficiency improvement	Distribution efficiency improvement	Regulation efficiency improvement	Renewable energy system penetration	Electric efficiency improvement	Solar radiation control	Ventilation heating loss reduction	Suitable ventilation
Façade insulation	Not applicable										
Roof insulation	SB EC		SB EC								
Windows replacement	SB EC	SB EC	SB EC						SB EC		
Glazing replacement	Not applicable										
LED lamps installation								SB EC			
LED lamps installation in common areas	Not applicable										
Heat Pump installation for air conditioning				EC		EC					
HVAC system replacement	Not applicable										
Heat Pump installation for DHW				SB		SB					
Electric water heater installation				EC		EC					
Photovoltaic panels installation							SB EC				

2.4.5 Lisbon demonstrator benefits and evaluation targets

Considering the actions taking place in each of the buildings, it is expected that both buildings experience the same benefits, as shown in Table 2-18. The same system was used as in Table 2-17: “SB” stands for the building in Rua de São Bento and “EC” stands for the building in Esperança do Cardal.

Table 2-18 - Summary of direct effects in relation to the benefits in the private residential buildings in Lisbon

Benefits / Direct effects	Energy saving	Thermal comfort improvement	Visual comfort improvement	Indoor air quality improvement	Emissions reduction
Winter heat loss control	SB EC	SB EC			SB EC
Summer heat gains control	SB EC	SB EC			SB EC
Indoor temperature improvement		SB EC			
Generation efficiency increase	SB EC				SB EC
Distribution efficiency improvement					
Regulation efficiency increase	SB EC	SB EC			SB EC
Renewable energy system					SB EC
Electric efficiency increase	SB EC				SB EC
Solar radiation control	SB EC	SB EC	SB EC		
Ventilation heating loss reduction					
Suitable ventilation					

It is then expected that both buildings experience the following benefits:

- Energy savings as a results of the improvement of the envelope, the use of more efficient systems and lighting;
- Thermal comfort improvement from the improvements of the envelope and the use more easily regulated systems;
- Visual comfort improvement from the use of better glazing solutions;
- Emissions reduction from the improvements of the envelope, the use of more energy efficient systems and the installation of electricity production units.

Table 2-19 shows the evaluations targets correspondence to the expected benefits and whether they are applied in the project or not. For the private housing buildings renovation assessment, the main constraints are the fact that the buildings were unoccupied prior to renovation, privacy issues and the available data sources.

Table 2-19 – Benefits and evaluation targets tor the private residential buildings in Lisbon.

Benefits	Evaluation targets	Applied in the project
Energy savings	Energy savings for heating	Included in total electricity consumption of tenants
	Energy savings for cooling	Included in total electricity consumption of tenants
	Energy savings for ventilation	no
	Energy savings for lighting	Included in total energy consumption of tenants plus the common areas
	Energy savings for domestic hot water	Included in total electricity consumption of tenants
	Energy savings for cooking	no
	Energy savings for plug load/ appliances	no
	Energy from renewable sources	X
Indoor thermal comfort improvement	Tenants thermal comfort level	no
	Tenants satisfaction	X
Indoor visual comfort improvement	Indoor visual comfort level	no
Indoor acoustic comfort improvement	Indoor acoustic comfort level	no
Indoor air quality improvement	Indoor air quality level	no
Emissions reduction	Air pollution level	no
Building resilience	Performance reliability	no
City resilience	Building energy supply reliability	no
	City energy generation relief	no
	City electricity networks infrastructure relief	no
Increase willingness to install	Operator perception of system functionality	no
	Operators perception of system control	no
	Stakeholder willingness to retrofit	no

2.4.6 Lisbon specific data collection protocol

Table 2-20 Shows the measurable indicators and whether and how they will be applied in Lisbon to assess the effects of retrofit in private residential housing in Lisbon. As mentioned, because the

building was unoccupied there are no measurable indicators that can be applied in the pre-retrofit intervention stage.
One way of comparing pos-retrofit results with pre-retrofit values is by preforming simulations of the buildings' operation prior to renovation, assuming similar behaviours. The energy savings from the improvement on the envelope, the installation of heat pumps, LEDs and electric water heaters will be evaluated from aggregated electricity consumption of the tenants' of each building. Consequently, it is not possible to pin point what is the contribution of each retrofitting action. The savings due to the installation of LED lighting in common areas will be evaluated from the electricity consumption of the common areas.

Table 2-20 - List of evaluation targets and indicators for the private residential buildings in Lisbon (measurable indicators refers to the building level unless specifically stated)

N.	Evaluation target	Measurable indicator(s)	Unit	Applied in the pre-retrofit intervention	Applied in the post-retrofit intervention	Data collection method(s)	Measure frequency	Data recording frequency	Data sending frequency	Critical issues?	Necessary actions to achieve the measure?
1	Energy savings for heating	Primary energy	kWh	No	Included in total energy consumption of tenants	Delivered energy + primary energy factor	Continuously	15'			
		Delivered energy	kWh, m^3, kg	No	Included in total energy consumption of tenants	Electrical energy meters	Continuously	15'			
		Energy delivered by the generation system	kWh	No	No						
		Apartment energy use	kWh	No	No						
2	Energy savings for cooling	Primary energy	kWh	No	Included in total energy consumption of tenants	Delivered energy + primary energy factor	Continuously	15'			
		Delivered energy	kWh, m^3, kg	No	Included in total energy consumption of tenants	Electrical energy meters	Continuously	15'			
		Energy delivered by the generation system	kWh	No	No						
		Apartment energy use	kWh	No	No						
3	Energy savings for ventilation	Primary energy	kWh	No	No						
		Delivered energy	kWh	No	No						
4	Energy use for lighting	Primary energy	kWh	No	Included in total energy consumption of tenants plus common areas	Delivered energy + primary energy factor	Continuously	15'			

N.	Evaluation target	Measurable indicator(s)	Unit	Applied in the pre-retrofit intervention	Applied in the post-retrofit intervention	Data collection method(s)	Measure frequency	Data recording frequency	Data sending frequency	Critical issues?	Necessary actions to achieve the measure?
		Delivered energy	kWh	No	Included in total energy consumption of tenants plus common areas	Electrical energy meters	Continuously	15'			
		Apartment energy use (delivered and primary)	kWh	No	No						
5	Energy savings for domestic hot water	Primary energy	kWh	No	Included in total energy consumption of tenants	Delivered energy + primary energy factor	Continuously	15'			
		Delivered energy	kWh, m^3, kg	No	Included in total energy consumption of tenants	Electrical energy meters	Continuously	15'			
		Energy delivered by the generation system	kWh	No	No						
		Apartment energy use	kWh	No	No						
6	Energy savings for cooking	Apartment energy use	m^3	No	No						
7	Energy savings for plug load/ appliances	Apartment energy use (delivered and primary)	kWh	No	No						
8	Energy from renewable sources	Renewable energy produced on the building site	kWh	No	Yes	Electrical energy meter	Continuously	15'			
		Renewable energy produced and exported from the building site	kWh	No	Yes	Electrical energy meter	Continuously	15'			

N.	Evaluation target	Measurable indicator(s)	Unit	Applied in the pre-retrofit intervention	Applied in the post-retrofit intervention	Data collection method(s)	Measure frequency	Data recording frequency	Data sending frequency	Critical issues?	Necessary actions to achieve the measure?
		Renewable energy produced and used on site	kWh	No	Yes	Electrical energy meter	Continuously	15'			
		Renewable energy stored in and released by the storage battery	kWh	No	No						
9	Indoor thermal comfort level	Air temperature and relative humidity as proxy for thermal comfort	°C, %	No	No						
		Operative temperature	°C	No	No						
		PMV	-	No	No						
		PPD	%	No	No						
10	Indoor visual comfort level	Illuminance	Lux	No	No						
11	Indoor acoustic comfort level	Sound Pressure Level	dB(A)	No	No						
12	Indoor air quality level	CO_2	ppm	No	No						
13	Tenants satisfaction	-	Grade 1-5	No	Yes	Tenants surveys	one time pre- and one time post-retrofit	one time pre- and one time post-retrofit	one time pre- and one time post-retrofit	Privacy	PIA
14	Air pollution level	Pollutants emitted (NO_x, PM)	kg	No	No						
15	Performance reliability	Minor repair	per year	No	No						

N.	Evaluation target	Measurable indicator(s)	Unit	Applied in the pre-retrofit intervention	Applied in the post-retrofit intervention	Data collection method(s)	Measure frequency	Data recording frequency	Data sending frequency	Critical issues?	Necessary actions to achieve the measure?
		Major repair	per year	No	No						
16	Building energy supply reliability	Frequency of blackouts	-	No	No						
17	City energy generation relief	Generation capacity factor	%	No	No						
18	City electricity networks infrastructure relief	Distribution network capacity	%	No	No						
		Transition network capacity	%	No	No						
19	Operator perception of system functionality	-	Grade 1-5	No	No						
20	Operators perception of system control	-	Grade 1-5	No	No						
21	Stakeholder willingness to retrofit	-	Grade 1-5	No	No						

2.5 Public service buildings

2.5.1 Lisbon demonstrator actions

The local government in Lisbon will also be retrofitting one of its main tertiary buildings, the Lisbon City Hall, under the Sharing Cities project. This building has 5 080 m^2. This is a historic building right in heart of the city.

The requalification of buildings in historic and ancient areas raises several constraints, mainly concerning central administration regulations that are in place for several years, such as the maintenance of the historical traits and the protection of panoramic views. These regulations constrain the type of measures that can be implemented as well as their extent. For example, the number of panels to be proposed had to be limited and the windows have to maintain a wooden frame instead of being changed to PVC.

- The main retrofitting actions in the Town Hall will be:
- Replacement of the glazing of the windows for a low-e 8 mm glazing, maintaining the wooden frame;
- Substitution of the HVAC system for one with better heating and cooling efficiencies;
- Replacement of 58% of the lights for LEDs;
- Installation of PV panels on the roof.

The measures are summarized in Table 2-21 as are the expected direct effects.

Table 2-21 - Summary of retrofit actions in relation to the direct effects for the public service building in Lisbon.

Direct effects / Retrofit actions	Winter heat loss control	Summer heat gains control	Indoor temperature improvement	Generation efficiency improvement	Distribution efficiency improvement	Regulation efficiency improvement	Renewable energy system penetration	Electric efficiency improvement	Solar radiation control	Ventilation heating loss reduction	Suitable ventilation
Façade insulation	Not applicable										
Roof insulation	Not applicable										
Windows replacement											
Glazing replacement	X	X	X						X		
LED lamps installation								X			
LED lamps installation in common areas	Not applicable										
Heat Pump installation for air conditioning	Not applicable										
HVAC system replacement				X		X					
Heat Pump installation for DHW	Not applicable										
Electric water heater installation	Not applicable										
Photovoltaic panels installation							X				

2.5.2 Lisbon demonstrator benefits and evaluation targets

The expected benefits for the Town Hall depend on the measures being deployed in the building. The main expected benefits from the direct are:

- Energy savings from the improvement of the glazing solution, the use of more efficient heating and cooling systems and the installation of LED lamps;

- Thermal comfort improvement from the use of a better HVAC system and the improvement of the glazing solution;
- Visual comfort improvement from the use of a low-e glazing solution;
- Emissions reduction from the energy savings and the installation of PV panels.

Table 2-22 presents a summary of the expected benefits from the predicted direct effects. This building will also support the installation of a building energy management under the Sharing Cities project task 3.2. Even though it is not a retrofitting action, energy savings and improved thermal comfort may also result from its deployment.

Table 2-22 - Summary of direct effects in relation to the benefits for public service building in Lisbon.

Benefits / **Direct effects**	Energy saving	Thermal comfort improvement	Visual comfort improvement	Indoor air quality improvement	Emissions reduction
Winter heat loss control	X	X			X
Summer heat gains control	X	X			X
Indoor temperature improvement		X			
Generation efficiency	X				X
Distribution efficiency					
Regulation efficiency		X			
Renewable energy system penetration	X				X
Electric efficiency improvement	X				X
Solar radiation control		X	X		
Ventilation heating loss reduction					
Suitable ventilation					

In order to evaluate to which degree the benefits are achieved, evaluation targets are defined for each expected benefit. As there is no access to disaggregated energy consumption all the loads area aggregated and it may be challenging to say whether a decrease in energy consumption is a result of an action or another.
Table 2-23 summarizes the expected benefits, the corresponding evaluation target and information on whether each evaluation target is applied to the project.

Table 2-23 - Benefits and evaluation targets for the public service buildings in Lisbon

Benefits	Evaluation targets	Applied in the project
Energy savings	Energy savings for heating	Included in total energy consumption of the building
	Energy savings for cooling	Included in total energy consumption of the building
	Energy savings for ventilation	No
	Energy savings for lighting	Included in total energy consumption of the building
	Energy savings for domestic hot water	No
	Energy savings for cooking	No
	Energy savings for plug load/ appliances	No
	Energy from renewable sources	Included in total energy consumption of the building
Indoor thermal comfort improvement	Tenants thermal comfort level	No
	Tenants satisfaction	X

Benefits	Evaluation targets	Applied in the project
Indoor visual comfort improvement	Indoor visual comfort level	No
Indoor acoustic comfort improvement	Indoor acoustic comfort level	No
Indoor air quality improvement	Indoor air quality level	No
Emissions reduction	Air pollution level	No
Building resilience	Performance reliability	No
City resilience	Building energy supply reliability	No
	City energy generation relief	no
	City electricity networks infrastructure relief	no
Increase willingness to install	Operator perception of system functionality	no
	Operators perception of system control	no
	Stakeholder willingness to retrofit	no

2.5.3 Lisbon specific data collection protocol

Having established what are the main retrofitting activities, what are the expected benefits and the corresponding evaluation target, Table 2-24 gives the currently available detail on how the actions in the public service building will be evaluated under the existing constraints for data collection.

Table 2-24 - List of evaluation targets and indicators for the public service building in Lisbon (measurable indicators refers to the building level unless specifically stated)

N.	Evaluation target	Measurable indicator(s)	Unit	Applied in the pre-retrofit intervention	Applied in the post-retrofit intervention	Data collection method(s)	Measure frequency	Data recording frequency	Data sending frequency	Critical issues?	Necessary actions to achieve the measure?
1	Energy savings for heating	Primary energy	kWh	Included in total energy consumption of the building	Included in total energy consumption of the building	Delivered energy + primary energy factor	Continuously	15'			
		Delivered energy	kWh, m^3, kg	Included in total energy consumption of the building	Included in total energy consumption of the building	Electrical energy meters	Continuously	15'			
		Energy delivered by the generation system	kWh	No	No						
		Apartment energy use	kWh	No	No						
2	Energy savings for cooling	Primary energy	kWh	Included in total energy consumption of the building	Included in total energy consumption of the building	Delivered energy + primary energy factor	Continuously	15'			
		Delivered energy	kWh, m^3, kg	Included in total energy consumption of the building	Included in total energy consumption of the building	Electrical energy meters	Continuously	15'			
		Energy delivered by the generation system	kWh	No	No						
		Apartment energy use	kWh	No	No						
3	Energy savings for ventilation	Primary energy	kWh	No	No						
		Delivered energy	kWh	No	No						
4	Energy use for lighting	Primary energy	kWh	Included in total energy consumption of the building	Included in total energy consumption of the building	Delivered energy + primary energy factor	Continuously	15'			

N.	Evaluation target	Measurable indicator(s)	Unit	Applied in the pre-retrofit intervention	Applied in the post-retrofit intervention	Data collection method(s)	Measure frequency	Data recording frequency	Data sending frequency	Critical issues?	Necessary actions to achieve the measure?
		Delivered energy	kWh	Included in total energy consumption of the building	Included in total energy consumption of the building	Electrical energy meters	Continuously	15'			
		Apartment energy use (delivered and primary)	kWh	No	No						
5	Energy savings for domestic hot water	Primary energy	kWh	Included in total energy consumption of the building	Included in total energy consumption of the building	Delivered energy + primary energy factor	Continuously	15'			
		Delivered energy	kWh, m^3, kg	Included in total energy consumption of the building	Included in total energy consumption of the building	Electrical energy meters	Continuously	15'			
		Energy delivered by the generation system	kWh	No	No						
		Apartment energy use	kWh	No	No						
6	Energy savings for cooking	Apartment energy use	m^3	No	No						
7	Energy savings for plug load/ appliances	Apartment energy use (delivered and primary)	kWh	No	No						
8	Energy from renewable sources	Renewable energy produced on the building site	kWh	No	Yes	Electrical energy meter	Continuously	15'			
		Renewable energy produced and exported from the building site	kWh	No	Yes	Electrical energy meter	Continuously	15'			

N.	Evaluation target	Measurable indicator(s)	Unit	Applied in the pre-retrofit intervention	Applied in the post-retrofit intervention	Data collection method(s)	Measure frequency	Data recording frequency	Data sending frequency	Critical issues?	Necessary actions to achieve the measure?
		Renewable energy produced and used on site	kWh	No	Yes	Electrical energy meter	Continuously	15'			
		Renewable energy stored in and released by the storage battery	kWh	No	No						
9	Indoor thermal comfort level	Air temperature and relative humidity as proxy for thermal comfort	°C, %	No	No						
		Operative temperature	°C	No	No						
		PMV	-	No	No						
		PPD	%	No	No						
10	Indoor visual comfort level	Illuminance	Lux	No	No						
11	Indoor acoustic comfort level	Sound Pressure Level	dB(A)	No	No						
12	Indoor air quality level	CO_2	ppm	No	No						
13	Tenants satisfaction	-	Grade 1-5	No	Yes	Tenants surveys	one time pre- and one time post-retrofit	one time pre- and one time post-retrofit	one time pre- and one time post-retrofit	Privacy	PIA
14	Air pollution level	Pollutants emitted (NO_x, PM)	kg	No	No						
15	Performance reliability	Minor repair	per year	No	No						
		Major repair	per year	No	No						

N.	Evaluation target	Measurable indicator(s)	Unit	Applied in the pre-retrofit intervention	Applied in the post-retrofit intervention	Data collection method(s)	Measure frequency	Data recording frequency	Data sending frequency	Critical issues?	Necessary actions to achieve the measure?
16	Building energy supply reliability	Frequency of blackouts	-	No	No						
17	City energy generation relief	Generation capacity factor	%	No	No						
18	City electricity networks infrastructure relief	Distribution network capacity	%	No	No						
		Transition network capacity	%	No	No						
19	Operator perception of system functionality	-	Grade 1-5	No	No						
20	Operators perception of system control	-	Grade 1-5	No	No						
21	Stakeholder willingness to retrofit	-	Grade 1-5	No	No						

3 DCPS FOR T3.2 – SEMS

3.1 Overview of leader cities actions

The goal of this task is to test the integration of Sustainable Energy Management Systems (SEMS) that integrate different energy vectors, optimise their operation and energy use, and provide means that support users in obtaining more information and be more efficient in their consumption. SEMS can enable the possibility of implementing Advanced Process Control (APC), allowing the smart integration of infrastructure and equipment to achieve optimized operation and forecast control. Initial expected benefits from the deployment of such systems included operational cost reduction, energy consumption reduction and a better use of existing city infrastructure investment.
In the project, SEMS will be implemented at different scales with a variety of different objectives, captured below in Table 3-1 by the use cases that have been identified.

