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TOWARDS SMART ZERO CO_2 CITIES ACROSS EUROPE

VITORIA-GASTEIZ + TARTU + SØNDERBORG

Deliverable 7.6: District retrofitting monitoring program

WP7, Task 7.2

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[1] PU = Public

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Abbreviations and Acronyms

Abbreviation/Acronym	Description
BEMS	Building Energy Management System
CIOP	City Information Open Platform
CTI	Common Telecommunications Infrastructure
DEMS	District Energy Management System
DH	District Heating
DHW	Domestic Hot Water
EV	Electrical Vehicles
HEMS	Home Energy Management System
ICT	Information and Communication Technologies
IoT	Internet of Things
KPI	Key Performance Indicator
LH	Lighthouse
PV	Photovoltaic
SmartEnCity	Towards Smart Zero CO2 Cities across Europe

Table 1: Abbreviations and Acronyms

0 Publishable Summary

The objective of the monitoring program task under WP7 (monitoring and evaluation) is the definition of monitoring programs for the LH cities. Three parallel documents are being generated covering the monitoring and metering aspects for three main pillars of the project: the district intervention actions, the vehicles and urban mobility actions and the actions related to the integrated infrastructure pillar.

All the necessary requirements defined up to now for the interventions have been taken into account to define systems for monitoring, metering and data acquisition, to be chosen according to the set of KPIs selected to quantify the result reached after the execution of the interventions and actions in each LH city as were established on the evaluation protocols defined in D7.3 and D7.4.

This specific report compiles the monitoring program for the actions related to district intervention pillar for the three LH cities participating in SmartEnCity project, following the evaluation strategy drawn through the different documents delivered previously on WP7 and applying the evaluation protocols of each city. This document jointly with the other two monitoring deliverables and the data collection approach deliverable show how the data gathering and collection from the different sources (dwellings, buildings, district, vehicles, etc.) will be done to allow the proper evaluation of the final performance.

It was intended to include on this document more specific details of devices and monitoring equipment to be installed, but no many final monitoring equipment has been yet decided being thus instead included indications, recommendations and guidelines for the definition on the cases needed. A final report including the detailed and more comprehensive information of all monitoring elements and the data collection process will be done at the end of the project (D7.12).

In the meantime a follow-up process will be done to check periodically the advances of the actuations, and the implementation of the different measures, as well as the data collection process. This will be contemplated on internal periodic reports and also on the supervision of the interventions deliverables (D7.5, D7.10 and D7.11).

1 Introduction

1.1 Purpose and target group

This deliverable aims to provide a general description of the monitoring to be installed relative to the district retrofitting actions. The KPIs included on D7.3 “Evaluation Protocols” and in some cases indicators coming from the D7.4 “City impact evaluation procedure” are further deployed to match the monitoring element that will provide the information for the project interventions evaluation stage.

The direct target group is the three LH cities.

1.2 Contributions of partners

The following Table 2 depicts the main contributions from participant partners in the development of this deliverable.

Participant short name	Contributions
CAR	Core of the document and main contributions.
MON	Specific contribution about Vitoria-Gasteiz monitoring equipment.
SONF	Specific contribution about Sonderborg monitoring equipment. Connection to information about Sonderborg through D5.2.
TREA	Specific contribution about Tartu monitoring equipment.
MON, GIR, CEA, TEC	Connection to information about Vitoria-Gasteiz through D3.2.
TREA, ET, TAR, FTAR	Connection to information about Tartu through D4.2.
VIS, TREA	Deliverable review

Table 2: Contribution of partners

1.3 Relation to other activities in the project

The following Table 3 depicts the main relationship of this deliverable to other activities (or deliverables) developed within the SmartEnCity project and that should be considered along with this document for further understanding of its contents.

Deliverable Number	Contributions
D7.3 & D7.4	Reference for the evaluation protocols and project impacts measurement
D7.7 & D7.8	Other two twin monitoring documents, referred to the mobility and integrated infrastructures actions respectively. The one for mobility will be launched once the actions on each city are definitely signed once the current amendment process is finished.
D7.5, D7.10, D7.11	Supervision of interventions in LH projects (Versions 1, 2 and 3). The monitoring and commissioning aspects treated here are reflected on those 3 documents.
D7.9	Data collection approach. This document includes a detailed description of connections between KPIs and data sources whit a high interconnection to the monitoring process.
D3.2, D4.2, D5.2	Integrated planning reports for the three LH cities. Each of these documents gather information applied to all project domains including building retrofitting, integrated infrastructures, ICT deployment (SmartEnCity platform) and sustainable mobility, that has been valuable to report the monitoring basis.
D7.12	Monitoring summary. This document foreseen for the end of the project will contain specific information gathered from the project actuations based on the monitoring documents.

Table 3: Relation to other activities in the project

2 Overall Approach

The content of this deliverable is structured as follows:

- Introduction, objectives and expected impacts: These previous sections introduce the purpose of the report, the relation with other tasks of the project and contributions from different partners.
- Sections 3, 4 and 5: These sections include the monitoring approach for each one of the LH cities on SmartEnCity. Initially they are depicted the KPIs & city indicators applicable for the district retrofitting actions evaluation that set the monitoring needs from the KPI calculation point of view, and then some additional data perspectives are included that cover the non-KPI related monitoring requirements. Finally an exercise to define the kind of equipment to be used and related location in order to measure all the variables is done.
- Section 6: This section makes a general summary of the structured information of the previous ones that is common for the three LH cities.
- Section 7: This section contains the guidelines for the commissioning plan including the main steps that have to be followed for a complete procedure.
- Final general sections 8 and 9 include the potential deviations to the plan (none mayor in this case) as well as the relation of this document with the previous and future reports to come in further stages of the project that will be fed with the information contained in this deliverable.