Table 3-1: Use cases defined for T3.2

No.	Use Case	Objective	Lisbon	London	Milan
1	Heat network optimization	Minimize end-user heat costs		USP	
2	Building mounted PV	Maximize building-level utilisation of renewable self-generation	SEMS	USP	Monet
3	Building energy management	Minimize building electricity costs by load management	SEMS	USP	Monet
4	Local grid-connected PV Microgrid management	Maximise the use of renewables (PV) electricity generation on local grid and minimize consumer electricity costs	USP	USP	Monet
5	Forecasting EV/PV (district level)	Encourage effective integration of renewables and utilisation of EVs	SEPS	USP	Monet
6	Demand side response (DSR)	SME and residential electricity consumers benefiting from their demand flexibility		USP	2
7	Integration with the E015 platform	This user case is to provide information of energy flows at regional level by publishing such data via the E015 platform.			X

The main objectives in Lisbon are to demonstrate the potential benefits of energy monitoring and management in public services buildings and at the city scale, which will be achieved by tackling the following use cases:

- 2 – Building mounted PV, with the objective of maximizing building-level utilisation of renewable self-generation;
- 3 – Building energy management, with the objective of minimizing building electricity costs via load management;´
- 4 – Local grid-connected PV microgrid management, with the objective of maximizing the use of renewables (PV) electricity generation on local grid and minimizing consumer electricity costs;
- 5 – Forecasting EV/PV (district level), with the objectives of promoting behaviour change (encourage effective integration of renewables including utilisation of eV/PV), creating a consumption and production map through the acquisition of data from multiple sources (city specific application) and visualizing estimated production and consumption balances for each building.

To implement the described use cases, two main actions will be deployed: a SEMS at the building level and a Sustainable Energy Planning System (SEPS) at the district level, as presented in Figure 3.1. It is expected that all activities associated with T3.2 will be performed by M33 (Sep/2018).

Figure 3.1: Activities being deployed in Lisbon under task 3.2

3.2 Lisbon SEMS-BL

3.2.1 Demonstrator actions

The main objective is to test and explore new business models that promote the integrated consumer-producer paradigm. This will be tested in a public services building, the city hall, where the PVs will be installed under task 3.1. The deployment is expected to have two layers, as shown in Figure 3.2, one at the city hall building and one at the parking lot located next to the building.

Figure 3.2: SEMS-BL at building level aerial view

Figure 3.3 demonstrates what will be monitored in each layer of the SEMS-BL, indicating the expected interactions between the building, the equipment, the energy manager and the SEMS-BL.

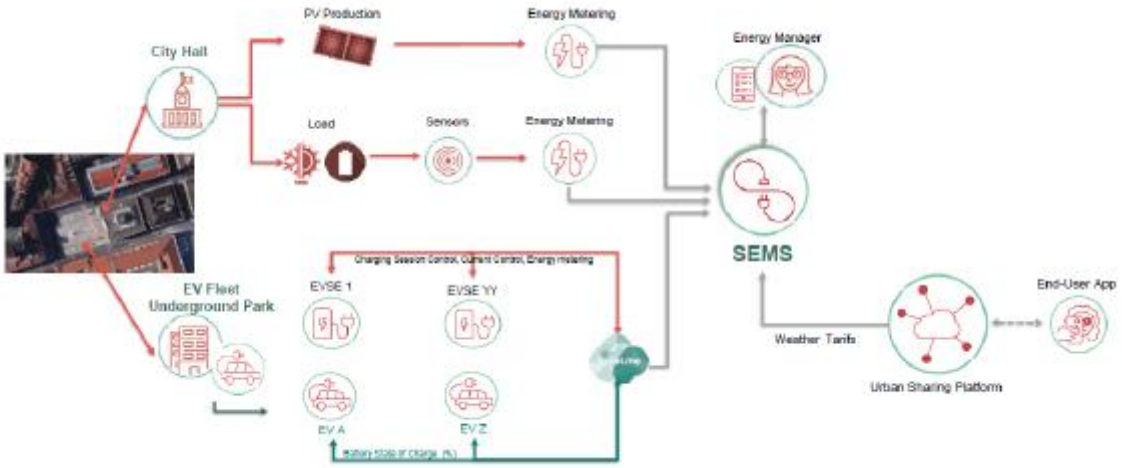


Figure 3.3: SEMS-BL Lisbon

3.2.2 Demonstrator benefits and evaluation targets

The SEMS-BL to be implemented will:

i. Enable a better management of the building by allowing the automated control of specific appliances using smart meters with power limitation capabilities and equipment control plugs. The loads will be scheduled to optimize the self-consumption of the electricity produced by the PV panels and reduce the electricity bill of the building.

ii. Encourage the use of the electric vehicles (EV) charging system existing in the parking lot to assess the potential integration of local electricity production from renewable energy sources (RES) and electric mobility.

Table 3-2 presents the expected benefits that may achieved and the possible evaluation targets that will allow, once expressed in terms of performance indicators, to measure the performance of the SEMS-BL.

Table 3-2: Benefits and evaluation targets for the SEMS-BL

Benefits	Evaluation targets
Improved energy efficiency	Energy use for heating
	Energy used for appliances
	Energy used for hot water
	Energy from renewable sources
Reduction of costs	Demonstrator financial success
	Procurement mechanisms success
	Change in energy delivery cost
	Change in upkeep cost
Improved national sustainability	Air pollution
	Energy generation relief
	Fossil fuel imports reduction
Increased willingness to install	Operator perception of system control
	Operator perception of system functionality
	Stakeholder willingness to install

3.2.3 Site specific data collection protocol

In this section, the list of possible measurable indicators that can be used to assess the proposed evaluation targets are listed and characterized in terms of their units, possible data collection methods, critical issues, measurement frequency, etc.

Table 3-3 shows the specific indicators to be monitored during the project, specifying in detail what indicators will be monitored during before and after the installation of the SEMS-BL. In addition to units, data collection methods, critical issues and actions necessary to achieve the measure, also the frequency of measure or sampling, the frequency of data recording, and the frequency of data sending are reported.

Table 3-3 – List of evaluation targets and indicators for the Lisbon SEMS-BL

N.	Evaluation target	Measurable indicator(s)	Unit	Applied pre-intervention	Applied post-intervention	Data collection method(s)	Measure frequency	Data recording frequency	Data sending frequency	Critical issues?	Necessary actions to achieve the measure?
1	Energy use for heating	Primary energy	kWh	Yes	Yes	Delivered energy + primary energy factor	Continuously	15'	Daily		
		Delivered energy	kWh	Yes	Yes	Electrical energy meter, individual plugs	Continuously	15'	Daily		
2	Energy used for appliances	Primary energy	kWh	Yes	Yes	Delivered energy + primary energy factor	Continuously	15'	Daily		
		Delivered energy	kWh	Yes	Yes	Electrical energy meter, individual plugs	Continuously	15'	Daily		
3	Energy used for hot water	Primary energy	kWh	Yes	Yes	Delivered energy + primary energy factor	Continuously	15'	Daily		
		Delivered energy	kWh	Yes	Yes	Electrical energy meter, individual plugs	Continuously	15'	Daily		
4	Energy from renewable sources	Renewable energy produced on the building site	kWh	No	Yes	Electrical energy meter	Continuously	15'	Daily		
		Renewable energy produced and exported from the building site	kWh	No	Yes	Electrical energy meter	Continuously	15'	Daily		
		Renewable energy produced and used on site	kWh	No	Yes	Electrical energy meter	Continuously	15'	Daily		
5	Demonstrator financial success	Money saved	€	No	Yes	Electricity bills	Continuously	Monthly	Monthly		
6	Procurement mechanisms success	-	Grade 1-5	No	No	Survey	One time				
7	Change in energy delivery cost	Money spent	€	No	Yes	Electricity bills	Continuously	Monthly	Monthly		
8	Change in upkeep cost	Money spent	€	No	Yes	Survey	One time				
9	Air pollution	CO_2 emissions	kg	No	Yes	Electricity demand reduction + CO_2 factor	Continuously	15'	Daily		

N.	Evaluation target	Measurable indicator(s)	Unit	Applied pre-intervention	Applied post-intervention	Data collection method(s)	Measure frequency	Data recording frequency	Data sending frequency	Critical issues?	Necessary actions to achieve the measure?
10	Energy generation relief	Electricity demand reduction	kWh	No	Yes	Electrical energy meter	Continuously	15'	Daily		
11	Fossil fuel imports reduction	Energy used from fossil fuels	kWh	No	Yes	Electricity demand reduction + energy conversion factor	Continuously	15'	Daily		
12	Operator perception of system control		Grade 1-5	No	Yes	Survey	One time				
13	Operator perception of system functionality		Grade 1-5	No	Yes	Survey	One time				
14	Stakeholder willingness to install		Grade 1-5	No	Yes	Survey	One time				

3.3 Lisbon SEPS

3.3.1 Demonstrator actions

The main objective is to develop an electricity consumption/production map through the installation of smart meters, the instrumentation of the electricity distribution points, and the use of the solar potential chart developed by Lisboa E-Nova. This map will be made available to stakeholders and citizens in general.

3.3.2 Demonstrator benefits and evaluation targets

The SEPS to be implemented will have the main purpose of promoting awareness towards the need to reduce electricity consumption and increase the local production from RES.

Table 3-4 presents the expected benefits that may achieved and the possible evaluation targets that will allow, once expressed in terms of performance indicators, to measure the performance of the SEPS.

Table 3-4: Benefits and evaluation targets for the SEPS

Benefits	Evaluation targets
Improved energy efficiency	Energy use
	Energy from renewable sources
Improved national sustainability	Air pollution
	Energy generation relief
	Fossil fuel imports reduction
Increased awareness to sustainability	Stakeholder willingness to promote energy efficiency
	Stakeholder willingness to install RES

3.3.3 Site specific data collection protocol

In this section, the list of possible measurable indicators that can be used to assess the proposed evaluation targets are listed and characterized in terms of their units, possible data collection methods, critical issues, measurement frequency, etc.

Table 3-5 shows the specific indicators to be monitored during the project, specifying in detail what indicators will be monitored during before and after the installation of the SEPS. In addition to units, data collection methods, critical issues and actions necessary to achieve the measure, also the frequency of measure or sampling, the frequency of data recording, and the frequency of data sending are reported.

Table 3-5 – List of evaluation targets and indicators for the Lisbon SEPS

N.	Evaluation target	Measurable indicator(s)	Unit	Applied pre-intervention	Applied post-intervention	Data collection method(s)	Measure frequency	Data recording frequency	Data sending frequency	Critical issues?	Necessary actions to achieve the measure?
1	Energy used	Primary energy	kWh	Yes	Yes	Delivered energy + primary energy factor	Continuously	15'	Daily		
		Delivered energy	kWh	Yes	Yes	Electrical energy meters	Continuously	15'	Daily		
2	Energy from renewable sources	Renewable energy produced on the building site	kWh	No	Yes	Electrical energy meter	Continuously	15'	Daily		
		Renewable energy produced and exported from the building site	kWh	No	Yes	Electrical energy meter	Continuously	15'	Daily		
		Renewable energy produced and used on site	kWh	No	Yes	Electrical energy meter	Continuously	15'	Daily		
3	Air pollution	CO_2 emissions	kg	No	Yes	Electricity demand reduction + CO_2 factor	Continuously	15'	Daily		
4	Energy generation relief	Electricity demand reduction	kWh	No	Yes	Electrical energy meter	Continuously	15'	Daily		
5	Fossil fuel imports reduction	Energy used from fossil fuels	kWh	No	Yes	Electricity demand reduction + energy conversion factor	Continuously	15'	Daily		
6	Stakeholder willingness to promote energy efficiency		Grade 1-5	No	Yes	Survey	One time				
7	Stakeholder willingness to install RES		Grade 1-5	No	Yes	Survey	One time				

3.4 Milan SEMS

3.4.1 Milan Demonstrator actions

Milan Sustainable Energy Management System (SEMS) is a tool able to process all buildings energetic data. This device will monitor the consumption curves and it will realize consumption prediction in order to maximize the renewable use and decrease financial costs.
The system will be implemented by Siemens Monet platform, in order to manage buildings consumptions.
Through Monet energy and environmental data collected in Milan district will be sent to the local platform.
Milan SEMS is composed by three main assets:

- Electric meters: these instruments are necessary to measure voltage and energy used by the users.
- Gateways and SIM cards: these devices are necessary to enable communications functionalities, collecting information and sending to the Monet platform.
- Monet system: the core of the SEMS, thanks to Monet the system is able to provide (real-time) energy monitoring and energy reporting, integrate data coming from other systems to correlate consumptions information, integrate energy tariffs model to estimate and simulate energy costs.

All SEMS actions and correlate direct effects are summarized in Table 3-6.

Table 3-6 - Summary of SEMS actions in relation to the direct effects for SEMS in Milan

SEMS actions \ **Direct effects**	Catching information and sending them to the central system	Activating communication in the assessed area	Measuring voltage and energy	Data "cleaning"	Data aggregation and representation	Rules management	Algorithms management	Fees management (possibility to define energy cost for user bands)
Electric meters			X					
Gateways and SIM cards	X	X						
Monet system				X	X	X	X	X

3.4.2 Milan demonstrator benefits and evaluation targets

The SESM direct effects will generate many benefits for the project:

- Real time consumption awareness by building inhabitants.
- Possibility to compare and asses the building situation pre and post retrofit.
- Helping to reduce energy consumptions.
- As a consequence of the energy savings, there will be a cost reduction for the users.
- Thanks to the SEMS the meters turning off will be reduced.

In Table 3-7 direct effects and correlate benefits for Milan SEMS are summarized.

Table 3-7: Summary of direct effects in relation to the benefits for SEMS in Milan

Benefits / Direct effects	Real time consumption awareness	After-before comparison and assessment	Consumption reduction / energy saving	Costs reduction	Meter turning off reduction
Catching information and sending them to	X				
Activating communication in the assessed area			X	X	X
To measure voltage	X				X
Data "cleaning"	X	X			
Data aggregation and representation	X	X			
Rules management			X		
Algorithms			X	X	X
Fees management (possibility to define energy cost for use				X	

In Table 3-8 benefits are linked to the possible evaluation targets that will allow, once expressed in terms of performance indicators, to measure SEMS performance.
Highlighted in bold, in Table 3-8, the core-benefits and their relative evaluation targets, that are related to the SEMS actions foreseen by the Sharing Cities project in Milan.
In Italics, the benefits which may result ad indirect consequence of the SEMS actions.

Table 3-8: Benefits and evaluation targets for SEMS in Milan

Benefits	Evaluation targets	Applied in the project
Real time consumption awareness	Efficiency of electricity supply	X
After-before comparison and assessment	Efficiency of electricity supply	X
	Efficiency of gas supply	No
	Efficiency of hot water supply	No
	Efficiency of heat/cool supply	No
	Energy efficiency (hot water)	No
	Energy supply reliability	No
	Leakage	No
Consumption reduction / energy saving	Efficiency of gas supply	No
	Efficiency of hot water supply	No
	Efficiency of heat/cool supply	No
	Energy efficiency (hot water)	No
	Energy supply reliability	No
	Leakage	No
Costs reduction	Efficiency of electricity supply	X
	Efficiency of gas supply	No
	Efficiency of hot water	No

	supply	
	Efficiency of heat/cool supply	No
	Energy efficiency (hot water)	No
	Energy supply reliability	No
	Leakage	No
Meter turning off reduction	Efficiency of electricity supply	X
	Performance reliability	X
Stakeholder experience	Operator perception of system functionality	No
	Operators perception of system control (e.g. demand spikes)	No
	Stakeholder willingness to retrofit	No
Emissions reduction	Air pollution	X
City resilience	City energy generation relief	No
	City distribution and transmission networks infrastructure relief	No

3.4.3 Milan specific data collection protocol

In this section, the list of possible measurable indicators that can be used to assess the proposed evaluation targets is reported. In Table 3-9 every measurable indicator is characterized in terms of unit, possible data collection methods, critical issues, measurement frequency, etc.

Table 3-9 shows the specific indicators to be monitored during the project, specifying in detail which indicators will be monitored before and after SEMS installation. In addition to unit, data collection methods, critical issues and actions necessary to achieve the measure, also the frequency of measure or sampling, the frequency of data recording and the frequency of data sending are reported.

Table 3-9: List of evaluation targets and indicators for Milan SEMS

N.	Evaluation target	Measurable indicator(s)	Unit	Applied pre-intervention	Applied post-intervention	Data collection method(s)	Measure frequency	Data recording frequency	Data sending frequency	Critical issues?	Necessary actions to achieve the measure?
1	Efficiency of heat/cool supply	Utilization of local heat used	%	No	No						
2	Efficiency of electricity supply	Local production used	%	No	Yes	System logger data	Continuously	15'	15'	System presence	Verify inverter and meter presence
		Green production used	%	No	No						
		Substation thermal constraint breaches	%	No	No						
		Voltage stability	%	No	Yes	System logger data	Continuously	15'	15'	Not directly connected to actions	Purchase suitable meters
3	Efficiency of gas supply	Energy used	kWh	No	No						
4	Efficiency of hot water supply	Energy used	kWh	No	No						
5	Performance reliability	Electricity blackouts	Hours/year	No	No						
			Quantity	No	No						
		Heat pump system out	Hours/year	No	Yes	Operational data	Continuously	20'	20'		Verify the WP3.1 monitoring with Lorawan
		Electricity substation thermal constraint breaches	Quantity	No	No						

N.	Evaluation target	Measurable indicator(s)	Unit	Applied pre-intervention	Applied post-intervention	Data collection method(s)	Measure frequency	Data recording frequency	Data sending frequency	Critical issues?	Necessary actions to achieve the measure?
6	Operator perception of system functionality		Grade (1-5)	No	No						
7	Operators perception of system control (e.g. demand spikes)		Grade (1-5)	No	No						
8	Stakeholder willingness to retrofit		Grade (1-5)	No	No						
9	Energy efficiency (hot water)	Utilization of local resources	%	No	No						
		Utilization of green resources	%	No	No						
		Energy used from storage?	kWh	No	No						
10	Energy supply reliability	Frequency of supply shortage		No	No						
11	Leakage	Water volume	m^3	No	No						
		Gas volume	m^3	No	No						
12	Air pollution	Pollutants emitted (NOx, PM)	kg	Yes	Yes	Emission model	Monthly	Monthly	Monthly		Function of energy consumption
13	City energy generation relief	Generation capacity		No	No						
14	City distribution and transmission networks infrastructure relief	Distribution network capacity		No	No						
		Transition network capacity		No	No						

4 DCPS FOR T3.3 – MOBILITY

4.1 Overview of leader cities actions

The Royal Borough of Greenwich in south-east London, is implementing a Low Emission Neighbourhood (LEN). The scheme is focused on improving air quality in the Greenwich West and Peninsula wards. It will use a mixture of 'smart technology' and tried-and-tested techniques to reduce transport emissions and make the area a more people-friendly neighbourhood. The scheme is anticipated to involve:

- car-free days in the town centre
- new technology trials to encourage the take-up of electric vehicles or vehicles with cleaner emissions
- new, green public spaces and pocket parks
- community-focused streets that are more pedestrian- and cyclist-friendly
- an incentive scheme to encourage walking and cycling
- bus priority measures
- initiatives to improve air quality in and around schools
- better management of freight and servicing transport to help reduce local pollutants in the air.

The Sharing Cities project is anticipated to contribute to the development of the (LEN) through the development of the means for establishing a shift towards green, shared and, electric mobility. Figure 4.1 illustrates the map of the LEN area with the implemented measures.

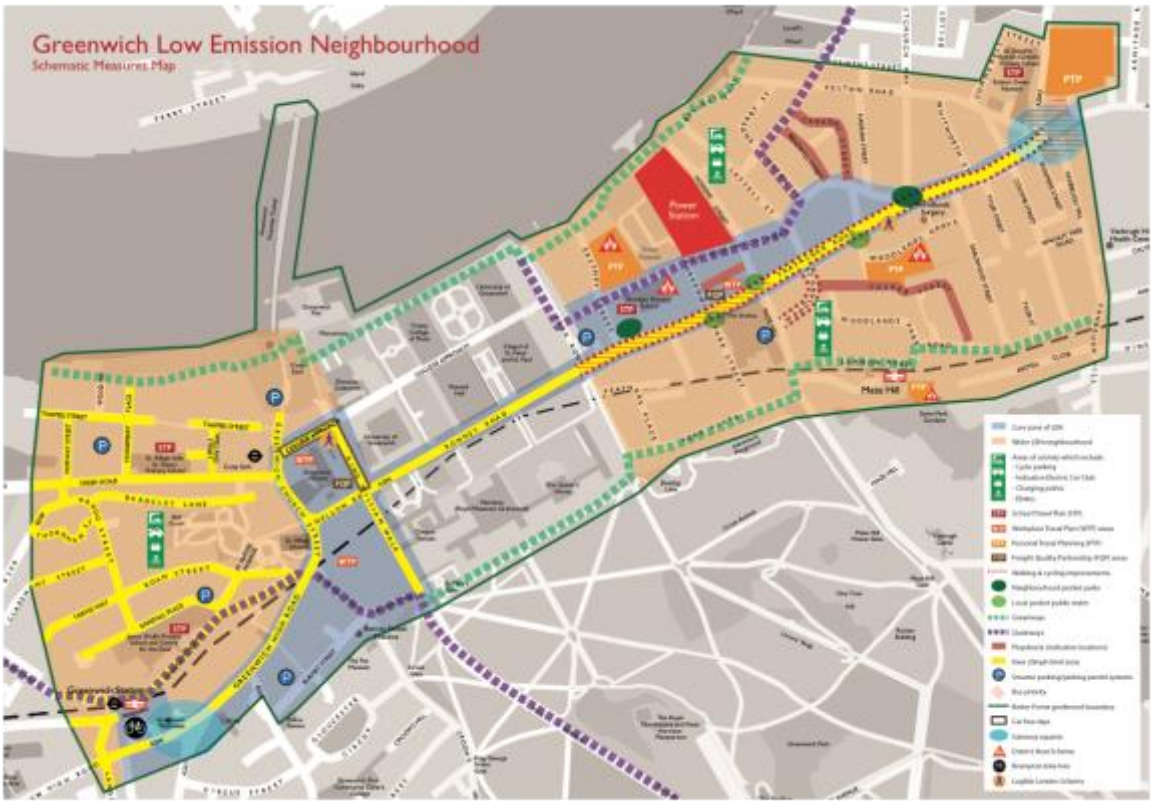


Figure 4.1: Royal Borough of Greenwich Low Emission Neighbourhood map

4.2 E-bike sharing

4.2.1 London demonstrator actions

The Royal Borough of Greenwich procured the operation of an e-bike sharing scheme in November 2016. The 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 encourages the use of sustainable mobility as e-bikes are green electric vehicles that will be shared by 12 users over the period of 1 year, that the demonstrator is anticipated to run.

The main features of the scheme are:

- It concerns residents and businesses in and around the LEN area (see Figure 4.2).
- 16 e-bikes are loaned for a period of 4 weeks to participants
- Exchanges take place at monthly sessions within the LEN (that tie in with the rental period).
- The scheme is anticipated to run for a year

Figure 4.2: London's Royal Borough of Greenwich Low Emissions Neighbourhood (LEN)

Taking into account the demonstrator actions and aims set by the local authority, Table 4-1 illustrates the direct effects activated by demonstrator actions involved in the RBG e-bike share.

Table 4-1: London e-bike demonstrator actions and direct effects

Direct effects / **e-Bike share actions**	Available parking awareness	Shift to electric mobility	Renewable/ green energy production	Shift to shared mobility	Shift to green/ no emissions mobility	Multi-modality	Traffic management	Improved pathfinding	Parking demand reduction
e-bikes		X							
Bike sharing				X	X				X

Bike docking station	N/A								
Charging at bike docking			X		X				
PVs at charging station	N/A								
Park & ride				X		X			X
Adaptive pricing					X	X	X		X

4.2.2 London demonstrator benefits and evaluation targets

The aim of the RBG e-bike sharing scheme is to:

- Achieve mode-shift from private vehicles to cycling and sustain this change after the loan period.
- Monitor the journeys made to shape the development of phase 2 (a public bike sharing scheme)
- Calculate the emissions prevented through mode-shift.

Taking into account the demonstrator direct effects described in Table 4-1, the final benefits enabled by specific direct effects is illustrated in

Table 4-2: Benefits enabled by RBG e-bike demonstrator

Final benefits / **Direct effects**	Pollutants reduction	Mobility increase	Car use reduction	De-congestion/ Travel time reduction	Accessibility	Urban space utilization	Travel safety
Available parking awareness	N/A						
Shift to electric mobility	X	X					
Renewable/ green energy production	X						
Shift to shared mobility	X	X	X			X	
Shift to green/ no emissions mobility	X		X		X		
Multi-modality	X	X	X	X	X		X
Traffic management		X		X			X
Improved pathfinding	N/A						
Parking demand reduction					X	X	

Every demonstrator benefit is associated to evaluation targets as shown in Table 4-3. Highlighted in bold, the core-benefits and their relative evaluation targets, that are related to the retrofit actions foreseen by the Sharing Cities project in the private buildings in Milan. The “X” in the right column, indicates what evaluation targets is applied to the project.

Table 4-3: Evaluation targets associated to benefits

Benefits	**Evaluation targets**	**Monitored in the project**
Pollutants reduction	Modal split (trips generated)	X
	Modal split (distance travelled)	X

	Level of road congestion	
	Emission concentration	
	Street level noise	
Mobility increase	Total trips generated	X
	Total trips distance	X
Car use reduction	Car trips generated	X
	Car trip distance	X
	Vehicle occupancy	
	Vehicle ownership	X
De-congestion/ Travel time reduction	Peak time space mean speed	
	Average trip time	
	Average speed	
	Flows at intersection	
Accessibility	Travel time	
	Cost of travel	
	Generalized cost of travel	X
Urban space utilization	Parking occupancy	
	Parking demand	
	Vehicle utilization	
Travel safety	Accidents (KSI)	
	Traffic violations	

4.2.3 London site specific data collection protocol

In order to accurately assess the level of mode shift achieved during the trial, travel patterns during the bike trial will be compared with the counterfactual provided by the baseline data. This will enable to identify if there is a substitution between frequent car trips with e-bike trips.

Information about the trip frequency and the trip distances of the substituted trips can provide an indicator of the reduced car mileage and be related to emission reductions at the level of the user. Mileage reductions achieved during the trial, could be then scaled up to the population level of the borough, under different scenarios of e-bike penetration amongst car drivers (low, medium high penetration scenarios). Indication of the sustained mode-shift beyond the trial will be assessed based on data collected future intentions on e-bike purchase or subscription to e-bike hire schemes. The evaluation will also test for the effect of the e-bike demonstrator on changes with respect to such intentions and changes in attitudes towards cycling and e-cycling.

For evaluating the performance of the RBG e-bike share demonstrator, the data required are:

- User survey
    - Baseline survey before rental
    - Follow up survey after rental
- GPS tracking of the e-bike for the duration of use
- Travel diary's
    - Pen and paper
    - Google maps

The user survey is conducted before and after the demonstrator in order to assess whether the modal shift is permanent or temporary. The user survey questionnaires are presented in the Appendix section of this report. GPS tracking of the e-bike movement provides information on:

- the occupancy of the bike,
- the distance travelled,
- the number of users, and
- the trips generated.

All these factors influence the assessment of modal split and contribute to accurately measure the evaluation targets described in Table 4-3. The travel diaries are undertaken for at least 5 days prior to the bike rental, for at least one week during the rental period, and for at least 5 days after the rental period is completed. An established and standardized methodology for travel diaries collection is described in the National Travel Survey Technical Report. The Technical Report recognizes the existence or sampling errors in the data collection process, which considerably increases when the travel diary data collection is not done in-person. To address the issue of data errors as best as possible, the travel diary data for the e-bike demonstrator in London are collected either in person or by using the Google Maps Timeline, that trucks users' trips over the entire e-bike rental period.

4.2.4 Milan Demonstrator actions

The Sharing Cities project, in order to enhance the level of Milan bike sharing service in the assessed area, provides 14 bike sharing stations and 150 e-bikes.

The hire system allows to reserve the vehicles, showing the available ones and promoting the shift from private cars to electric vehicles. Thanks to an original allocation system, a traditional one and another based on service users, a constant number of vehicles is guaranteed. Moreover, the possibility to recharge e-bikes battery at e-cars charging stations is allowed.

In Table 4-4 E-bike sharing actions are connected with direct effects they contribute to activate. The "X" shows the E-bike sharing actions implemented and to what direct effect they are contributing to.

Table 4-4: Summary of Mobility actions in relation to the direct effects for E-bike sharing in Milan

Direct effects / **E-bike sharing actions**	Shift to electric mobility
Charging points	X
Bikesharing stations	X
E-bikes	X

4.2.5 Milan demonstrator benefits and evaluation targets

E-bike sharing direct effects will generate many benefits for the project:

- Reduction of pollutants emissions.
- Reduction of the private motorization rate.
- Reduction of traffic congestion level and vehicles travels.
- Improvement of some area accessibility within the project district.

In Table 4-5 direct effects and correlated benefits for Milan E-bike sharing are summarized.

The "X" shows the contribution of direct effects foreseen in E-bike sharing to the final benefits.

Table 4-5: Summary of direct effects in relation to the benefits for E-bike sharing in Milan

Benefits / **Direct effects**	Pollutants reduction	Motorization rate reduction	Congestion reduction / travels reduction	Area accessibility improvement

Shift to electric mobility	X	X	X	X

In Table 4-6 benefits are linked to the possible evaluation targets that will allow, once expressed in terms of performance indicators, to measure E-bike sharing performances.
Highlighted in bold, the core benefits and their relative evaluation targets, that are related to E-bike sharing actions foreseen by the Sharing Cities project in Milan.
In italics, the benefits which may result as indirect consequence of the actions.
The "X" in the right column, indicates what evaluation targets is applied to the project.

Table 4-6: Benefits and evaluation targets for E-bike sharing in Milan

Benefits	Evaluation targets	Applied in the project
Pollutants reduction	Distribution of eV user drive style energy efficiency	No
	Local emissions	No
Motorization rate reduction	Easy of hire - Docking station user interface	No
	Vehicle utilization	X
	Car ownership	No
	Travel mode choice/ Mode replacement survey	No
	Shared eMobility awareness	No
	How satisfied are people with demonstrator/ service	No
	Policy makers response to eMobility demonstrators	No
	Distribution of congestion level	No
Congestion reduction / travels reduction	Easy of hire - Docking station user interface	No
	Ease of hire - Station location	No
	Ease of finding a parking spot/ charging/ refuelling station	No
	Vehicle utilization	X
	Level/ Amount of mobility	X
	Distance per trip	X
	Willingness to use eVehicle	X
	Global emissions	No
	Noise pollution	No
	Distribution of congestion level	No
Area accessibility improvement	Ease of finding a parking spot/ charging/ refuelling station	No
	eVs rebalancing (full/empty docking stations)	No
	Trip purpose	No
	Route choice criteria - choice between simpler, faster, shorter route	No
	Safety rule compliance	No
	Shared eMobility awareness	No
	Shared eMobility familiarity	No
	Distribution of congestion level	No

Benefits	Evaluation targets	Applied in the project
Route spaces availability improvement	Vehicle occupancy	No
	Ease of use - Users that include eV in multimodal trips	No
	Shared eMobility awareness	No
Better user experience	Distribution of battery charge level at hire/ drop-off	No
	Vehicle utilization	No
	Range anxiety	No
	Minimum reliable battery charge at hire	No
	How frequently do cars run out of battery	No
	eMobility demand	No
	Distance per trip	No
	Driving style (aggressive / eco-friendly)	No
	Safety rule compliance	No
	Shared eMobility awareness	No
	Shared eMobility familiarity	No
	How satisfied are people with demonstrator/ service	No
	Safe mobility	No
Better operator experience	Maintenance need	No
	How frequently do cars run out of battery	No
	Policy makers response to eMobility demonstrators	No
	Safe mobility	No

4.2.6 Milan specific data collection protocol

In this section, the list of possible measurable indicators that can be used to assess the proposed evaluation targets is reported. In Table 4-7 every measurable indicator is characterized in terms of unit, possible data collection methods, critical issues, measurement frequency, etc.

Table 4-7 shows the specific indicators to be monitored during the project, specifying in detail which indicators will be monitored before and after E-bike sharing interventions. In addition to unit, data collection methods, critical issues and actions necessary to achieve the measure, also the frequency of measure or sampling, the frequency of data recording and the frequency of data sending are reported.