3 Vitoria-Gasteiz district retrofitting actions monitoring

The first lighthouse city considered is Vitoria-Gasteiz, located in Spain, as already explained in D3.1. From the monitoring point of view, one key aspect is the retrofitting actions that are being implemented in the demo site. Hence, in order to establish the framework under which the monitoring equipment has to be deployed, a brief summary of the actions is described below:

- Energy efficient building retrofitting, where the total intervention covers 750 dwellings and new façade and roof insulation systems are being integrated, as well as windows replacement.
- District heating solution in order to substitute current individual gas boilers with a district heating to supply both heating and Domestic Hot Water (DHW). In this way, the solutions include new smart thermostats to manage the energy consumption in the dwellings.
- Deployment of management systems for the smart grid and district heating. This includes the Home Energy Management Systems (HEMS) and infrastructure at dwelling level in order to monitor and manage both electricity and thermal energy consumption.
- Sustainable mobility which promotes the electric vehicles, including the charging stations and the needed infrastructure.
- Development of a City Information Open Platform (CIOP).

Having in mind the map of the interventions, within this deliverable, those related to the buildings are being analysed. That is to say, building retrofitting actuations, HEMS and their related infrastructure. The case of mobility is part of the D7.7, while district heating, smart grids and CIOP are part of the integrated infrastructures (D7.8).

3.1 Collection of KPIs & city indicators applicable for the district retrofitting actions evaluation

Using as base of information deliverable D7.3 – Evaluation protocols – and also D7.4 – City impact evaluation procedure – (as some city indicators also apply or are based on D7.3 KPIs) this section includes for Vitoria-Gasteiz LH city the specific KPIs that will be used for the evaluation of the district retrofitting actions. All protocols have been checked and the selected KPIs included in this monitoring program are those related to district retrofitting taken from the energy and the economic protocols. For each KPI the variables to be measured need to be defined. These measurements could come from sensors or other sources, which are also determined in order to take all the variables into account in the monitoring program.

ENERGY			
Name of indicator	Definition	Unit	Data source
Energy demand	Energy that the building requires to meet its needs/uses (i.e. heating, DHW, cooling, electricity…)	kWh/ m²a	Simulation/ theoretical calculation
Delivered energy (for buildings)	Delivered energy is 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…) or to produce electricity (EN 15603:2008[2]). Often, comparability with respect to electricity can be achieved if only lighting and auxiliary energy are considered. Thus, user-dependent electricity consumer (computer, refrigerator etc.) are not considered. To enable the comparability between buildings, the delivered energy is related to the size of the building (e.g. gross floor area or net floor area, heated floor area) and the considered time interval (e.g. year).	kWh/m²a	Energy meters
Primary energy (for buildings)	The primary energy approach makes possible the simple addition from different types of energies (e.g. thermal and electrical) because primary energy includes the losses of the whole energy chain, including those located outside the building system boundary. These losses (and possible gains) are included in a primary energy factor. The energy performance of a building is the balance of the delivered energy and the exported energy. The annual amount of primary energy (net delivered primary energy) is calculated as the difference between the weighed delivered energy, summed over all energy carriers and weighed exported energy summed over all energy carriers (EN 15603:2008).	kWh/m²a	Energy meters and primary energy factors (standards, tables)
CO2 equivalent (for buildings)	The CO_2 emissions of a building correspond to the emissions that are caused by different areas of application (i.e. space heating, space cooling, domestic water heating, electrical appliances). In different variants of this indicator, the emissions caused by the production of the building components can be either included or excluded. To enable the comparability between buildings, the emissions relate to the size of the building (e.g. gross floor area or net floor area, heated floor area) and the considered interval of time (e.g. year). The greenhouse gases are considered as t of carbon dioxide (CO_2) or a CO_2 equivalent (CO_2e).	t CO_2/ m²a	Energy meters and primary energy factors (standards, tables)

[2] This standard will be phased out and replaced by the EN-ISO 52000-1 in the near future.

ENERGY			
Name of indicator	Definition	Unit	Data source
Density of energy demand	The indicator is defined as ratio of final energy demand (for heating or cooling) of a cohesive set of buildings and a simple figure representing the effort that a district heating or cooling network operator would have in order to supply these buildings. For the latter the territory area or the number of buildings is chosen in order to represent the length of the network and the number of connections that are required.	kWh/m²a	Estimated
Peak load and load profile of electricity demand	The load profile describes the demand characteristics over time, while peak load is what the electricity supply has to be able to cover. The load profile gives information about the possibilities or potentials of storage, demand-side management and self-supply via photovoltaic etc.	kW	Energy meters
Peak load and load profile of thermal (heating/cooling) energy demand	The peak load and the load profile of the thermal (heat and cold) energy demand require a high temporal resolution. The load profile describes the demand characteristics over time. The thermal energy supply has to be able to cover the peak load. The load profile gives information about the possibilities or potentials of storage as well as supply-side and demand-side management.	kW	Energy meters
Degree of congruence of calculated annual final energy demand and monitored consumption	Ratio of the theoretical energy demand of a building or set of buildings (calculated) and the final energy consumption of a building or set of buildings (measured) over a period of time (e.g. year)	%	Estimated

Table 4: KPIs for energy about district renovation for Vitoria

COMFORT			
Name of indicator	Definition	Unit	Data source
Internal air temperature	This parameter is directly involved in the determination of internal comfort condition but it also allows to investigate (with another parameter as the heat quantity for set point achievement) how much energy is necessary to reach a particular desired condition known as set point. Use both this parameter (before and after an Energy Conservation Measure (ECM) considering the same set point condition) allows to know how much heating energy has been saved thanks to the ECM’s interventions.	ºC	Meters
Heat quantity for set point achievement	This parameter allows to collect information about the quantity of energy that is needed to reach a particular temperature condition known as set point. Using this data before and after an ECM (considering the same set point condition) allows to know how much heating energy has been saved thanks to the ECM’s interventions.	kWh	Simulation/ Meters

COMFORT			
Name of indicator	Definition	Unit	Data source
Thermal comfort	This indicator represents the level of thermal comfort measured as the number of hours that the indoor temperature and relative humidity conditions are within range of values defined. The range of comfort values varies with the seasons (as it depends on the metabolic rate and clothing of the building users) and the climatology of each city (average monthly temperatures (max & min) and average monthly relative humidity).	-	Meters and questionnaires