Table 4-7: List of evaluation targets and indicators for Milan E-bike sharing

N.	Evaluation target	Measurable indicator(s)	Unit	Applied pre-intervention	Applied post-intervention	Data collection method(s)	Measure frequency	Data recording frequency	Data sending frequency	Critical issues?	Necessary actions to achieve the measure?
1	Distribution of eV user drive style energy efficiency	Energy consumption per km	miles/ kWh	No	No						
2	Distribution of battery charge level at hire/ drop-off	Battery fullness at hire and drop-off	% or kWh	No	No						
3	Easy of hire - Docking station user interface	Duration of hire/ drop-off	time	No	No						
4	Ease of hire - Station location	Distance/ Time to station	time (minutes) or distance (km)	No	No						
5	Ease of finding a parking spot/ charging/ refuelling station	Time spent/ distance driven in search of charging station	minutes (or km) / trip (or per user)	No	No						
		Time spent/ distance driven in search of parking station	minutes (or km) / trip (or per user)	No	No						
6	Vehicle utilization	Distribution of (or not) use (w.r.t. time) - w.r.t. demand	time/time (i.e. %)	No	Yes	Station data logger	Each rental	Daily	Monthly	NDA	AMAT data owner
		Duration vehicle is available (not charging)	time/time	No	Yes	Station data logger	Each rental	Daily	Monthly	NDA	AMAT data owner
		Frequency of vehicle use	Users/ Hires per day	No	Yes	Station data logger	Each rental	Daily	Monthly	NDA	AMAT data owner
7	Range anxiety	battery charge @ hire /(over trip) trip distance	kWh/km	No	No						
8	Minimum reliable battery charge at hire	range anxiety metric / average trip distance	kWh (%)	No	No						
9	eVs rebalancing (full/empty docking stations)	eVs repositioned per day	eVs/day	No	No						
10	Arrival accuracy in deliveries	On time delivery success rate	%	No	No						
11	Performance reliability	Frequency of failure	Miles driven per failure	No	No						
12	Maintenance need	Frequency of minor repair	Time (or km) between repairs	No	No						
		Frequency of major repair	Time (or km) between repairs	No	No						
		Time a vehicle is not	%	No	No						

N.	Evaluation target	Measurable indicator(s)	Unit	Applied pre-intervention	Applied post-intervention	Data collection method(s)	Measure frequency	Data recording frequency	Data sending frequency	Critical issues?	Necessary actions to achieve the measure?
		available for service for repair purposes									
		Battery half-life	Battery capacity (kWh) w.r.t time	No	No						
13	How frequently do cars run out of battery	Mobility Charging Units calls	calls /month	No	No						
14	Car ownership	Vehicles per citizen (or household)	Number of vehicles	No	No						
15	Level/ Amount of mobility	Distance travelled	km/ user (or day)	No	No						
		Trips generated	trips/user/day (or year)	No	Yes		Bikesharing: define it with service manager;	Bikesharing: define it with service manager;	Bikesharing: define it with service manager;	Evaluate route and distance for bike sharing service;	
16	eMobility demand	How frequently potential users log on to the online platform to check vehicle condition	Online platform visitors	No	No						
17	Distance per trip	Distribution /Average trip distance	km	No	Yes	User survey					
				No	Yes	Data logger & GPS info	Each rental	Each rental	Bikesharing: define it with service manager;		Define necessary data for bikesharing
				No	Yes	Odometer, Docking time, Starting & finishing station, model	Each rental	Each rental	Bikesharing: define it with service manager;		
18	Trip purpose	Trip intention (commute, leisure, exercise)	Number of trips for each category	No	No						
19	Travel mode choice/ Mode replacement survey	Modal split	Trips / vehicle type	No	No						
20	Vehicle occupancy	Distribution /Average number of occupants per vehicle	occupants/ vehicle	No	No						
21	Ease of use - Users that include eV in multimodal trips	Multimodal trips/ All trips	%	No	No						

N.	Evaluation target	Measurable indicator(s)	Unit	Applied pre-intervention	Applied post-intervention	Data collection method(s)	Measure frequency	Data recording frequency	Data sending frequency	Critical issues?	Necessary actions to achieve the measure?
22	Route choice criteria - choice between simpler, faster, shorter route	User route choice intention	Number of trips for each category	No	No						
		Route features comparison (directness, travel time, etc.)		No	No						
23	Driving style (aggressive / eco-friendly)	Drive cycle (focus on acceleration/ deceleration)		No	No						
				No	No						
24	Safety rule compliance	Helmet use	% of users wearing helmet	No	No						
		Number of collisions/ traffic incidents	incidents per year	No	No						
		Tripping hazard from charging cables	incidents per year	No	No						
25	Shared eMobility awareness	Awareness of mobility - options available	Grade (1-5)	No	No						
		Awareness of environmental friendly mobility benefits	Grade (1-5)	No	No						
26	Shared eMobility familiarity	User familiarity with eVehicle/ smart mobility features	Grade (1-5)	No	No						
		User familiarity with shared mobility features	Grade (1-5)	No	No						
		Operator familiarity with shared eVehicle features and performance	Grade (1-5)	No	No						
27	Willingness to use eVehicle	Users registered in online platform	Number of registrations	Yes	Yes	Operator data/ User survey	Yearly	Yearly	Yearly		Get in touch with vehicles service manager
28	How satisfied are people with demonstrator/ service	Satisfaction level	Grade (1-5)	No	No						
29	Policy makers response to eMobility demonstrators	Intention to invest further	Grade (1-5)	No	No						
		Intention to introduce supportive policies	Grade (1-5)	No	No						
30	Local emissions	Emission free vehicle distance driven	km	No	No						
		Pollutants emitted (NOx, PM)	kg	No	No						
		CO_2	kg	No	No						

N.	Evaluation target	Measurable indicator(s)	Unit	Applied pre-intervention	Applied post-intervention	Data collection method(s)	Measure frequency	Data recording frequency	Data sending frequency	Critical issues?	Necessary actions to achieve the measure?
31	Global emissions	Distance driven now compared to distance driven normally		No	No						
32	Noise pollution	Level on street noise	dB	No	No						
33	Safe mobility	Record incidents	incidents/mile travelled	No	No						
34	Distribution of congestion level	Travel time	Travel time/ trip	No	No						
		Flow	veh/h	No	No						
35	Asset deterioration/ maintenance requirements	Road maintenance budget	£	No	No						
		Total distance travelled	km	No	No						

4.3 E-car sharing

4.3.1 Milan Demonstrator actions

The Milan citywide sharing of the city already exists, thanks to Sharing Cities this service is enhanced in the project area with the installation of 10 recharging stations and the introduction of 60 e-cars.
The 10 recharging stations, or Mobility Areas, are equipped with 6 smart charging stations powered by solar energy thanks to the installation of 60 KW of photovoltaic power plants. Photovoltaic will be installed both on *mobility areas* and existing buildings located in the project's area as retrofit installation.
Solar energy will provide fuel to electric vehicles for about 60.000 km per year, guaranteeing pure and clean energy for more about 100 electric vehicles.
In Table 4-8 E-car sharing actions are connected with direct effects they contribute to activate. The "X" shows the E-car sharing actions implemented and to what direct effect they are contributing to.

Table 4-8: Summary of Mobility actions in relation to the direct effects for E-car sharing in Milan

Direct effects / **E-car sharing actions**	Shift to electric mobility	Renewable energy production
Charging points	X	
PV on car sharing charging points		X
E-cars	X	

4.3.2 Milan demonstrator benefits and evaluation targets

E-car sharing direct effects will generate many benefits for the project:

- Reduction of pollutants emissions.
- Reduction of the private motorization rate.
- Reduction of traffic congestion level and vehicles travels.
- Improvement of some area accessibility within the project district.

In Table 4-9 direct effects and correlated benefits for Milan E-car sharing are summarized.
The "X" shows the contribution of direct effects foreseen in E-car sharing to the final benefits.

Table 4-9 - Summary of direct effects in relation to the benefits for E-car sharing in Milan

Benefits / **Direct effects**	Pollutants reduction	Motorization rate reduction	Congestion reduction / travels reduction	Area accessibility improvement
Shift to electric mobility	X	X	X	X
Renewable energy production	X			

In Table 4-10 benefits are linked to the possible evaluation targets that will allow, once expressed in terms of performance indicators, to measure E-car sharing performances.
Highlighted in bold, the core benefits and their relative evaluation targets, that are related to E-car sharing actions foreseen by the Sharing Cities project in Milan.
In italics, the benefits which may result as indirect consequence of the actions.

The “X” in the right column, indicates what evaluation targets is applied to the project.

Table 4-10: Benefits and evaluation targets for E-car sharing in Milan

Benefits	Evaluation targets	Applied in the project
Pollutants reduction	Distribution of eV user drive style energy efficiency	X
	Local emissions	X
Motorization rate reduction	Car ownership	No
	Travel mode choice/ Mode replacement survey	X
	Shared eMobility awareness	No
	How satisfied are people with demonstrator/ service	X
	Policy makers response to eMobility demonstrators	No
	Distribution of congestion level	No
	Easy of hire - Docking station user interface	X
	Vehicle utilization	X
	Maintenance need	No
	Range anxiety	X
	Willingness to use eVehicle	X
Congestion reduction / travels reduction	Ease of hire - Station location	X
	Ease of finding a parking spot/ charging/ refuelling station	No
	Level/ Amount of mobility	No
	Global emissions	X
	Noise pollution	No
	Distribution of congestion level	No
	Easy of hire - Docking station user interface	X
	Vehicle utilization	X
	Maintenance need	No
	Distribution of battery charge level at hire/ drop-off	X
	Distance per trip	X
	Willingness to use eVehicle	X
Area accessibility improvement	Ease of finding a parking spot/ charging/ refuelling station	No
	eVs rebalancing (full/empty docking stations)	No
	Trip purpose	X
	Route choice criteria - choice between simpler, faster, shorter route	No
	Safety rule compliance	No
	Shared eMobility awareness	No
	Shared eMobility familiarity	No
	Distribution of congestion level	No
Route spaces availability	Vehicle occupancy	X

Benefits	Evaluation targets	Applied in the project
improvement		
	Ease of use - Users that include eV in multimodal trips	No
	Shared eMobility awareness	No
Better user experience	Minimum reliable battery charge at hire	No
	How frequently do cars run out of battery	No
	eMobility demand	No
	Distance per trip	No
	Driving style (aggressive / eco-friendly)	No
	Safety rule compliance	No
	Shared eMobility awareness	No
	Shared eMobility familiarity	No
	Willingness to use eVehicle	No
	How satisfied are people with demonstrator/ service	No
	Safe mobility	No
Better operator experience	Maintenance need	No
	How frequently do cars run out of battery	No
	Policy makers response to eMobility demonstrators	No
	Safe mobility	No

4.3.3 Milan specific data collection protocol

In this section, the list of possible measurable indicators that can be used to assess the proposed evaluation targets is reported. In Table 4-11 every measurable indicator is characterized in terms of unit, possible data collection methods, critical issues, measurement frequency, etc.

Table 4-11 shows the specific indicators to be monitored during the project, specifying in detail which indicators will be monitored before and after E-car sharing interventions. In addition to unit, data collection methods, critical issues and actions necessary to achieve the measure, also the frequency of measure or sampling, the frequency of data recording and the frequency of data sending are reported.

Table 4-11: List of evaluation targets and indicators for Milan E-car sharing

N.	Evaluation target	Measurable indicator(s)	Unit	Applied pre-intervention	Applied post-intervention	Data collection method(s)	Measure frequency	Data recording frequency	Data sending frequency	Critical issues?	Necessary actions to achieve the measure?
1	Distribution of eV user drive style energy efficiency	Energy consumption per km	miles/ kWh	No	Yes	Vehicle data logger (distance, energy consumed)	Each rental	Each rental	Monthly	NDA	Need to know battery capacity
2	Distribution of battery charge level at hire/ drop-off	Battery fullness at hire and drop-off	% or kWh	No	Yes	Vehicle data logger / Station data logger	Each rental	Each rental	Monthly	NDA	To measure the previous indicator
3	Easy of hire - Docking station user interface	Duration of hire/ drop-off	time	No	Yes	User survey	Yearly	Yearly	Yearly	We will attend data from operators and the data regards the Milan situation	Define survey questions and share them with survey's responsible (vehicles service manager)
4	Ease of hire - Station location	Distance/ Time to station	time (minutes) or distance (km)	No	Yes	User survey	Yearly	Yearly	Yearly	The survey regards, at moment, only CS Free Floating operators in Milan and one question is the investigation of the time spent for going to car reserved.	Define survey questions and share them with survey's responsible (vehicles service manager)
5	Ease of finding a parking spot/ charging/ refuelling station	Time spent/ distance driven in search of charging station	minutes (or km) / trip (or per user)	No	No						
		Time spent/ distance driven in search of parking station	minutes (or km) / trip (or per user)	No	No						
6	Vehicle utilization	Distribution of (or not) use (w.r.t. time) - w.r.t. demand	time/time (i.e. %)	No	Yes	Station data logger	Each rental	Daily	Monthly	NDA	AMAT data owner
		Duration vehicle is available (not charging)	time/time	No	Yes	Station data logger	Each rental	Daily	Monthly	NDA	AMAT data owner
		Frequency of vehicle use	Users/ Hires per day	No	Yes	Station data logger	Each rental	Daily	Monthly	NDA	AMAT data owner

N.	Evaluation target	Measurable indicator(s)	Unit	Applied pre-intervention	Applied post-intervention	Data collection method(s)	Measure frequency	Data recording frequency	Data sending frequency	Critical issues?	Necessary actions to achieve the measure?
7	Range anxiety	battery charge @ hire /(over trip) trip distance	kWh/km	No	Yes	Station data logger	Each rental	Daily	Monthly	NDA	AMAT data owner
8	Minimum reliable battery charge at hire	range anxiety metric / average trip distance	kWh (%)	No	No						
9	eVs rebalancing (full/empty docking stations)	eVs repositioned per day	eVs/day	No	No						
10	Arrival accuracy in deliveries	On time delivery success rate	%	No	No						
11	Performance reliability	Frequency of failure	Miles driven per failure	No	No						
12	Maintenance need	Frequency of minor repair	Time (or km) between repairs	No	No						
		Frequency of major repair	Time (or km) between repairs	No	No						
		Time a vehicle is not available for service for repair purposes	%	No	No						
		Battery half-life	Battery capacity (kWh) w.r.t time	No	No						
13	How frequently do cars run out of battery	Mobility Charging Units calls	calls /month	No	No						
14	Car ownership	Vehicles per citizen (or household)	Number of vehicles	No	No						
15	Level/ Amount of mobility	Distance travelled	km/ user (or day)	No	No						
		Trips generated	trips/user/day (or year)	No	No						
16	eMobility demand	How frequently potential users log on to the online platform to check vehicle condition	Online platform visitors	No	No						

N.	Evaluation target	Measurable indicator(s)	Unit	Applied pre-intervention	Applied post-intervention	Data collection method(s)	Measure frequency	Data recording frequency	Data sending frequency	Critical issues?	Necessary actions to achieve the measure?
17	Distance per trip	Distribution /Average trip distance	km	No	Yes	User survey					
				No	Yes	Data logger & GPS info					
				No	Yes	Odometer, Docking time, Starting & finishing station, model	Each rental	Each rental	Carsharing: monthly		
18	Trip purpose	Trip intention (commute, leisure, exercise)	Number of trips for each category	No	Yes	User survey	Yearly	Yearly	Yearly		Define survey questions and share them with survey's responsible (vehicles service manager)
19	Travel mode choice/ Mode replacement survey	Modal split	Trips / vehicle type	No	Yes	User survey/ eV usage data				Difficult to obtain information only for the project area	
20	Vehicle occupancy	Distribution /Average number of occupants per vehicle	occupants/ vehicle	No	Yes	User survey	Yearly	Yearly	Yearly		Define survey questions and share them with survey's responsible (vehicles service manager)
21	Ease of use - Users that include eV in multimodal trips	Multimodal trips/ All trips	%	No	No						
22	Route choice criteria - choice between simpler, faster, shorter route	User route choice intention	Number of trips for each category	No	No						
		Route features comparison (directness, travel time, etc.)		No	No						
23	Driving style (aggressive / eco-friendly)	Drive cycle (focus on acceleration/ deceleration)		No	No						
				No	No						
24	Safety rule compliance	Helmet use	% of users wearing helmet	No	No						

N.	Evaluation target	Measurable indicator(s)	Unit	Applied pre-intervention	Applied post-intervention	Data collection method(s)	Measure frequency	Data recording frequency	Data sending frequency	Critical issues?	Necessary actions to achieve the measure?
		Number of collisions/ traffic incidents	incidents per year	No	No						
		Tripping hazard from charging cables	incidents per year	No	No						
25	Shared eMobility awareness	Awareness of mobility - options available	Grade (1-5)	No	No						
		Awareness of environmental friendly mobility benefits	Grade (1-5)	No	No						
26	Shared eMobility familiarity	User familiarity with eVehicle/ smart mobility features	Grade (1-5)	No	No						
		User familiarity with shared mobility features	Grade (1-5)	No	No						
		Operator familiarity with shared eVehicle features and performance	Grade (1-5)	No	No						
27	Willingness to use eVehicle	Users registered in online platform	Number of registrations	Yes	Yes	Operator data/ User survey	Yearly	Yearly	Yearly		Get in touch with vehicles service manager
28	How satisfied are people with demonstrator/ service	Satisfaction level	Grade (1-5)	No	Yes	User survey	Each rental	Each rental	Monthly		Define survey questions and share them with survey's responsible (vehicles service manager)
29	Policy makers response to eMobility demonstrators	Intention to invest further	Grade (1-5)	No	No						
		Intention to introduce supportive policies	Grade (1-5)	No	No						
30	Local emissions	Emission free vehicle distance driven	km	No	Yes	Usage data	Each rental	Each rental	Monthly	Get in touch with AMAT Environment division	Measure route distance, vehicle load level and other parameters
		Pollutants emitted (NOx, PM)	kg	No	Yes	Emission model	Each rental	Each rental	Monthly	Get in touch with AMAT Environment division	Measure vehicles electric consumption
		CO_2	kg	No	Yes	Emission model	Each rental	Each rental	Monthly	Get in touch	Measure

N.	Evaluation target	Measurable indicator(s)	Unit	Applied pre-intervention	Applied post-intervention	Data collection method(s)	Measure frequency	Data recording frequency	Data sending frequency	Critical issues?	Necessary actions to achieve the measure?
										with AMAT Environment division	vehicles electric consumption
31	Global emissions	Distance driven now compared to distance driven normally		No	Yes	Usage data	Yearly	Yearly	Yearly	It often depends by users subjectivity	Define survey questions and share them with survey's responsible (vehicles service manager)
32	Noise pollution	Level on street noise	dB	No	No						
33	Safe mobility	Record incidents	incidents/mile travelled	No	No						
34	Distribution of congestion level	Travel time	Travel time/ trip	No	No						
		Flow	veh/h	No	No						
35	Asset deterioration/ maintenance requirements	Road maintenance budget	£	No	No						
		Total distance travelled	km	No	No						

4.4 Milan E-logistic

4.4.1 Milan Demonstrator actions

The E-logistic is a new service for Milan Sharing Cities district and includes 9 e-vans and 2 e-bikes. The e-logistic platform, equipped with fast charging points, hosts all the vehicles of this service.