Table 5: KPIs for comfort about district renovation for Vitoria

ECONOMIC			
Name of indicator	Definition	Unit	Data source
Resident costs	Monetary amount the residents must pay at the beginning of the project: total project investment minus total Grant per dwelling square meter	€/m^2	Questionnaires
Grant rate	Percentage of grant of the total investment	---	Questionnaires
Total annual costs	Annual costs for residents due to maintenance and energy per year per dwelling square meter	€/m^2	Questionnaires
Total annual benefits for residents	Subtraction among Old costs and total annual costs per dwelling square meter.	€/m^2	Questionnaires
Cost saving rate	Percentage of annual benefits of the project. Rate between total annual benefits for residents and old costs.	%	Questionnaires
Net present value for resident	Net present value of an investment causing energy savings or energy production in comparison to a baseline. It is defined as the sum of the discounted net annual incoming related to the investment less initial costs for the residents	€/m^2	Estimated
Return of Investment (ROI) for resident	Internal rate of return of an investment causing energy savings or energy production in comparison to a baseline	%	Estimated
Payback for resident	The payback period is the time that takes to cover investment costs. It can be calculated from the number of years elapsed between the initial investment and the time at which cumulative savings offset the investment.	Years	Estimated
Total investment of the district for renovation from local and regional public funding, EC funding and private funding	Includes dwellings' owners, energy companies, social housing companies, etc.. It should be specified for each type of fund.	€	Questionnaires, bills, etc.

Table 6: KPIs for economics about district renovation for Vitoria

3.2 Non-KPI related monitoring requirements

This sections deals with the necessary monitoring elements that are required for the activities of the project and are not directly linked with the KPIs. At time of writing this deliverable, two sources have been identified: Weather conditions and forecast. Weather data is useful when applying the Measurement and Verification protocols because they require the calculation of correlations between metered energy and climate conditions. Weather forecasting can be used to predict and improve operation of building management systems, and to inform the citizens in advance about possible modifications or energy management strategies.

Starting with the weather station, there exist two possibilities, either installing a weather station or making use of existing weather services. The first approach is included in the next section. The second case is possible by means of open data APIs. In Spain, AEMET is the meteorological state service (https://opendata.aemet.es/), whose information is available on multi-platform programming languages based on REST API. In the specific case of Vitoria, the weather station is “Foronda-Txokiza” located on the coordinates 42° 52' 55" N; 2° 44' 6" W, having both instantaneous and historical data available to query. The information that is possible to obtain, as well as useful for the project, is:

- Temperature, monthly average temperature, monthly maximum/minimum average temperature, whose measures support the calculation of Heating/Cooling Degree Days.
- Relative humidity and monthly average relative humidity.

For the forecast services, from WP7, Weather Underground is suggested because of the advantages in contrast to other weather forecast services. First of all, in contrast to AEMET, WUnderground is international, therefore, replicable from the other lighthouse cities. Secondly, it offers up to 10 days of hourly forecast. Third, there exists an open free API to access data both in XML and JSON formats, allowing 500 calls per day (and 10 per minute). Last but not least, the amount of variables that WUnderground provides is listed below:

- Geolookup
- Autocomplete
- Current conditions
- 3-day forecast summary
- Astronomy
- Almanac for today
- 10-day forecast summary
- Hourly 1-day forecast
- Satellite thumbnail
- Dynamic Radar image
- Severe alerts
- Tides and Currents
- Tides and Currents Raw
- Hourly 10-day forecast
- Yesterday's weather summary
- Travel Planner
- Webcams thumbnails
- Dynamic animated Radar image

- Dynamic animated Satellite image
- Current Tropical Storms

Of course, all the information is not necessary from the project point of view, nevertheless, once implemented; including more information is relatively easy. That is to say, the information is connected to the CIOP, which in the future could require other type of forecasted information, such as dynamic radar images.

We are aware of the existence of other elements used for the control and management of the different installations in the buildings (valves, pumps or similar, etc.) that can be a source of determined information that is directly used for the installations management only. Such information doesn't provide any added value and thus has been not considered on purpose.

3.3 Monitoring equipment and other sources of information

After clarifying the monitoring needs from the KPI calculation and additional data perspectives, the next step is to define the monitoring equipment and its location, in order to measure all the variables. This section focuses on the recommendations about sensors and meters and their placement within the sensor network, for the measurement of the variables stated before. The LH cities will determine more specifications about the monitoring systems during tendering and commissioning processes. It is also important to note that the variables measured with the meters are integrated in the data collection approach (see D7.9).

In terms of monitoring, two levels of data are identified: monitoring equipment, which refers hardware equipment, and other sources that provide information. Table 7 and Table 8 below summarise both cases.

Variable	Definition	Meter	Location
Building heating energy	This variable provides the information about the consumption of the building related to the heating part of the energy.	Heat meter	Output of the building substation (heating circuit)
Dwelling heating energy	Similar to building, but at dwelling level.	Heat meter	Output of the building substation (DHW circuit)
Building DHW energy	Similar to the case of heating in the building, but for the DHW distribution circuit.	Heat meter	Inlet dwelling (heating circuit)
Dwelling DHW energy	Similar to building, at dwelling level.	Heat meter	Inlet dwelling (DHW circuit)
Electricity	Electricity consumption related to the dwelling, as well as some existing appliances.	Wattmeter	General circuit, appliances plugs
Temperature	For comfort conditions, the temperature inside the dwelling will be measured.	Temperature probe	Main room
Outdoor temperature	If a weather station is installed, the data are gathered via sensors.	Temperature probe	Roof

Variable	Definition	Meter	Location
Outdoor humidity	Similar to temperature, this variable would be in case of installation of weather station physically, otherwise, see table below.	Humidity probe	Roof

Table 7: Monitoring equipment for Vitoria

Variable	Definition	Source	Type
Energy demand	This is the simulation result about the energy performance of the dwellings/buildings.	Simulation engine	CSV (or similar) files
Costs/Investments	The economic KPIs required some information, which is collected from bills, investment plans, etc.	Bills	Files
Climate forecast	For the aforementioned forecast services, the source of information is necessary to be collected.	API	XML/JSON
Weather conditions	In case of weather station API, the information of the weather conditions are an external source.	API	Rest

Table 8: Other sources of information for Vitoria

In the case of dwelling monitoring, a number of ICT solutions have been assessed to monitor energy and comfort parameters. There are certain constraints that have condition the final selection. These constraints are:

- Different electrical infrastructure is already installed in the houses (smart meters, electrical panels, etc.). While some dwellings already have smart meters others still use old meters that reduce the possibilities for connectivity. The location of those smart meters is also a constraint. There is high heterogeneity among installations in the dwellings.
- Legislation restricts the possibility to connect to smart meters to utilities in such a manner that third parties can only collect data through these institutions with previous consent from residents.
- The objective is to install no invasive meters. That is, install equipment that does not require civil works or manipulation of other equipment such as the main electrical panel.
- Try to install the same solution (energy-comfort) in all the dwellings/buildings.

Having these constraints in mind, the selection of the equipment is the one represented in Figure 1, where the devices (temporarily installed, but easily decommissioned) are:

- Energy Monitor: The energy monitor is a display that integrates the electrical energy measurements of several sensors (sensor clamps + mini transmitters). It is a multi-channel device and can monitor up to 10 power sources. The monitor also gathers and collects data registered by the temperature sensor. The monitor is a device which receives real-time energy usage data from the sensors and sends 5 minutes average data to a server by connecting with it through a modem or a broadband router. The measuring frequency is established to be every 5 minutes, but may be varied.

- Current sensor clamp: The sensor clamp (Figure 2) comes with a sensor / clamp (CT Sensor clamp) and a transmitter. It is used to measure single-phase or three-phase supplies at 240V (depending on the transmitter). The transmitter can be used to monitor loads independently. The transmitter comes with a sensor that can be placed around cables of up to 15mm. The transmitter connects with the Energy Monitor to send instant power data about the load being measured. The connection process is as follows: The sensor is clamped around the live cable to be measured. The transmitter is engaged with the Energy Monitor via a button of the front panel of the energy monitor. Once engaged, measurements can be seen/monitored in the energy monitor. The Energy Monitor receives from the transmitter the instant power in watts (every 6 seconds). The Energy Monitor calculates the average power in watts for the last 5 minutes and sends that information to the remote server expressed in a single measurement.
- Temperature Sensor is a wireless sensor that measures the temperature of the location where it is placed (living room, bedroom...). The sensor uses wireless technology to connect with the Energy Monitor and send temperature data about the location being measured. The Energy Monitor receives from the temperature sensor the temperature in Celsius degrees (ºC) (every 6 seconds). The Energy Monitor calculates the average temperature in Celsius degrees (ºC) for the last 5 minutes and sends that information to the remote server expressed in a single measurement.

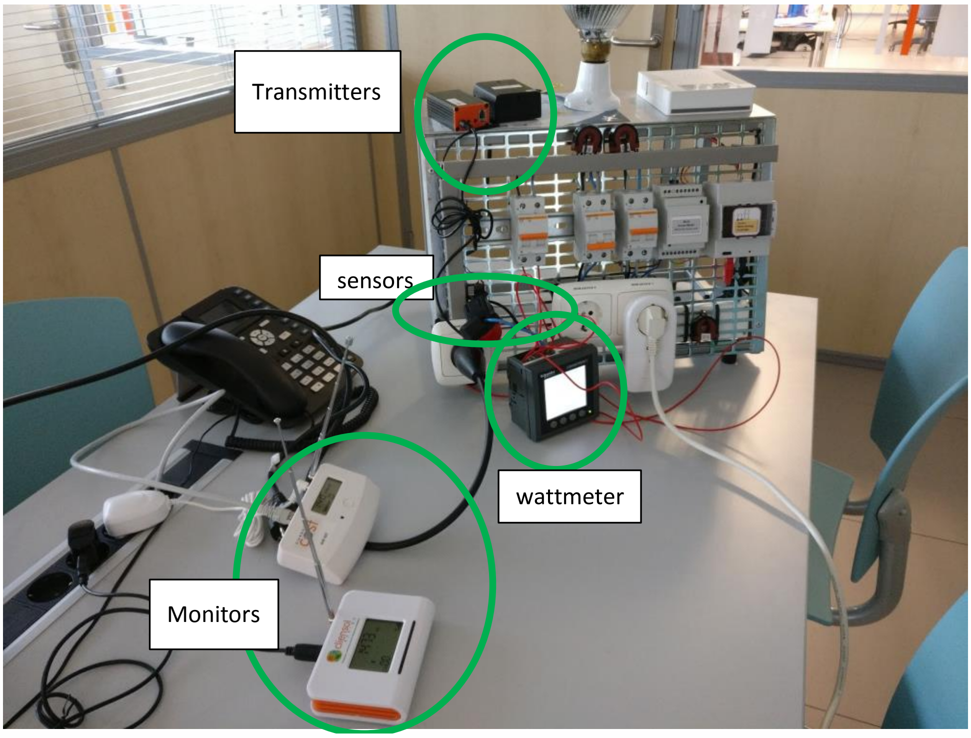

Figure 1: Dwelling monitoring equipment in Vitoria

Figure 2: Current clamp in Vitoria

The HEMS solution presented in the previous paragraphs by itself is focused on the private area of the house and requires connectivity to reach the monitoring platform. Additionally the infrastructure can be used to offer applications and ICT solutions to the residents. The BEMS infrastructure proposal for Vitoria includes the usage of the CTI (Common Telecommunications Infrastructure) already available at building level to communicate the houses in a central point. That is, the BEMS communication system will use the ICT infrastructure that covers from the television distribution system to the television sockets installed in every user's home as seen in the figure. This will avoid providing independent internet access for each of the house and consequently reduce the cost of the interventions. It will also provide a centralised point in the building to receive, send and share information, from private homes and public community places, like elevators, community light or heating.