In Table 4-12 E-logistic actions are connected with direct effects they contribute to activate. The "X" shows the E-logistic actions implemented and to what direct effect they are contributing to.

Table 4-12: Summary of Mobility actions in relation to the direct effects for E-logistic in Milan

Direct effects / **E-logistic actions**	Parking/restricted area monitoring	Shift to electric mobility
Parking sensor	X	
eVehicles logistic		X
RFD sensors	X	

4.4.2 Milan demonstrator benefits and evaluation targets

E-logistic direct effects will generate many benefits for the project:

- Reduction of pollutants emissions.
- Reduction of the private motorization rate.
- Reduction of traffic congestion level and vehicles travels.
- Improvement of some area accessibility within the project district.
- Improvement of route spaces availability.

In Table 4-13 direct effects and correlated benefits for Milan E-logistic are summarized.
The "X" shows the contribution of direct effects foreseen in E-logistic to the final benefits.

Table 4-13: Summary of direct effects in relation to the benefits for E-logistic in Milan

Benefits / **Direct effects**	Pollutants reduction	Motorization rate reduction	Congestion reduction / travels reduction	Area accessibility improvement	Route spaces availability improvement
Parking/restricted area monitoring	X		X	X	X
Shift to electric mobility	X	X	X	X	

In Table 4-14 benefits are linked to the possible evaluation targets that will allow, once expressed in terms of performance indicators, to measure E-logistic performances.
Highlighted in bold, the core benefits and their relative evaluation targets, that are related to E-logistic actions foreseen by the Sharing Cities project in Milan.
In italics, the benefits which may result as indirect consequence of the actions.
The "X" in the right column, indicates what evaluation targets is applied to the project.

Table 4-14: Benefits and evaluation targets for E-logistic in Milan

Benefits	Evaluation targets	Applied in the project

Benefits	Evaluation targets	Applied in the project
Pollutants reduction	Distribution of eV user drive style energy efficiency	X
	Local emissions	X
Motorization rate reduction	Travel mode choice/ Mode replacement survey	No
	Shared eMobility awareness	No
	How satisfied are people with demonstrator/ service	No
	Policy makers response to eMobility demonstrators	No
	Distribution of congestion level	No
Congestion reduction / travels reduction	Ease of hire - Station location	No
	Ease of finding a parking spot/ charging/ refuelling station	No
	Level/ Amount of mobility	No
	Global emissions	X
	Noise pollution	No
	Distribution of congestion level	No
Area accessibility improvement	Ease of finding a parking spot/ charging/ refuelling station	X
	eVs rebalancing (full/empty docking stations)	No
	Route choice criteria - choice between simpler, faster, shorter route	No
	Safety rule compliance	No
	Distribution of congestion level	No
Route spaces availability improvement	Ease of use - Users that include eV in multimodal trips	No
Better user experience	Ease of hire - Station location	No
	Vehicle utilization	
Better operator experience	Maintenance need	
	How satisfied are people with demonstrator/ service	No
	Policy makers response to eMobility demonstrators	No

4.4.3 Milan specific data collection protocol

In this section, the list of possible measurable indicators that can be used to assess the proposed evaluation targets is reported. In Table 4-15 every measurable indicator is characterized in terms of unit, possible data collection methods, critical issues, measurement frequency, etc.

Table 4-15 shows the specific indicators to be monitored during the project, specifying in detail which indicators will be monitored before and after E-logistic interventions. In addition to unit, data collection methods, critical issues and actions necessary to achieve the measure, also the frequency of measure or sampling, the frequency of data recording and the frequency of data sending are reported.

Table 4-15: List of evaluation targets and indicators for Milan E-logistic

N.	Evaluation target	Measurable indicator(s)	Unit	Applied pre-intervention	Applied post-intervention	Data collection method(s)	Measure frequency	Data recording frequency	Data sending frequency	Critical issues?	Necessary actions to achieve the measure?
1	Distribution of eV user drive style energy efficiency	Energy consumption per km	miles/ kWh	No	Yes	Vehicle data logger (distance, energy consumed)	Each rental	Each rental	Monthly	NDA	Need to know battery capacity
2	Distribution of battery charge level at hire/ drop-off	Battery fullness at hire and drop-off	% or kWh	No	Yes	Vehicle data logger / Station data logger	Each rental	Each rental	Monthly	NDA	To measure the previous indicator
3	Easy of hire - Docking station user interface	Duration of hire/ drop-off	time	No	Yes	User survey	Yearly	Yearly	Yearly	If we need to realize a survey we have to communicate our question to the mobility service manager, within the end of April	Define survey questions and share them with survey's responsible (vehicles service manager)
4	Ease of hire - Station location	Distance/ Time to station	time (minutes) or distance (km)	No	Yes	User survey	Yearly	Yearly	Yearly	If we need to realize a survey we have to communicate our question to the mobility service manager, within the end of April	Define survey questions and share them with survey's responsible (vehicles service manager)
5	Ease of finding a parking spot/ charging/ refuelling station	Time spent/ distance driven in search of charging station	minutes (or km) / trip (or per user)	No	No						
		Time spent/ distance driven in search of parking station	minutes (or km) / trip (or per user)	No	No						
6	Vehicle utilization	Distribution of (or not) use (w.r.t. time) - w.r.t. demand	time/time (i.e. %)	No	No						
		Duration vehicle is available (not charging)	time/time	No	No						

N.	Evaluation target	Measurable indicator(s)	Unit	Applied pre-intervention	Applied post-intervention	Data collection method(s)	Measure frequency	Data recording frequency	Data sending frequency	Critical issues?	Necessary actions to achieve the measure?
		Frequency of vehicle use	Users/ Hires per day	No	No						
7	Range anxiety	battery charge @ hire /(over trip) trip distance	kWh/km	No	No						
8	Minimum reliable battery charge at hire	range anxiety metric / average trip distance	kWh (%)	No	No						
9	eVs rebalancing (full/empty docking stations)	eVs repositioned per day	eVs/day	No	No						
10	Arrival accuracy in deliveries	On time delivery success rate	%	No	Yes	User survey	Yearly	Yearly	Yearly	Get in touch with vehicles service manager	Define survey questions and share them with survey's responsible (vehicles service manager)
11	Performance reliability	Frequency of failure	Miles driven per failure	No	No						
12	Maintenance need	Frequency of minor repair	Time (or km) between repairs	No	No						
		Frequency of major repair	Time (or km) between repairs	No	No						
		Time a vehicle is not available for service for repair purposes	%	No	No						
		Battery half-life	Battery capacity (kWh) w.r.t time	No	No						
13	How frequently do cars run out of battery	Mobility Charging Units calls	calls /month	No	No						
14	Car ownership	Vehicles per citizen (or household)	Number of vehicles	No	No						
15	Level/ Amount of mobility	Distance travelled	km/ user (or day)	No	No						
		Trips generated	trips/user/day (or year)	No	No						

N.	Evaluation target	Measurable indicator(s)	Unit	Applied pre-intervention	Applied post-intervention	Data collection method(s)	Measure frequency	Data recording frequency	Data sending frequency	Critical issues?	Necessary actions to achieve the measure?
16	eMobility demand	How frequently potential users log on to the online platform to check vehicle condition	Online platform visitors	No	No						
17	Distance per trip	Distribution /Average trip distance	km	No	Yes	User survey	Yearly	Yearly	Yearly	Get in touch with vehicles service manager	
				No	Yes	Data logger & GPS info	Each rental	Each rental	Monthly	Get in touch with vehicles service manager	
				No	Yes	Odometer, Docking time, Starting & finishing station, model	Each rental	Each rental	Monthly	Get in touch with vehicles service manager	
18	Trip purpose	Trip intention (commute, leisure, exercise)	Number of trips for each category	No	No						
19	Travel mode choice/ Mode replacement survey	Modal split	Trips / vehicle type	No	No						
20	Vehicle occupancy	Distribution /Average number of occupants per vehicle	occupants/ vehicle	No	No						
21	Ease of use - Users that include eV in multimodal trips	Multimodal trips/ All trips	%	No	No						
22	Route choice criteria - choice between simpler, faster, shorter route	User route choice intention	Number of trips for each category	No	No						
		Route features comparison (directness, travel time, etc.)		No	No						
23	Driving style (aggressive / eco-friendly)	Drive cycle (focus on acceleration/ deceleration)		No	No						
				No	No						
24	Safety rule compliance	Helmet use	% of users wearing helmet	No	No						

N.	Evaluation target	Measurable indicator(s)	Unit	Applied pre-intervention	Applied post-intervention	Data collection method(s)	Measure frequency	Data recording frequency	Data sending frequency	Critical issues?	Necessary actions to achieve the measure?
		Number of collisions/ traffic incidents	incidents per year	No	No						
		Tripping hazard from charging cables	incidents per year	No	No						
25	Shared eMobility awareness	Awareness of mobility - options available	Grade (1-5)	No	No						
		Awareness of environmental friendly mobility benefits	Grade (1-5)	No	No						
26	Shared eMobility familiarity	User familiarity with eVehicle/ smart mobility features	Grade (1-5)	No	No						
		User familiarity with shared mobility features	Grade (1-5)	No	No						
		Operator familiarity with shared eVehicle features and performance	Grade (1-5)	No	No						
27	Willingness to use eVehicle	Users registered in online platform	Number of registrations	No	No						
28	How satisfied are people with demonstrator/ service	Satisfaction level	Grade (1-5)	No	No						
29	Policy makers response to eMobility demonstrators	Intention to invest further	Grade (1-5)	No	No						
		Intention to introduce supportive policies	Grade (1-5)	No	No						
30	Local emissions	Emission free vehicle distance driven	km	No	Yes	Usage data	Each rental	Each rental	Monthly	Get in touch with vehicles service manager	Measure route distance, vehicle load level and other parameters
		Pollutants emitted (NOx, PM)	kg	No	Yes	Emission model	Each rental	Each rental	Monthly	Get in touch with vehicles service manager	Measure vehicles electric consumption
		CO_2	kg	No	Yes	Emission model	Each rental	Each rental	Monthly	Get in touch with vehicles service manager	Measure vehicles electric consumption

N.	Evaluation target	Measurable indicator(s)	Unit	Applied pre-intervention	Applied post-intervention	Data collection method(s)	Measure frequency	Data recording frequency	Data sending frequency	Critical issues?	Necessary actions to achieve the measure?
31	Global emissions	Distance driven now compared to distance driven normally		No	Yes	Usage data	Yearly	Yearly	Yearly	It often depends by users subjectivity	Define survey questions and share them with survey's responsible (vehicles service manager)
32	Noise pollution	Level on street noise	dB	No	No						
33	Safe mobility	Record incidents	incidents/mile travelled	No	No						
34	Distribution of congestion level	Travel time	Travel time/ trip	No	No						
		Flow	veh/h	No	No						
35	Asset deterioration/ maintenance requirements	Road maintenance budget	£	No	No						
		Total distance travelled	km	No	No						

5 DCPS FOR T3.4 – LAMPPOST

5.1 Milan Lamppost

In the initial period of the project, Milan completed a city-wide LED replacement programme: old traditional lamps were substituted with LED lamps. This important action, out of the project, will provide a more efficient lighting system and, as a consequence, will help the city to save energy and avoid gas emissions.

This important starting point was essential to enable other important smart functionalities of the deployed lampposts, which are considered within the Sharing Cities project.

Using the lampposts infrastructure and the A2A Lorawan network, it is realized a network enabling all the services within the project district area.

Data concentrators, which are deployed in the district, receive data from sensors positioned within the project district. Both data concentrator and sensor are accommodated on the lampposts in order to guarantee their widespread distribution in the area.

The infrastructure of public lighting evolves into an IOT network infrastructure. The lamps represent the nodes in order to detect and carry the other components of the data related to the project: air quality, traffic and parking control, noise, water management, etc.

The assessment scheme (actions, direct effects, benefits, evaluation target) adopted to analyse building, SEMS and mobility performances is not use for lampposts because these devices, for Milan situation, are used to host sensors and data concentrator in order to support the other actions monitoring and to measure parameters that could be considered within the Sharing Cities project.

Following the sensors which are placed on lampposts:

- Environmental monitoring sensors: these sensors are used to measure environmental parameters near the lamppost (pollutants, temperature, humidity, rainfall, noise).
- Traffic flow control sensors: these sensors are used to control the traffic congestion level; they could be used also to control smart parking right use (at this stage of the project is not sure if this functionality will be activated).
- Water management sensors: these sensors are placed near the lampposts in order to control the rain water level in manholes.

6 APPENDIX

6.1 'Smartainability' methodology

Smartainability is a methodology developed to support decision makers to understand and quantify possible benefits deriving from deploying innovative technologies enabling smart services for the cities. The aim of the *Smartainability* approach is to estimate, with qualitative and quantitative information, to what extent smart cities are sustainable thanks to the deployment of smart technologies.
The word *Smartainability* originates from the two terms Smartness and Sustainability, while the methods is derived from two existing methodologies: *Guidelines for conducting a cost-benefit analysis of Smart Grid projects*, a study made by European Commission JRC (Giordano et al, 2012), and *Smart Cities – Ranking of European medium-sized cities*, realized by Vienna University of Technology, University of Lubljana and Delft University of Technology to evaluate smart cities sustainability (Giffinger et al, 2007).
From the JRC study (Giordano et al, 2012), *Smartainability* derived the Assets-Functionalities-Benefits methodology to examine smart technologies. The aim of this approach is to identify functionalities (services) enabled by one or more assets (enabling technologies). Functionalities create benefits that are evaluated with qualitative and quantitative performance indicators (KPI). An example of this methodology is the follow: in an hypothetical lighting system the *LED lamps* asset enables the *Advanced lighting management* functionality. This functionality is able to activate many benefits, and one of these is *Pollutant emissions reduction*. To quantify this benefit it's possible to consider *Greenhouse gases*, *Acid gases*, *Particulate* KPIs.

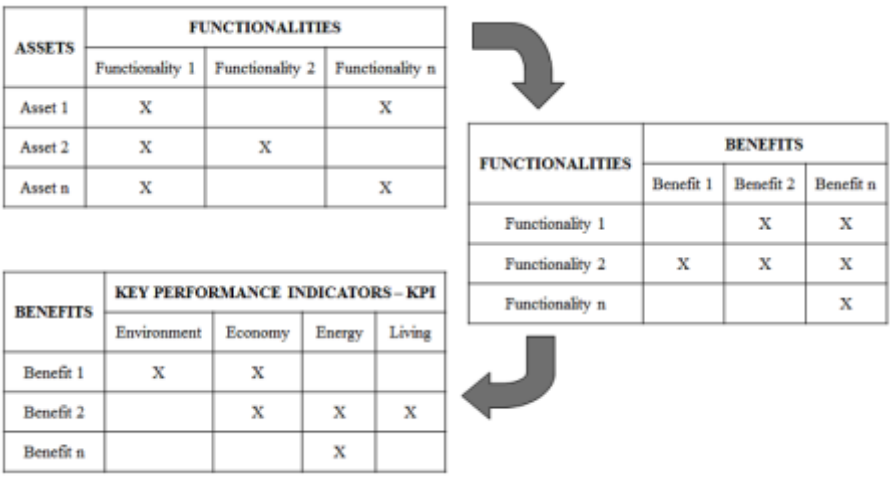


Figure 6.1: Example of Assets-Functionalities-Benefits matrix scheme

More generally, for each group of technologies, applied in an integrated way to a single field such as mobility, energy grids, buildings, the assets are identified. Then functionalities enabled by the assets are identified as well. A two-dimensional array is filled with assets and functionalities, in order to verify which functionalities are activated by the project's assets. The next step is to identify the potential benefits that can be enabled by functionalities. Like the previous case, a two-dimensional array is filled with functionalities and benefits: it is possible to understand which benefits are activated by each functionality. Benefits are then classified in different sustainable development dimensions (Environment, Economy, Energy, Living, etc.) and for each of these dimensions one or more indicators are identified to evaluate benefits in a quantitative (or at least qualitative) way. This ensures that all the dimensions of sustainability are taken into account. Finally a two-dimensional array is filled with benefits and KPIs. In Figure 6.1 is explained and sketched the previous methodology.