The main innovations introduced by the communication system inside the building are:

- No internet connection is needed to manage energy inside the community.
- Ability to manage the energy of the entire community, not just in isolated areas as home users.
- The communication network will use the existing ICT network of the building with no new cables or works.
- The energy management elements are owned by the community.
- The installation of the BEMS inside the TV header does not require that all residents have the HEMS in home. It would be a scalable and modular system.
- The infrastructure created and deployed could be used for other services demanded by the community.

4 Tartu district retrofitting actions monitoring

Second lighthouse city to be treated about the monitoring equipment is Tartu, Estonia. In this case, D4.1 explains the peculiarities of the demo site. In order to summarise the actions being implemented, following list describes the proposed interventions:

- Building refurbishment by means of insulation systems in the façade and roof, as well as replacement of windows and doors.
- Integration of PV panels for electricity generation at building level.
- Individual heating systems are being replaced, as well as the ventilation systems.
- Integration of ICT solutions, such as new thermostats and monitoring equipment so as to manage the energy consumption.
- District heating/cooling based on PV and biofuels.
- Street lighting with intelligent control systems.
- Sustainable mobility based on electrical vehicles and charging stations, as well as car sharing approaches.
- Implementation of the CIOP.

According to these interventions, as happening in the case of Vitoria, those related to district retrofitting are being included in this deliverable, i.e. refurbishment and integration of PV panels at building level, as well as the integration of monitoring.

4.1 Collection of KPIs & city indicators applicable for the district retrofitting actions evaluation

As stated in the Vitoria case, a set of indicators has already been defined for the evaluation of the impact of the actions in D7.3 and D7.4 (Evaluation protocols and City impacts). Selected indicators related to the district renovation actions have been included in the present document. To calculate the KPIs, some variables need to be measured with specific monitoring equipment, and this has been taken into consideration in the monitoring program. *Table 9: KPIs for energy about district renovation in Tartu* and *Table 10: KPIs for comfort about district renovation in Tartu*

gather the KPIs for energy, comfort and economics in Tartu.

ENERGY			
Name of indicator	Definition	Unit	Data source
Energy demand	Energy that the building requires to meet its needs/uses (i.e. heating, DHW, cooling, electricity…)	kWh/ m²a	Simulation/ theoretical calculation/ Energy meters

ENERGY			
Name of indicator	Definition	Unit	Data source
Delivered energy (for buildings)	Delivered energy is 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…) or to produce electricity (EN 15603:2008). Often, comparability with respect to electricity can be achieved if only lighting and auxiliary energy are considered. Thus, user-dependent electricity consumer (computer, refrigerator etc.) are not considered. To enable the comparability between buildings, the delivered energy is related to the size of the building (e.g. gross floor area or net floor area, heated floor area) and the considered time interval (e.g. year).	kWh/m²a	Energy meters
Primary energy (for buildings)	The primary energy approach makes possible the simple addition from different types of energies (e.g. thermal and electrical) because primary energy includes the losses of the whole energy chain, including those located outside the building system boundary. These losses (and possible gains) are included in a primary energy factor. The energy performance of a building is the balance of the delivered energy and the exported energy. The annual amount of primary energy (net delivered primary energy) is calculated as the difference between the weighed delivered energy, summed over all energy carriers and weighed exported energy summed over all energy carriers (EN 15603:2008).	kWh/m²a	Energy meters and primary energy factors (standards, tables)
CO2 equivalent (for buildings)	The CO_2 emissions of a building correspond to the emissions that are caused by different areas of application (i.e. space heating, space cooling, domestic water heating, electrical appliances). In different variants of this indicator, the emissions caused by the production of the building components can be either included or excluded. To enable the comparability between buildings, the emissions relate to the size of the building (e.g. gross floor area or net floor area, heated floor area) and the considered interval of time (e.g. year). The greenhouse gases are considered as t of carbon dioxide (CO_2) or a CO_2 equivalent (CO_2e).	t CO_2/ m²a	Energy meters and primary energy factors (standards, tables)
Density of energy demand	The indicator is defined as ratio of final energy demand (for heating or cooling) of a cohesive set of buildings and a simple figure representing the effort that a district heating or cooling network operator would have in order to supply these buildings. For the latter the territory area or the number of buildings is chosen in order to represent the length of the network and the number of connections that are required.	kWh/m²a	Estimated

ENERGY			
Name of indicator	Definition	Unit	Data source
Peak load and load profile of electricity demand	The load profile describes the demand characteristics over time, while peak load is what the electricity supply has to be able to cover. The load profile gives information about the possibilities or potentials of storage, demand-side management and self-supply via photovoltaic etc.	kW	Energy meters
Peak load and load profile of thermal (heating/cooling) energy demand	The peak load and the load profile of the thermal (heat and cold) energy demand require a high temporal resolution. The load profile describes the demand characteristics over time. The thermal energy supply has to be able to cover the peak load. The load profile gives information about the possibilities or potentials of storage as well as supply-side and demand-side management.	kW	Energy meters
Degree of congruence of calculated annual final energy demand and monitored consumption	Ratio of the theoretical energy demand of a building or set of buildings (calculated) and the final energy consumption of a building or set of buildings (measured) over a period of time (e.g. year)	%	Estimated

Table 9: KPIs for energy about district renovation in Tartu

COMFORT			
Name of indicator	Definition	Unit	Data source
Thermal comfort	This indicator represents the level of thermal comfort measured as the number of hours that the indoor temperature and relative humidity conditions are within range of values defined. The range of comfort values varies with the seasons (as it depends on the metabolic rate and clothing of the building users) and the climatology of each city (average monthly temperatures (max & min) and average monthly relative humidity).	-	Questionnaires

Table 10: KPIs for comfort about district renovation in Tartu

ECONOMIC			
Name of indicator	Definition	Unit	Data source
Resident costs	Monetary amount the residents must pay at the beginning of the project: total project investment minus total Grant per dwelling square meter	€/m^2	Bills
Grant rate	Percentage of grant of the total investment	---	Questionnaires
Total annual costs	Annual costs for residents due to maintenance and energy per year per dwelling square meter	€/m^2	Bills
Total annual benefits for residents	Subtraction among Old costs and total annual costs per dwelling square meter.	€/m^2	Questionnaires and bills

ECONOMIC			
Name of indicator	Definition	Unit	Data source
Cost saving rate	Percentage of annual benefits of the project. Rate between total annual benefits for residents and old costs.	%	As previous.
Total investment of the district for renovation from local and regional public funding, EC funding and private funding	Includes dwellings' owners, energy companies, social housing companies, etc. It should be specified for each type of fund.	€	Questionnaires, bills, etc.

Table 11: KPIs for economics about district renovation in Tartu

4.2 Non-KPI related monitoring requirements

Similar to Vitoria case, the non-KPI related monitoring requirements are related to the weather conditions. It is true that these variables are not necessary from the KPI calculation point of view, but they have a double use: information to the citizens and allowing measurement and verification plans (i.e. correlation between energy consumptions and weather conditions).

In contrast to Vitoria, Tartu case is implementing the local weather services (https://www.ilmateenistus.ee/) that provides both weather conditions and forecast, having in a single service all the available information. Here, up to 4-day forecast are available, apart from other measurements that could be useful in further implementations/services of the CIOP for Tartu.

Additionally, Tartu requires more monitoring equipment in order to perform control actions at building and dwelling level. Starting with building use cases, the control systems are defined for heating and ventilation, therefore, basically, temperatures and CO2 levels are necessary for control purposes. Nevertheless, energy prices will be used for optimization processes, being required the collection of these data..

We are aware of the existence of other elements used for the control and management of the different installations in the buildings (valves, pumps or similar, etc.) that can be a source of determined information that is directly used for the installations management only. Such information doesn't provide any added value and thus has been not considered on purpose.

4.3 Monitoring equipment and other sources of information

Once the monitoring requirements are clearly defined, the equipment to measure the variables associated to the indicators and the non-KPI related measurements needs to be specified. Similar to Vitoria, the variables, their definition, type of meter and location are summarised in *Table 12: Monitoring equipment for Tartu*, where the recommendations for monitoring are established, as well as other sources to collect information.

Variable	Definition	Meter	Location
Gas consumption	Measurement of the gas consumption per building in order to determine the total gas consumption.	Gas meter	Inlet of the building (gas substation)
Dwelling gas consumption	Similar to building, but at dwelling level.	Gas meter[3]	Inlet of the dwelling
Heating energy	Total heating energy consumption related to the building.	Heat meter	Inlet of the building (heating circuit)
Dwelling heating energy	Similar to building, at dwelling level.	Heat meter	Inlet dwelling (heating circuit)
DHW energy	Total DHW energy consumption related to the building.	Heat meter	Inlet of the building (DHW circuit)
Dwelling DHW energy	Similar to building, at dwelling level.	Heat meter	Inlet dwelling (DHW circuit)
Electricity	Total electricity consumption of the building, which is useful for the PV contribution.	Electricity meter[4]	Electricity switch centre
Dwelling electricity	Total electricity consumption of the dwelling.	Electricity meter	Electricity main cabinet
PV production	The PV is integrated at building level, therefore, it contributes to the electricity of the building.	Electricity meter	Output of the PV
Radiation	Related to the production of electricity, sun radiation level of PV panels location will be gathered from official weather service to calculate the efficiency of PV panels.	Radiation probe	Web service
Cold water	Although it is directly not related with KPIs, Tartu is measuring the water consumption.	Flowmeter	Inlet of water at building
Dwelling cold water	Similar to before, but at dwelling level.	Flowmeter	Inlet of water at dwelling
Air flow	Related to the ventilation system, in order to control this HVAC element, the air flow in the ducts is usually necessary, then, being measured and integrated.	Flowmeter	Ventilation ducts
Air temperature	Complementary to the air flow, temperature of this air is required so as to assure air quality conditions.	Temperature probe	Ventilation ducts
Temperature	Thermostats are being integrated in the dwellings, therefore, the temperature is measured.	Temperature probe	Main room of the dwelling
Humidity	Complementary to temperature, humidity is being measured in order to calculate the comfort levels.	Humidity probe	Main room of the dwelling

[3] Flow meters are used. Used energy is calculated by factors from national regulations or supplier factors for period.

[4] Only electricity meters installed by electricity supplier are used for monitoring in Tartu. All energy meters in Estonia allow remote reading and every owner can see their hourly based electricity consumption by default from power grid maintenance company webpage.

Variable	Definition	Meter	Location
CO2	One of the actions is the improvement of the ventilation system. Hence, one of the pivotal measurements is the air quality (i.e. CO2).	CO2 probe	Ventilation ducts

Table 12: Monitoring equipment for Tartu

Variable	Definition	Meter	Location
Energy demand	This is the simulation result about the energy performance of the dwellings/buildings.	Simulation engine	CSV (or similar) files
Costs/Investments	The economic KPIs required some information, which is collected from bills, investment plans, etc.	Bills	Files
Energy prices	For the optimization processes of the control system.	API	Rest
Weather conditions	In case of weather station API, the information of the weather conditions are an external source.	API	Web service

Table 13: Other sources of information for Tartu

5 Sonderborg district retrofitting actions monitoring

Last but not least, Sonderborg lighthouse, placed in Denmark, whose explanation may be found in D5.1. In this city, various departments have implemented different energy retrofitting measures. The measures include;

- Insulation of facades and roofs, as well as, new energy efficient windows and doors.
- New ventilation systems with heat recovery replacing traditional exhaust air ventilation systems.
- New indoor LED in common areas and in kitchens and bathrooms.
- RES-supply for the district heating based on heat pumps with sea water as source.
- New LED outdoor street lighting in the surrounding ground areas.
- Automatic heating control systems in district heating supply of the buildings
- Installation of in total 6.000 m² of building integrated solar photovoltaic plants for electricity supply with focus on good architectural integration of the solar panels in roofs and façades.
- Sustainable mobility with biogas buses, as well as electric vehicles with charging stations.
- Implementation of monitoring and CIOP deployment, including energy manager in order to manage the energy facilities.