From the document *Smart Cities – Ranking of European medium-sized cities* (Giffinger et al, 2007)[5], *Smartainability* derived the concept of the dimensions of analysis suitable for a sustainable smart city.
Smartainability considers five dimensions of analysis and each of them is able to analyse, with suitable indicators, a sustainable aspect of a smart city:

- Environment: this dimension includes all indicators which allow to evaluate the technologies' environmental performances (gas emissions, water consumptions, solid wastes production).
- Economy: this dimension includes indicators suitable to evaluate the technologies' economic performances (purchase, management and disposal costs)
- Energy: this dimension includes all indicators which evaluate technologies' energy performances (saved energy, renewable or fossil energy used).
- Living: this dimension includes all indicators which evaluate citizens' life quality improving thanks to technologies deployment.
- People: this dimension includes all indicators which evaluate the citizens community life quality improving thanks to technologies deployment, considering social cohesion and inclusion aspects.

The indicators represent the performance gain between the infrastructural smart technology and similar traditional technology. The indicators are quantified, where feasible, considering a life cycle perspective following the ISO 14040 (ISO - The International Organization for Standardization, 2006) [6] . Concerning the Environment and Energy dimensions, the assessment is realised evaluating the whole life cycle of the technology with a life cycle assessment approach.
Thanks to this methodology is possible to evaluate the performance of an activity, contemplating the whole life of a technology. For each asset the assessment takes into account the main life cycle phases: extraction and manufacturing, materials transport, construction, use, disposal. The assessment of all these phases allows to identify the emissions (solid, liquid, gas), the resources consumption (energy especially) and shows an evaluation of the environment influences of a technology during its life. Considering the other indicators, for the Economy dimension purchase, management and disposal costs are considered.
For the Living and People dimensions the assessment is realised following the method presented in Giffinger et al which evaluates with quantitative or qualitative indicators the smartness performance.
Smartainability methodology is able to give decision makers useful information on benefits generated by smart solutions deployment. This aspect is due to three relevant issue: benefits are expressed with quantitative indicators; indicators are estimated before technologies or solutions implementation; benefits are connected to technologies or solutions deployment.

6.2 RBG e-bikes

6.2.1 Baseline travel survey

[5] Giffinger, R., Fertner, C., Kramar, H., Kalasek, R., Pichler-Milanović, N. and E. Meijers, 2007. Smart Cities: Ranking of European medium-sized cities.
[6] International Organization of Standardization, 2006. Environmental management, Life-cycle assessment, Principles and Framework.

As part of the Greenwich Low Emission Neighbourhood (LEN) and Sharing Cities programmes e-bikes will be trialled from April 2017 to March 2018. Residents of Greenwich town centre and Peninsula may be able to borrow an e-bike for 4 weeks for just £10!

If you use a car or taxi for the majority of your travel, you will be eligible to trial an e-bike instead. E-bikes provide great exercise with a little bit of extra power. Better yet, you can reduce your impact on local air quality and breathe better air by using quiet back streets.

Please take a few minutes to answer the following questions. This information will help us to gain a better understanding of your travel habits and your views on cycling. Survey responses will be kept confidential and the results will be used for research purposes only.

Many thanks!

Section A: About your travel

A1. What best describes your current employment status?

- ☐ Full-time employed
- ☐ Part-time employed
- ☐ Student
- ☐ Retired
- ☐ Unemployed

A2. How often do you travel by:

	No trips made	At least once a year	At least once a month	At least once a week	3 or more times per week
Bus	☐	☐	☐	☐	☐
Train	☐	☐	☐	☐	☐
Underground, tram or light rail	☐	☐	☐	☐	☐
Own bicycle	☐	☐	☐	☐	☐
Bike hire (not electric)	☐	☐	☐	☐	☐
Electric bicycle	☐	☐	☐	☐	☐
Taxi	☐	☐	☐	☐	☐
Private car (as driver)	☐	☐	☐	☐	☐
Private car (as passenger)	☐	☐	☐	☐	☐
Car club (as driver or passenger)	☐	☐	☐	☐	☐
Walking (for more than 20 minutes)	☐	☐	☐	☐	☐

A3. How do you usually travel to work, or school/college/university if you are a student?

Please choose the option that you use for the longest part of your journey.

- ☐ Bus
- ☐ Train
- ☐ Underground, tram or light rail
- ☐ Own bicycle
- ☐ Bike hire (not electric)
- ☐ Electric bicycle
- ☐ Taxi
- ☐ Private car (as driver)
- ☐ Private car (as passenger)
- ☐ Car club (as driver or passenger)
- ☐ Walking

A4. Do you usually cycle for part of your trip to work, or school/college/university if you are a student?

- ☐ Yes
- ☐ No

Section B: Joining the e-bike trial

B1. Which of the following statements reflect your reasons for joining this e-bike trial?

- ☐ I am thinking of buying an electric bike and this is a good way to try it out
- ☐ I am curious to try an electric bike but not interested in buying one
- ☐ I joined in order to make specific journeys that I already make (using a different form of transport, including regular bike)

To have access to an electric bike without the hassle of owning one ☐

B2. **What is the main type of trip that you expect to use the electric bike for?**

Please choose the type of trip that you are most likely to make

- Business (work-related trips that are not your commute) ☐
- Commuting (your journey to/from work) ☐
- Education (including doing the school run) ☐
- Leisure (e.g. going for swimming or to the cinema) ☐
- Cycling for pleasure ☐
- Cycling for fitness ☐
- Personal business (e.g. going to the bank, hairdresser, dentist etc.) ☐
- Shopping ☐
- Visiting friends/family ☐
- I don't know ☐

B3. **Are there any other types of trips you expect to make occasionally using electric bikes?**

- Business (work-related trips that are not your commute) ☐
- Commuting (your journey to/from work) ☐
- Education (including doing the school run) ☐
- Leisure (e.g. going for swimming or to the cinema) ☐
- Cycling for pleasure ☐
- Cycling for fitness ☐
- Personal business (e.g. going to the bank, hairdresser, dentist etc.) ☐
- Shopping ☐
- Visiting friends/family ☐

Section C: Bike news

C1. **Have you ever subscribed to any specialist magazines or Internet forums related to biking/e-bikes?**

- Yes ☐
- No ☐

C2. **Could you please specify which magazine(s)/forum(s) related to biking/e-bikes?**

[ ]

C3. **How often do you read/access it?**

- Rarely ☐
- 2-3 times a month ☐
- Once a week ☐
- 2-3 times a week ☐
- Daily ☐

C4. **How often do you read/listen to pieces of news related to biking/e-bikes?**

- Rarely ☐
- 2-3 times a month ☐
- Once a week ☐
- 2-3 times a week ☐
- Daily ☐

Section D: Your views on cycling

D1. **How likely are you to do the following within the next year?**

	Highly Unlikely	Unlikely	Neither likely nor unlikely	Likely	Highly Likely
Buy a car	☐	☐	☐	☐	☐
Buy a regular bike	☐	☐	☐	☐	☐
Buy an electric bike	☐	☐	☐	☐	☐
Use an E-bike sharing scheme on a daily basis	☐	☐	☐	☐	☐
Sign up for a year to an E-bike sharing scheme	☐	☐	☐	☐	☐

D2. **How much do you agree with the following statements?**

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
I would like to cycle and enjoy nature	☐	☐	☐	☐	☐
I would like to cycle to keep fit	☐	☐	☐	☐	☐
Public transport in London is expensive	☐	☐	☐	☐	☐

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
Finding a parking space for a car is very complicated	☐	☐	☐	☐	☐
Driving in London is easy	☐	☐	☐	☐	☐
I feel safer in a car during the night	☐	☐	☐	☐	☐
I can avoid traffic jam by taking the train	☐	☐	☐	☐	☐
Driving a car is very comfortable	☐	☐	☐	☐	☐
I would not like to take public transport when trains/buses are very crowded	☐	☐	☐	☐	☐
I can read/study while traveling on a train/bus	☐	☐	☐	☐	☐
I can listen to music by driving a car	☐	☐	☐	☐	☐
Travel by car is faster	☐	☐	☐	☐	☐
I would not like to wait for public transport	☐	☐	☐	☐	☐
I would not like transfers when using public transport	☐	☐	☐	☐	☐
Public transport is cheaper than car	☐	☐	☐	☐	☐
Using public transport is beneficial for the environment	☐	☐	☐	☐	☐
I prefer to cycle to save money	☐	☐	☐	☐	☐
I prefer to cycle to save time (less travel time, no need for parking space)	☐	☐	☐	☐	☐
I prefer to cycle to avoid the crowds in buses and tubes	☐	☐	☐	☐	☐
I would not like to cycle when it rains	☐	☐	☐	☐	☐
I would not like to cycle on a hot day	☐	☐	☐	☐	☐
I can cycle for many hours	☐	☐	☐	☐	☐
I would not feel safe to cycle in London without a helmet	☐	☐	☐	☐	☐
I would not feel safe to cycle through a congested road	☐	☐	☐	☐	☐
I would like to cycle on separated bicycle lanes	☐	☐	☐	☐	☐
It will be difficult to look at the GPS on my phone while cycling	☐	☐	☐	☐	☐
Riding an electric bike is faster	☐	☐	☐	☐	☐

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
Riding an electric bike makes it easier to cycle longer distances	☐	☐	☐	☐	☐
Riding an electric bike makes it easier to cycle an uphill route	☐	☐	☐	☐	☐
It is dangerous to ride an electric bike at 32 km/h	☐	☐	☐	☐	☐

D3. How much do you agree with the following statements regarding your family and friends?

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
They generally ride a bicycle	☐	☐	☐	☐	☐
They generally drive	☐	☐	☐	☐	☐
They like cycling during their spare time	☐	☐	☐	☐	☐
They ride bicycles for sport	☐	☐	☐	☐	☐
Among them, cycling is considered to be cool	☐	☐	☐	☐	☐
They believe that having a car is a must	☐	☐	☐	☐	☐
They believe that cycling is a travel mode primarily for low income individuals	☐	☐	☐	☐	☐
They consider it dangerous to cycle alone at night	☐	☐	☐	☐	☐
They think drivers do not respect cyclists	☐	☐	☐	☐	☐
They generally wear a helmet when cycling	☐	☐	☐	☐	☐
They think the e-bike is too fast	☐	☐	☐	☐	☐
They think the e-bike makes it easier to cycle an uphill route	☐	☐	☐	☐	☐
They think the e-bike facilitates cycling over longer distances	☐	☐	☐	☐	☐
I generally encourage them to be respectful of the nature	☐	☐	☐	☐	☐
I generally encourage them to play sports	☐	☐	☐	☐	☐
I generally encourage them to cycle	☐	☐	☐	☐	☐
I usually ask friends to go out	☐	☐	☐	☐	☐
I love arranging meetings with my friends	☐	☐	☐	☐	☐

D4. How much do you agree with the following statements regarding other sources of information (a specialized magazine/newspaper/website article/forum/TV news)?

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
Newspapers, websites and TV encourage cycling in order to keep fit	☐	☐	☐	☐	☐
Newspapers, websites and TV encourage cycling in order to save money	☐	☐	☐	☐	☐
Newspapers, websites and TV encourage cycling in order to save time	☐	☐	☐	☐	☐
Newspapers, websites and TV encourage cycling in order to reduce pollution and congestion	☐	☐	☐	☐	☐
Newspapers, websites and TV encourage cycling with a helmet	☐	☐	☐	☐	☐
Magazines and websites suggest that riding an electric bike saves time	☐	☐	☐	☐	☐
Magazines and websites suggest that riding an electric bike makes it easier to cycle longer distances	☐	☐	☐	☐	☐
Magazines and websites suggest that riding an electric bike makes it easier to cycle an uphill route	☐	☐	☐	☐	☐
Magazines and websites suggest that riding an electric bike at maximum speed could be dangerous	☐	☐	☐	☐	☐

D5. In general, how influential are the following on your opinion of cycling?

	No influence	Slight influence	Sufficient influence	High influence
A discussion with a family member	☐	☐	☐	☐
A discussion with a friend	☐	☐	☐	☐
A discussion with a colleague	☐	☐	☐	☐
An article of a specialized magazine/website	☐	☐	☐	☐
A casual article of a newspaper/website	☐	☐	☐	☐
An Internet forum	☐	☐	☐	☐

Section E: About you

E1. How many adults/children are there in your household?

	0	1	2	3	4	5+
Adults	☐	☐	☐	☐	☐	☐
Children	☐	☐	☐	☐	☐	☐

E2. How many cars does your household own?

- 0 ☐
- 1 ☐
- 2 ☐
- 3 ☐
- More than 3 ☐

E3. Your annual household income is:

- Less than £20,000 ☐
- £20,000 to £34,999 ☐
- £35,000 to £49,999 ☐
- £50,000 to £64,999 ☐
- £65,000 to £79,999 ☐
- £80,000 to £104,999 ☐
- Greater than £105,000 ☐
- I prefer not to answer. ☐

E4. What is the highest education level you have completed?

- School/college ☐
- 1st degree ☐
- Higher degree ☐

You have completed the survey and your response has been saved. Thank you for participating. If you have any further questions, please contact cyclingprojects@lcc.org.uk

6.2.2 Pen & paper travel diary (NTS type)

DAY 1 Date:

JOURNEYS: Please record each journey on a new row

STAGES: Please insert in these columns the details of each stage of your jouney

	A	B	C	D	E		F	G	H	I	J	IF YOU USED A CAR OR OTHER MOTOR VEHICLE K	L	M	IF YOU USED PLUBLIC TANSPORT N	O	P	IF YOU TOOK A TAXI Q
	What was the purpose of your journey?	What time did you leave?	What time did you arrive?	Where did you start your jouney? (Tick Home or give the name of the village, town or area)	Where did you go? (Tick Home or give the name of the village, town or area)		What type of method of travel did you use for each stage of the journey	How far did you travel (Miles)	How long did you spend travelling? (Minutes)	How many people travelled including you?	Which car or other motor vehicle didi you use?	Were you the driver (D) or a passenger (P)?	How much did you pay for parking	How much did you pay for road tolls/congestion charges? (£)	What type of tiket did you use?	How much did your ticket cost? (£)	How many times did you board?	How much did you share of the taxi cost? (£)
1				[ ] Home	[ ] Home	1						[ ] D [ ] P						
		[ ] am	[ ] am			2						[ ] D [ ] P						
		[ ] pm	[ ] pm			3						[ ] D [ ] P						
2				[ ] Home	[ ] Home	1						[ ] D [ ] P						
		[ ] am	[ ] am			2						[ ] D [ ] P						
		[ ] pm	[ ] pm			3						[ ] D [ ] P						
3				[ ] Home	[ ] Home	1						[ ] D [ ] P						
		[ ] am	[ ] am			2						[ ] D [ ] P						
		[ ] pm	[ ] pm			3						[ ] D [ ] P						
4				[ ] Home	[ ] Home	1						[ ] D [ ] P						
		[ ] am	[ ] am			2						[ ] D [ ] P						
		[ ] pm	[ ] pm			3						[ ] D [ ] P						
5				[ ] Home	[ ] Home	1						[ ] D [ ] P						
		[ ] am	[ ] am			2						[ ] D [ ] P						
		[ ] pm	[ ] pm			3						[ ] D [ ] P						
6				[ ] Home	[ ] Home	1						[ ] D [ ] P						
		[ ] am	[ ] am			2						[ ] D [ ] P						
		[ ] pm	[ ] pm			3						[ ] D [ ] P						
7				[ ] Home	[ ] Home	1						[ ] D [ ] P						
		[ ] am	[ ] am			2						[ ] D [ ] P						
		[ ] pm	[ ] pm			3						[ ] D [ ] P						

6.3 Building Retrofit

6.3.1 Extended Current Comfort Survey

Extended Current Comfort Survey (Q1_LC_1)

Name:
Date:
Time:

1. TEMPERATURE

How do you feel at this precise moment? I am:		Do you find this....?		At this moment, would you prefer to be .....?	
Cold	☐	Comfortable	☐	Much cooler	☐
Cool	☐	Slightly uncomfortable	☐	Slightly cooler	☐
Slightly Cool	☐	Uncomfortable	☐	Neither warmer nor cooler	☐
Neither hot nor cold	☐	Very uncomfortable	☐	Slightly warmer	☐
Slightly Warm	☐	Extremely uncomfortable	☐	Much warmer	☐
Warm	☐				
Hot	☐				

Please describe any other issues related to temperature that is important to you.