Within the present deliverable, actions related to buildings and dwellings are being treated, including building insulation, ventilation systems, LED in common areas and monitoring, while D7.7 deals with the mobility monitoring and D7.8 is dedicated to the integrated infrastructures.

5.1 Collection of KPIs & city indicators applicable for the district retrofitting actions evaluation

Similar to the previous cases, the starting point is the collection of KPIs to be calculated within the demo site, which require a set of measurements to allow the evaluation process. Taking D7.3 and D7.4 as a basis for KPI description, *Table 14: KPIs for energy about district renovation in Sonderborg* and *Table 15: KPIs for comfort about district renovation in Sonderborg*

summarise the selected KPIs in terms of energy, comfort and economics to be determined in Sonderborg.

ENERGY			
Name of indicator	Definition	Unit	Data source
Energy demand	Energy that the building requires to meet its needs/uses (i.e. heating, DHW, cooling, electricity…)	kWh/ m²a	Simulation/ theoretical calculation

ENERGY			
Name of indicator	Definition	Unit	Data source
Delivered energy (for buildings)	Delivered energy is 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…) or to produce electricity (EN 15603:2008). Often, comparability with respect to electricity can be achieved if only lighting and auxiliary energy are considered. Thus, user-dependent electricity consumer (computer, refrigerator etc.) are not considered. To enable the comparability between buildings, the delivered energy is related to the size of the building (e.g. gross floor area or net floor area, heated floor area) and the considered time interval (e.g. year).	kWh/m²a	Energy meters
Primary energy (for buildings)	The primary energy approach makes possible the simple addition from different types of energies (e.g. thermal and electrical) because primary energy includes the losses of the whole energy chain, including those located outside the building system boundary. These losses (and possible gains) are included in a primary energy factor. The energy performance of a building is the balance of the delivered energy and the exported energy. The annual amount of primary energy (net delivered primary energy) is calculated as the difference between the weighed delivered energy, summed over all energy carriers and weighed exported energy summed over all energy carriers (EN 15603:2008).	kWh/m²a	Energy meters and primary energy factors (standards, tables)
CO2 equivalent (for buildings)	The CO_2 emissions of a building correspond to the emissions that are caused by different areas of application (i.e. space heating, space cooling, domestic water heating, electrical appliances). In different variants of this indicator, the emissions caused by the production of the building components can be either included or excluded. To enable the comparability between buildings, the emissions relate to the size of the building (e.g. gross floor area or net floor area, heated floor area) and the considered interval of time (e.g. year). The greenhouse gases are considered as t of carbon dioxide (CO_2) or a CO_2 equivalent (CO_2e).	t CO_2/ m²a	Energy meters and primary energy factors (standards, tables)
Density of energy demand	The indicator is defined as ratio of final energy demand (for heating or cooling) of a cohesive set of buildings and a simple figure representing the effort that a district heating or cooling network operator would have in order to supply these buildings. For the latter the territory area or the number of buildings is chosen in order to represent the length of the network and the number of connections that are required.	kWh/m²a	Estimated

ENERGY			
Name of indicator	Definition	Unit	Data source
Peak load and load profile of electricity demand	The load profile describes the demand characteristics over time, while peak load is what the electricity supply has to be able to cover. The load profile gives information about the possibilities or potentials of storage, demand-side management and self-supply via photovoltaic etc.	kW	Energy meters
Peak load and load profile of thermal (heating/cooling) energy demand	The peak load and the load profile of the thermal (heat and cold) energy demand require a high temporal resolution. The load profile describes the demand characteristics over time. The thermal energy supply has to be able to cover the peak load. The load profile gives information about the possibilities or potentials of storage as well as supply-side and demand-side management.	kW	Energy meters
Degree of congruence of calculated annual final energy demand and monitored consumption	Ratio of the theoretical energy demand of a building or set of buildings (calculated) and the final energy consumption of a building or set of buildings (measured) over a period of time (e.g. year)	%	Estimated

Table 14: KPIs for energy about district renovation in Sonderborg

COMFORT			
Name of indicator	Definition	Unit	Data source
Thermal comfort	This indicator represents the level of thermal comfort measured as the number of hours that the indoor temperature and relative humidity conditions are within range of values defined. The range of comfort values varies with the seasons (as it depends on the metabolic rate and clothing of the building users) and the climatology of each city (average monthly temperatures (max & min) and average monthly relative humidity).	-	Questionnaires

Table 15: KPIs for comfort about district renovation in Sonderborg

ECONOMIC			
Name of indicator	Definition	Unit	Data source
Resident costs	Monetary amount the residents must pay at the beginning of the project: total project investment minus total Grant per dwelling square meter	€/m^2	Questionnaires
Grant rate	Percentage of grant of the total investment	---	Questionnaires
Total annual costs	Annual costs for residents due to maintenance and energy per year per dwelling square meter	€/m^2	Questionnaires
Total annual benefits for residents	Subtraction among Old costs and total annual costs per dwelling square meter.	€/m^2	Questionnaires

ECONOMIC			
Name of indicator	Definition	Unit	Data source
Cost saving rate	Percentage of annual benefits of the project. Rate between total annual benefits for residents and old costs.	%	Questionnaires
Total investment of the district for renovation from local and regional public funding, EC funding and private funding	Includes dwellings' owners, energy companies, social housing companies, etc. It should be specified for each type of fund.	€	Questionnaires, bills, etc.

Table 16: KPIs for economics about district renovation in Sonderborg

5.2 Non-KPI related monitoring requirements

With respect to non-KPI related monitoring requirements, there is no substantial difference in contrast to the previous lighthouse cities. The main information is related to weather conditions allowing integration in the CIOP, as well as carrying out activities of the measurement and verification plans.