2. AIR MOVEMENT

How do you find the air movement in your flat at this time?		Do you find this....?		At this moment, how would you prefer to have .....?	
Very low	☐	Comfortable	☐	Much more air movement	☐
Low	☐	Slightly uncomfortable	☐	A bit more air movement	☐
Slightly low	☐	Uncomfortable	☐	No Change	☐
Neither high nor low	☐	Very uncomfortable	☐	A bit less air movement	☐
Slightly high	☐	Extremely uncomfortable	☐	Much less air movement	☐
High	☐				
Very high	☐				

Please describe any other issues related to air movement that is important to you.

3. HUMIDITY

How do find the humidity of the air in your flat at this time?		Do you find this....?		At this moment, how would you prefer the air .....?	
Very humid	☐	Comfortable	☐	Much drier	☐
Humid	☐	Slightly uncomfortable	☐	A bit drier	☐
Slightly humid	☐	Uncomfortable	☐	No change	☐
Neither humid nor dry	☐	Very uncomfortable	☐	A bit more humid	☐
Slightly dry	☐	Extremely uncomfortable	☐	Much more humid	☐
Dry	☐				
Very dry	☐				

Please describe any other issues related to humidity that is important to you.

4.1 NATURAL LIGHTING

How do you find the natural lighting level at this time?

- Very bright ☐
- Bright ☐
- Slightly bright ☐
- Neither bright nor dim ☐
- Slightly dim ☐
- Dim ☐
- Very dim ☐

Do you find this....?

- Comfortable ☐
- Slightly uncomfortable ☐
- Uncomfortable ☐
- Very uncomfortable ☐
- Extremely uncomfortable ☐

At this moment, how would you prefer your working area to be ....?

- Much dimmer ☐
- A bit dimmer ☐
- No change ☐
- A bit brighter ☐
- Much brighter ☐

Which kind of solar shading systems are used at the moment?

- Shutters, awnings, blinds ☐
- Upstairs balconies ☐
- Natural systems, vegetation ☐
- There are no solar shading systems ☐
- Other

The existing solar shading systems are:

- Internal ☐
- External ☐

Please describe any other issues related to natural lighting that is important to you.

4.2 ARTIFICIAL LIGHTING

How do you find the artificial lighting level at this time?

- Very bright ☐
- Bright ☐
- Slightly bright ☐
- Neither bright nor dim ☐
- Slightly dim ☐
- Dim ☐
- Very dim ☐

Do you find this....?

- Comfortable ☐
- Slightly uncomfortable ☐
- Uncomfortable ☐
- Very uncomfortable ☐
- Extremely uncomfortable ☐

At this moment, how would you prefer your working area to be ....?

- Much dimmer ☐
- A bit dimmer ☐
- No change ☐
- A bit brighter ☐
- Much brighter ☐

Which kind of lighting system is used at the moment?

- LED ☐
- Fluorescence ☐
- Incandescent ☐
- The lighting system is off ☐

Please describe any other issues related to artificial lighting that is important to you.

5. NOISE

How do you find the background noise level in the flat at this time?

- Very noisy ☐
- Noisy ☐
- Slightly noisy ☐
- Neither noisy nor quiet ☐
- Slightly quiet ☐
- Quiet ☐
- Very quiet ☐

Do you find this....?

- Comfortable ☐
- Slightly uncomfortable ☐
- Uncomfortable ☐
- Very uncomfortable ☐
- Extremely uncomfortable ☐

At this moment, how would you prefer your working area to be ....?

- Much quieter ☐
- A bit quieter ☐
- No change ☐
- A bit noisier ☐
- Much noisier ☐

Please describe any other issues related to noise that is important to you.

6. AIR QUALITY

How would you describe the air quality at present?

- Very bad ☐
- Bad ☐
- Slightly bad ☐
- Neither bad nor good ☐
- Slightly good ☐
- Good ☐
- Excellent ☐

Do you find this….?

- Comfortable ☐
- Slightly uncomfortable ☐
- Uncomfortable ☐
- Very uncomfortable ☐
- Extremely uncomfortable ☐

Please describe any other issues related to air quality that is important to you.

---

7. OVERALL COMFORT

At this time, how would you rate your overall comfort in your flat?

- Very comfortable ☐
- Moderately comfortable ☐
- Slightly comfortable ☐
- Slightly uncomfortable ☐
- Moderately uncomfortable ☐
- Very uncomfortable ☐

Is this environment, in your opinion …..?

- Perfectly bearable ☐
- Slightly difficult to bear ☐
- Fairly difficult to bear ☐
- Very difficult to bear ☐
- Unbearable ☐

Please describe any other issues related to overall comfort that is important to you.

---

8. CLOTHING

What are you wearing right now?

- LS Thin Shirt/ Blouse ☐
- LS Med Shirt/ Blouse ☐
- LS Thick Shirt/ Blouse ☐
- SS Thin Short/ Blouse ☐
- SS Med Shirt/ Blouse ☐
- SS Thick Shirt/ Blouse ☐
- S/less Thin Shirt/ Blouse ☐
- S/less Med Shirt/ Blouse ☐
- S/less Thick Shirt/ Blouse ☐

- Tie/Scarf ☐

- LS Thin Dress ☐
- LS Med Dress ☐
- LS Thick Dress ☐
- SS Thin Dress ☐
- SS Med Dress ☐
- SS Thick Dress ☐
- S/less Thin Dress ☐
- S/less Med Dress ☐
- S/less Thick Dress ☐

- Open Thin W/coat ☐
- Open Med W/coat ☐
- Open Thick W/coat ☐
- Closed Thin W/coat ☐
- Closed Med W/coat ☐
- Closed Thick W/coat ☐

- Open Thin Jacket ☐
- Open Med Jacket ☐
- Open Thick Jacket ☐
- Closed Thin Jacket ☐
- Closed Med Jacket ☐
- Closed Thick Jacket ☐

- LS Thin Sweater ☐
- LS Med Sweater ☐
- LS Thick Sweater ☐
- SS Thin Sweater ☐
- SS Med Sweater ☐
- SS Thick Sweater ☐
- S/less Thin Sweater ☐
- S/less Med Sweater ☐
- S/less Thick Sweater ☐

Thin Trousers ☐
Med Trousers ☐
Thick Trousers ☐
Thin Shorts ☐
Med Shorts ☐
Thick Shorts ☐

AL Thin Skirt ☐
AL Med Skirt ☐
AL Thick Skirt ☐
BK Thin Skirt ☐
BK Med Skirt ☐
BK Thick Skirt ☐
AK Thin Skirt ☐
AK Med Skirt ☐
AK Thick Skirt ☐

Open Thin Cardigan ☐
Open Med Cardigan ☐
Open Thick Cardigan ☐
Closed Thin Cardigan ☐
Closed Med Cardigan ☐
Closed Thick Cardigan ☐

Boots ☐
Shoes ☐
Sandals ☐

Long Socks ☐
Short Socks ☐
Tights ☐

Vest ☐
T-Shirt ☐
Long U/wear ☐

Net/metal chair ☐
Wooden stool ☐
Standard office chair ☐
Executive chair ☐

Other: .....

Please describe any other issues related to clothing that is important to you.

---

9. ACTIVITIES

What activity were you performing in the last 10 minutes?

Sitting (few movements) ☐
Sitting (repeated movements around work station) ☐
Standing-relaxed ☐
Standing-working ☐
Walking - Indoors/slow ☐
Walking - Outdoors/fast ☐
Other: ..... ☐

What activity were you performing between 20 and 10 minutes ago?

Sitting (few movements) ☐
Sitting (repeated movements around work station) ☐
Standing-relaxed ☐
Standing-working ☐
Walking - Indoors/slow ☐
Walking - Outdoors/fast ☐
Other: ..... ☐

What activity were you performing between 30 and 20 minutes ago?

Sitting (few movements) ☐
Sitting (repeated movements around work station) ☐
Standing-relaxed ☐
Standing-working ☐
Walking - Indoors/slow ☐
Walking - Outdoors/fast ☐
Other: ..... ☐

What activity were you performing between 60 and 30 minutes ago?

Sitting (few movements) ☐
Sitting (repeated movements around work station) ☐
Standing-relaxed ☐
Standing-working ☐
Walking - Indoors/slow ☐
Walking - Outdoors/fast ☐
Other: ..... ☐

Please describe any other issues related to activities that is important to you.

---

10. CONTROLS

Which of te following are true?

Internal Door Open	☐
External Door Open	☐
General Heating On	☐
Localised Heater On	☐
General Air-Conditioning On	☐
Localised Fan/ Cooling On	☐
Window(s) Open	☐
Blinds/ Curtains Down	☐
General Lights On	☐
Localised Lighting On	☐

.....

Additional comments

6.3.2 Short Current Comfort Survey

Short Current Comfort Survey (Q1_LC_2)

Name:
Date:

	Time:	Time:	Time:	Time:	Time:
1. How do you feel at this precise moment? I am:					
Cold	☐	☐	☐	☐	☐
Cool	☐	☐	☐	☐	☐
Slightly cool	☐	☐	☐	☐	☐
Neither hot nor cold	☐	☐	☐	☐	☐
Slightly warm	☐	☐	☐	☐	☐
Warm	☐	☐	☐	☐	☐
Hot	☐	☐	☐	☐	☐
2. At this moment, would you prefer to be .....?					
Much cooler	☐	☐	☐	☐	☐
Slightly cooler	☐	☐	☐	☐	☐
Neither warmer nor cooler	☐	☐	☐	☐	☐
Slightly warmer	☐	☐	☐	☐	☐
Much warmer	☐	☐	☐	☐	☐
3. What are you wearing right now? (you can tick more than one box)					
Long sleeve shirt/blouse	☐	☐	☐	☐	☐
Short sleeve shirt/blouse	☐	☐	☐	☐	☐
Vest	☐	☐	☐	☐	☐
Trousers / Long skirt	☐	☐	☐	☐	☐
Shorts / Short skirt	☐	☐	☐	☐	☐
Dress	☐	☐	☐	☐	☐
Pullover	☐	☐	☐	☐	☐
Jacket	☐	☐	☐	☐	☐
Long socks	☐	☐	☐	☐	☐
Short socks	☐	☐	☐	☐	☐
Tights	☐	☐	☐	☐	☐
Tie	☐	☐	☐	☐	☐
Boots	☐	☐	☐	☐	☐
Shoes	☐	☐	☐	☐	☐
Saldals	☐	☐	☐	☐	☐
Other:	☐	☐	☐	☐	☐
4. What activity were you performing in the last 20 minutes?					
Sitting (few movements)	☐	☐	☐	☐	☐
Sitting (repeated movements around work station)	☐	☐	☐	☐	☐
Standing-relaxed	☐	☐	☐	☐	☐
Standing-working	☐	☐	☐	☐	☐
Walking - Indoors/slow	☐	☐	☐	☐	☐
Walking - Outdoors/fast	☐	☐	☐	☐	☐
Other:	☐	☐	☐	☐	☐
5. Which of the following are true? (you can tick more than one box)					
Door open	☐	☐	☐	☐	☐
Windows open	☐	☐	☐	☐	☐
Blind/curtains down	☐	☐	☐	☐	☐
Lights on	☐	☐	☐	☐	☐
Air condition on	☐	☐	☐	☐	☐
Heating on	☐	☐	☐	☐	☐
Fan on	☐	☐	☐	☐	☐
Extra heater on	☐	☐	☐	☐	☐
Other:	☐	☐	☐	☐	☐

6. Please describe any other issues that is important to you.

6.3.3 General Comfort Survey

General comfort survey (Q1_LG_1)

Name:

Date:

Time:

1. TEMPERATURE

How do you usually feel in your flat? I am:		Would you prefer it to be .....?		Are there any critical rooms?		Are there any critical seasons?	
Cold	☐	Much cooler	☐	Living room	☐	Winter	☐
Cool	☐	Slightly cooler	☐	Kitchen	☐	Spring	☐
Slightly Cool	☐	Neither warmer nor cooler	☐	Bathroom	☐	Summer	☐
Neither hot nor cold	☐	Slightly warmer	☐	Bedroom	☐	Autumn	☐
Slightly Warm	☐	Much warmer	☐	No	☐	No	☐
Warm	☐						
Hot	☐						

Please describe any other issues related to temperature that is important to you.

2. AIR MOVEMENT

How do you usually find the air movement in your flat?		Would you prefer it to be .....?		Are there any critical rooms?		Are there any critical seasons?	
Very low	☐	Much more air movement	☐	Living room	☐	Winter	☐
Low	☐	A bit more air movement	☐	Kitchen	☐	Spring	☐
Slightly low	☐	No Change	☐	Bathroom	☐	Summer	☐
Neither high nor low	☐	A bit less air movement	☐	Bedroom	☐	Autumn	☐
Slightly high	☐	Much less air movement	☐	No	☐	No	☐
High	☐						
Very high	☐						

Please describe any other issues related to air movement that is important to you.

3. HUMIDITY

How do you usually find the humidity of the air in your flat?		Would you prefer it to be .....?		Are there any critical rooms?		Are there any critical seasons?	
Very humid	☐	Much drier	☐	Living room	☐	Winter	☐
Humid	☐	A bit drier	☐	Kitchen	☐	Spring	☐
Slightly humid	☐	No change	☐	Bathroom	☐	Summer	☐
Neither humid nor dry	☐	A bit more humid	☐	Bedroom	☐	Autumn	☐
Slightly dry	☐	Much more humid	☐	No	☐	No	☐
Dry	☐						
Very dry	☐						

According to you, what's the main cause for thermohygrometric discomfort?

- Unfavorable orientation of some rooms of the apartment ☐
- Lack of insulation in opaque parts and low performance windows ☐
- Insufficient heating ☐
- Air infiltration ☐
- Other ☐

Please describe any other issues related to humidity that is important to you.

4.1 NATURAL LIGHTING

How do you usually find the natural lighting level?		Would you prefer it to be .....?		Are there any critical rooms?		Are there any critical seasons?	
Very bright	☐	Much dimmer	☐	Living room	☐	Winter	☐
Bright	☐	A bit dimmer	☐	Kitchen	☐	Spring	☐
Slightly bright	☐	No change	☐	Bathroom	☐	Summer	☐
Neither bright nor dim	☐	A bit brighter	☐	Bedroom	☐	Autumn	☐
Slightly dim	☐	Much brighter	☐	No	☐	No	☐
Dim	☐						
Very dim	☐						

Please describe any other issues related to natural lighting that is important to you.

4.2 ARTIFICIAL LIGHTING

How do you usually find the artificial lighting level?		Would you prefer it to be .....?		Are there any critical rooms?		Are there any critical seasons?	
Very bright	☐	Much dimmer	☐	Living room	☐	Winter	☐
Bright	☐	A bit dimmer	☐	Kitchen	☐	Spring	☐
Slightly bright	☐	No change	☐	Bathroom	☐	Summer	☐
Neither bright nor dim	☐	A bit brighter	☐	Bedroom	☐	Autumn	☐
Slightly dim	☐	Much brighter	☐	No	☐	No	☐
Dim	☐						
Very dim	☐						

According to you, what's the main cause for visual discomfort?

- Unfavorable orientation of some rooms of the apartment ☐
- Glare ☐
- Insufficient artificial lighting ☐
- Other ☐

Please describe any other issues related to artificial lighting that is important to you.

---

5. NOISE

How do you usually find the background noise level in your flat?		Would you prefer it to be .....?		Are there any critical rooms?		Are there any critical seasons?	
Very noisy	☐	Much quieter	☐	Living room	☐	Winter	☐
Noisy	☐	A bit quieter	☐	Kitchen	☐	Spring	☐
Slightly noisy	☐	No change	☐	Bathroom	☐	Summer	☐
Neither noisy nor quiet	☐	A bit noisier	☐	Bedroom	☐	Autumn	☐
Slightly quiet	☐	Much noisier	☐	No	☐	No	☐
Quiet	☐						
Very quiet	☐						

According to you, what's the main cause for acoustic discomfort?

- Lack of insulation ☐
- Excessive noise from neighboring apartments ☐
- Outdoor noises ☐
- Indoor noises ☐
- Other ☐

Please describe any other issues related to noise that is important to you.

---

6. AIR QUALITY

How do you usually find the air quality in your flat?

- Very bad ☐
- Bad ☐
- Slightly bad ☐
- Neither bad nor good ☐
- Slightly good ☐
- Good ☐
- Excellent ☐

Are there any critical rooms?

- Living room ☐
- Kitchen ☐
- Bathroom ☐
- Bedroom ☐
- No ☐

Are there any critical seasons?

- Winter ☐
- Spring ☐
- Summer ☐
- Autumn ☐
- No ☐

What's the main cause for indoor air quality discomfort?

- Dry air ☐
- Humidity ☐
- Mold ☐
- Indoor odors ☐
- Outdoor odors ☐
- Other ☐

Please describe any other issues related to air quality that is important to you.

---

7. OVERALL COMFORT

At this time, how would you rate your overall comfort in your work area?

- Very comfortable ☐
- Moderately comfortable ☐
- Slightly comfortable ☐
- Slightly uncomfortable ☐
- Moderately uncomfortable ☐
- Very uncomfortable ☐

Are there any critical rooms?

- Living room ☐
- Kitchen ☐
- Bathroom ☐
- Bedroom ☐
- No ☐

Are there any critical seasons?

- Winter ☐
- Spring ☐
- Summer ☐
- Autumn ☐
- No ☐

Please describe any other issues related to overall comfort that is important to you.

6.3.4 Electrical Appliances Survey

Electrical Appliances Survey (Q1_LG_2)

Name:

Date:

Time:

Module A: Household details

A1 Location details

Post code	
Phone number[1]	

[1] Required if you would like an evaluation of your electricity consumption

A2 A2 How many persons live in the household in the following age groups? (0/1/2/3/4/more than 4)

Age 12 and less	
Age from 13 to 18	
Age from 19 to 65	
Age more than 65	

A3 What is the highest education level in the household?(Mark only one answer)

No degree or certificate	
High school or equivalent	
Trade/Vocational certificate or equivalent	
University degree or equivalent	

A4 What was your electricity consumption invoiced by your electricity company last year?

In Euro	
In kWh (if known)	

A5 Do you use electric space heating?

Yes	
No	

A7 Do you use electric water heating?

Yes	
No	

Module B: Cold appliances

B1 Do you have one or several refrigerators without a freezer compartment?

Yes

No

If yes, please specify the age, the volume and the energy class (A++, A+, A, B, C, D, E, F, G) if known:

	Age (years) (less than 5, from 6 to 9, more than 10)	Volume (litres)	Energy class
1			
2			
3			

B2 Do you have one or several refrigerators with a freezer compartment?

Yes

No

If yes, please specify the age, the volume and the energy class (A++, A+, A, B, C, D, E, F, G) if known:

	Age (years) (less than 5, from 6 to 9, more than 10)	Volume (litres)	Energy class
1			
2			
0			

B3 How often do you clean the grid at the rear of the refrigerator?

Every month	
Every year	
Never	

B4 How often do you defrost your refrigerator?

Every month	
Every year	
Never	
Refrigerator has automatic defrost function	

B5 How do you adjust the thermostat of your refrigerator?

- Minimum (the coldest) ☐
- Middle position ☐
- Maximum (the warmest) ☐

B6 Is (one of) your refrigerator(s) located against a cooking appliance (cooker, oven, hobs)?

- Yes ☐
- No ☐

B7 Do you have one or several freezers?

- Yes
- No (Go to question B11)

If yes, please specify the age, the volume and the energy class (A++, A+, A, B, C, D, E, F, G) if known:

	Age (years) (less than 5, from 6 to 9,	Volume (litres)	Energy class
1			
2			
3			

B8 How often do you defrost your freezer?

- Every month ☐
- Every year ☐
- Never ☐
- Refrigerator has automatic defrost function ☐

B9 How do you adjust the thermostat of your freezer?

- Minimum (the coldest) ☐
- Middle position ☐
- Maximum (the warmest) ☐

B10 Is your freezer located against a cooking appliance (cooker, oven, hobs…)?

- Yes ☐
- No ☐

B11 Do you put cooked food into your refrigerator/freezer before it has cooled?

- Yes ☐
- No ☐

B12 Do you systematically cover the dishes before introducing them in the refrigerator?

- Yes ☐
- No ☐

B13 Do you check the energy label when purchasing a refrigerator or freezer?

- Yes ☐
- No ☐

B14 Please describe any other issues related to cold appliances that is important to you.

Module C: Waching appliances

C1 Have you got a washing machine?

- Yes
- No (Go to question C6)

If yes, please specify the age, the volume and the energy class (A++, A+, A, B, C, D, E, F, G) if known:

	Age (years) (less than 5, from 6 to 9, more than 10)	Volume (litres)	Energy class
1			
2			
3			

C2 Do you usually load your washing machine to:

- 25% ☐
- 50% ☐
- 75% ☐
- 100% ☐

C3 Do you pack clothes when loading the washing machine?

- Yes ☐
- No ☐

C4 If known, indicate the spin speed you usually use for:

Cotton	☐	rpm
Synthetic	☐	rpm
Sensitive linen (wool..)	☐	rpm

C5 Do you usually use the ECO button (if there is one on your machine)?

- ☐ Always
- ☐ Sometimes
- ☐ Never
- ☐ Not applicaple

C6 Have you got a tumble dryer?

- ☐ Si
- ☐ No (Go to question C9)

If yes, please specify the age, the volume and the energy class (A++, A+, A, B, C, D, E, F, G) if known:

	Age (years) (less than 5, from 6 to 9, more than 10)	Volume (litres)	Energy class
1			
2			
3			

C7 How does the drying cycle stop?

- ☐ with a timer (set by the user)
- ☐ Automatically (sensor)

C8 How frequently do you use your tumble dryer? (in % of washfor example 50% if you use it 1 wash out of 2); less than 50%/50%/more than 50%)

- ☐ Winter
- ☐ Autumn
- ☐ Summer
- ☐ Spring

C9 Have you got a dish washer?

- ☐ Yes
- ☐ No (Go to question C15)

If yes, please specify the age, the volume and the energy class (A++, A+, A, B, C, D, E, F, G) if known:

	Age (years) (less than 5, from 6 to 9, more than 10)	Volume (litres)	Energy class
1			
2			
3			

C10 Is your dish washer fed with hot water?

- ☐ Yes
- ☐ No
- ☐ I don't know

C11 Do you usually use the ECO button (if there is one on your machine)?

- ☐ Always
- ☐ Sometimes
- ☐ Never
- ☐ Not applicaple

C12 At which temperature is your dish washer usually set to?

- ☐ I don't know
- ☐ 50°C
- ☐ 65°C
- ☐ Other

C13 Do you rinse the dishes before putting them in the dish washer?

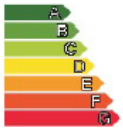
- ☐ Yes
- ☐ No

C14 How do you load the dish washer most of the time?

- ☐ 25%
- ☐ 50%
- ☐ 75%
- ☐ 100%

C15 Do you check the energy label when purchasing a washing appliance?

- ☐ Si
- ☐ No



C16 Please describe any other issues related to washing appliances that is important to you.

Module D: Cooking appliances

D1 How do you defrost your food?

- Micro-wave ☐
- Refridgerator ☐
- Left outside ☐
- In the pan ☐

D2 Do you usually put a lid on the pan when you cook?

- Always ☐
- Sometimes ☐
- Never ☐

D3 How much of your cooking do you make with a pressure cooker?

- 0% ☐
- 10% ☐
- 25% ☐
- 50% ☐
- 90% ☐

D4 Please describe any other issues related to cooking appliances that is important to you.

Module E: Office appliances

E1 Do you have an internet connection?

- Yes ☐
- No ☐

If yes, please specify the type of connection:

- Dial up phone line (analogue, ISDN) ☐
- Broadband or LAN (wireless, cable) ☐
- I don't know ☐

E2 When you are not using the following equipment, do you usually: (tick only if you own the appliance)

Appliance	Turn it off	Leave it on standby	Leave it on	I don't have it
Desktop				
Monitor				
Laptop				
Printer				
Multifunction printer (printer/scanner/copier)				
Scanner				
Copier				
Fax				
Modem				
Speakers				
Router/hub				
Other				

E3 When you leave your computer on without using it, what is the reason?

- No need to boot it at each use ☐
- Worried about damaging it ☐
- Tasks running ☐

E4 Are the electricity saving handler active on your monitor? (placing inactive monitor into a lower power sleep mode)

- Yes ☐
- No ☐
- I don't know ☐

E5 Are the electricity saving handler active on your desktop? (placing inactive computer into a lower power sleep mode)

Yes ☐
No ☐
I don't know ☐

E6 In your opinion does the activation of the screen saver save electricity?

Yes ☐
No ☐

E7 What do you think the Energy Star label refers to?

Electromagnetic compatibility ☐
Use of recyclable material ☐
Electricity saving handling ☐
Low energy consumption ☐
I don't know ☐

E8 When you buy an office appliance (computer, printer...) do you choose one with the energy star label?

Always ☐
Sometimes ☐
Never ☐

E9 Please describe any other issues related to office appliances that is important to you.

Module F: Home entertainment

F1 When you are not using the following equipment, do you usually: (tick only if you own the appliance)

Appliance	Turn it off with the on/off button	Turn it off with the remote control	Leave it in standby mode	Leave it on	don't have it
TV					
Home cinema					
VHS Recorder/Player					
DVD Recorder/Player					
HiFi					
Satellite/cable set top box					
Hard disc					
Video game					
other					

F2 What will you choose to replace your existing TV?

Plasma ☐
Flat screen (LCD) ☐
Cathode ray screen ☐
Projector ☐

F3 Do you know that some appliances use electricity even when they are turned off with the ON/OFF button but not unplugged?

Yes ☐
No ☐

F4 Do you usually leave chargers (phone, batteries...) plugged in without using them?

Always ☐
Often ☐
Sometimes ☐
Never ☐

F5 Do you use multiple sockets with a switch to disconnect all appliances from the mains?

Yes ☐
No ☐

F6 Please describe any other issues related to home entertainment appliances that is important to you.

Module G: Air conditioning/Comfort cooling

G1 Do you use an air conditioning system?

Yes ☐
No (go to question G7) ☐

G2 What is the floor area of your flat which is air conditioned ?

_____ sqm

G3 What share of the dwelling does it represent?

_____ %

Specify the type and number of air conditioning, and its energy class if known ("A,B,C,D,E,F,G, I don't know"):

Appliance	Number	Energy class
Centralized air conditioner (multi occupancy buildings)		
Heat pump		
Monosplit		
Multisplit		
Mobile air conditioner		
Humidifier		
Fan		
Other		

G5 Do you leave some outside doors or windows of the air conditioned room open while the air conditioning is on?

Yes ☐
No ☐

G6 What temperature do you set your airconditioning to?

_____ °C

G7 What do you consider as the inside comfort temperature in summer?

_____ °C

G8 Please describe any other issues related to air conditioning that is important to you.

Module H: Lighting

H1 Specify the number of light bulbs of each type and the room in which they are used:

Type		Living room	Bedrooms	Kitchen	Bathrooms	Hallways	Outdoors	Other rooms
Incandescent								
Low wattage halogen								
High wattage halogen (>70W)								
Fluorescent								
Compact Fluorescent								
LED								

H2 Do you leave the light on in unoccupied room?

- Always ☐
- Sometimes ☐
- Never ☐

H3 Do you buy low consumption light bulbs (Compact Fluorescent or LED) when you replace a bulb?

- Most of the time ☐
- Sometimes ☐
- Rarely ☐
- Never ☐

H4 If you never or rarely use them, why? (tick all the boxes which apply)

- Price ☐
- Lighting quality ☐
- Size ☐
- Appearance ☐
- Lifespan ☐
- Other ☐

H5 Have you changed your lighting habits with the lamps you have replaced by low consumption bulbs?

- Yes, I let them burn longer ☐
- No, I haven't changed anything ☐

H6 Please describe any other issues related to lighting that is important to you.

Module I: General points

I1 Rank the following criteria from 1 to 7 according to their importance when you purchase a new domestic appliance (1:more important, 7:not important)

- price ☐
- design/style ☐
- external dimensions ☐
- capacity ☐
- electricity consumption ☐
- ease of use ☐
- Other ☐

I2 Why do you think it is necessary to save electricity ? (1: more important 5: less important)

- Financial savings ☐
- Depletion of energy supplies ☐
- Greenhouse effect/Global warming ☐
- War risk due to electricity crisis ☐
- Other ☐

I3 Have you heard about electricity savings from any of the following sources?

- TV ☐
- Magazine/Newspaper ☐
- School ☐
- Internet ☐
- Radio ☐
- Conference ☐
- Work ☐
- Friends/Family ☐
- Other: ☐

I4 Additional comments.

6.3.5 Motivational Survey

Motivational survey (Q1_LG_3)

Name:
Date:
Hour:
Floor:
N° flat:

1 How many years have you lived in this building?

- Less than 1 year ☐
- 1-5 years ☐
- 5-10 years ☐
- More than 10 years ☐

2 How many people live in this flat?

- 1 ☐
- 2 ☐
- 3 ☐
- 4 ☐
- more than 4 ☐

3 What is your age?

- 30 or under ☐
- 31-50 ☐
- Over 50 ☐

4 What is your gender?

- Male ☐
- Female ☐

5 Which is your education?

- Primary schoool ☐
- Lower secondary school ☐
- Upper secondary school ☐
- University ☐
- PhD, master ☐

6 Which is your job?

- Entrepreneur, executive, freelancer ☐
- Self employed ☐
- Employee/teacher/other employee ☐
- Housewife ☐
- Student ☐
- Pensioner ☐
- Other… ☐

7 Country of origin

- Europe ☐
- Middle East ☐
- Asia ☐
- Africa ☐
- Other… ☐

8 Climate of origin

- Hot and humid climate ☐
- Hot and dry climate ☐
- Moderate climate ☐
- Cold climate ☐

9 Before living in this flat (or during childhood) was used to:

- Independent AC-unit ☐
- Radiative heating in winter ☐
- Sleep with windows open ☐
- Other ☐

10 In a typical week, how many hours do you spend in your flat?

- There is always at least one person all day ☐
- It depends on whether working day/public holiday ☐
- Only in the weekend ☐
- Occasionally ☐

11 Overall, how satisfied are you with the flat (from 1 to 5)?

- Environmental comfort ☐
- Location/accessibility ☐
- Overall size ☐
- Privacy (visual, acoustic) ☐

12 Which of the following do you personally adjust or control in your workspace? (check all that apply)

- Window blinds or shades ☐
- Operable window ☐
- Thermostat/radiator valves ☐
- Portable heater ☐
- Room air-conditioning unit ☐
- Portable fan ☐
- Ceiling fan ☐
- None of the above ☐
- Other…….. ☐

13 Overall, does the thermo-hygrometric quality (temperature, RH) in your flat enhance or interfere with your ability to get your activity done (study, pc work, read, other)?

- Enhances ☐
- Does not interfere ☐
- Interferes ☐
- Interferes only in winter ☐
- Interferes only in summer ☐

14 Overall, does the air quality in your flat enhance or interfere with your ability to get your activity done (study, pc work, read, other)?

- Enhances ☐
- Does not interfere ☐
- Interferes ☐
- Interferes only in winter ☐
- Interferes only in summer ☐

15 Overall, does the lighting quality enhance or interfere with your ability to get your activity done (study, pc work, other)?

- Enhances ☐
- Does not interfere ☐
- Interferes ☐
- Interferes only in winter ☐
- Interferes only in summer ☐

16 Overall, does the acoustic quality enhance or interfere with your ability to get your activity done (study, pc work, other)?

- Enhances ☐
- Does not interfere ☐
- Interferes ☐
- Interferes only in winter ☐
- Interferes only in summer ☐

17 Please estimate how your productivity is increased or decreased by the overall environmental conditions in the flat (e.g. thermal, air, lighting, acoustics):

- Increased 20% ☐
- Increased 5% ☐
- It does not affect my performance ☐
- Decreased 5% ☐
- Decreased 20% ☐

18 How would you grade your knowledge in terms of how is comfort control (thermal, air, lighting, acoustic quality) provided in your flat:

- Very knowledgeble ☐
- Don't care ☐
- Not at all knowledgeble ☐

19 In winter, how often do you perform these adaptive actions in your flat? (never/once a week/more than once a week/once a day/more than once a day)

- Open the windows when you feel hot
- Turn down the heater/Close the radiators when you feel too hot
- Add / remove layers of clothing when you feel cold / hot
- Open the windows to ventilate the spaces
- Raise the blinds to take advantage of natural light
- Moving shutters / blinds to control glare
- Moving shutters / blinds to take advantage of solar heating

20 In summer, how often do you perform these adaptive actions in your flat? (never/once a week/more than once a week/once a day/more than once a day)

- Open the windows when you feel hot
- Add / remove layers of clothing when you feel cold / hot
- Open the windows to ventilate the spaces
- Raise the blinds to take advantage of natural light
- Moving shutters / blinds to control glare
- Moving shutters / blinds to control overheating
- Turn on the fan when you feel hot
- Turn on the air conditioner when you feel hot
- Turn off the air conditioner when you feel too cold

21 I typically perform these adaptive opportunities in my flat during the day in order to:

Opening/closing windows

restore my comfort condition ☐

conserve energy ☐

Turning up/drawing blinds/shadings

restore my comfort condition ☐

conserve energy ☐

Turning on/off the heater/cooling when feeling too hot/too cold

restore my comfort condition ☐

conserve energy ☐

Using flexible dress code

restore my comfort condition ☐

conserve energy ☐

22 When you have a problem with comfort in your flat, do your needs are addressed by adaptive opportunities (e.g. natural ventilation)?

fully addressed/quite addressed/don't care/poorly addressed/not at all addressed

Thermal comfort _____

Visual comfort _____

IAQ _____

23 According to you, interacting with the control systems to make yourself comfortable in your flat will influence:

Reducing/Any change/Increasing

Energy consumption _____

My comfort level _____

My productivity _____

24 I am prone to accept more forgiving indoor environmental condition to conserve energy in my flat:

To reduce energy bills ☐

To be environmentally friendly ☐

25 Which are in your opinion the barriers to overcome to turn your willingness into a habit?

Lack of time ☐

Lack of convenience ☐

Technical barriers due to control system usability issues ☐

Lack of knowledge about the topic of comfort ☐

26 Which type of reward would you be willing to receive, to motivate you to perform sustainable energy actions in your flat?

Reduction in energy bills ☐

Being rewarded (non-financially) when adopting energy conservation opportunities (incentives) ☐

Real-time communication about user consumption ☐

27 Do you expect technology/control system help you to make yourself comfortable?

1 (Not at all) ☐

2 ☐

3 ☐

4 ☐

5 (A lot) ☐

28 How would you rate this building in terms of overall energy saving performance?

1 (low performing) ☐

2 ☐

3 ☐

4 ☐

5 (high performing) ☐

29 Additional comments