We are aware of the existence of other elements used for the control and management of the different installations in the buildings (valves, pumps or similar, etc.) that can be a source of determined information that is directly used for the installations management only. Such information doesn't provide any added value and thus has been not considered on purpose.

5.3 Monitoring equipment and other sources of information

Once the monitoring requirements are clearly defined, the equipment to measure the variables associated to the indicators and the non-KPI related measurements needs to be specified. Similar to the other LH cities, the variables, their definition, type of meter and location are summarised in *Table 17: Monitoring equipment for Sonderborg*

, where the recommendations for monitoring are established, as well as other sources to collect information.

Variable	Definition	Meter	Location
Building heating energy	This variable provides the information about the consumption of the building related to the heating part of the energy.	Heat meter	Output of the building substation (heating circuit)
Dwelling heating energy	Similar to building, but at dwelling level.	Heat meter	Output of the building substation (DHW circuit)
Building DHW energy	Similar to the case of heating in the building, but for the DHW distribution circuit.	Heat meter	Inlet dwelling (heating circuit)

Variable	Definition	Meter	Location
Dwelling DHW energy	Similar to building, at dwelling level.	Heat meter	Inlet dwelling (DHW circuit)
Temperature	For comfort conditions, the temperature inside the dwelling will be measured.	Temperature probe	Main room
Electricity	Consumption of electricity at building level in order to support the decision-making process for the PV feed.	Wattmeter	Building switch
Dwelling electricity	Similar than the building level, but on each dwelling.	Wattmeter	Dwelling cabinet
Lighting electricity consumption	Measurement of the consumption of the lights in the common zones to evaluate the LED replacement action.	Wattmeter	Lighting circuit
Dwelling lighting electricity consumption	Similar than the common zones, but, within dwellings, for those zones where the lighting systems is being replaced.	Wattmeter	Lighting circuit
PV production	The PV is integrated at building level, therefore, it contributes to the electricity of the building.	Wattmeter	Output of the PV
Radiation	Related to the production of electricity, radiation is usually integrated in the PV panels in order to predict the generated energy.	Radiation probe	PV panels/web service

Table 17: Monitoring equipment for Sonderborg

Variable	Definition	Meter	Location
Energy demand	This is the simulation result about the energy performance of the dwellings/buildings.	Simulation engine	CSV (or similar) files
Costs/Investments	The economic KPIs required some information, which is collected from bills, investment plans, etc.	Bills	Files
Weather conditions	Both data related to weather forecast and current conditions.	API	REST

Table 18: Other sources of information for Sonderborg

6 Summary of the monitoring program

From the previous sections, it may be extracted that the monitoring programs for each one of the lighthouse cities are similar, as correspond to similar actions and objectives in the cities. Monitoring requirements are also similar in order to calculate the well-established KPIs. Nevertheless, there are some specific actions that differ from one lighthouse city to other. These divergences are mainly referred to integrated infrastructures where the energy generation facilities may be diverse (e.g. PV, district heating, wind farms…).

At building level, as illustrated in Figure 3, the measurements are similar where the input energy for heating, cooling (if cooling actions are carried out), DHW and electricity are metered in order to determine the efficiency of the entire building.

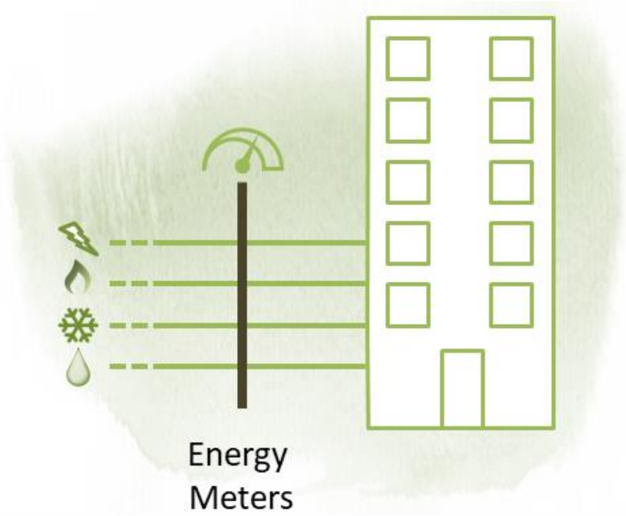

Figure 3: Meters at building level

A second level of measurements is taken for the dwellings, as depicted in Figure 4, where, apart from the energy consumptions, the comfort parameters are measured. This level of measurement is also very similar in the three LH cities.

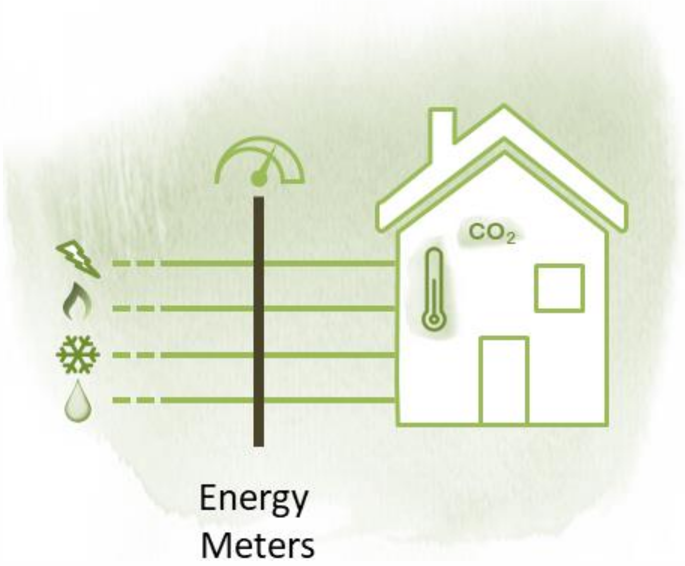

Figure 4: Meters at dwelling level

7 Commissioning plan guidelines

Commissioning is described by ASHRAE (Owner's quality-oriented process for achieving, evaluating, and documenting that the performance of buildings, systems, and assemblies meets defined objectives and criteria) as verifying and documenting that the facility and all of its systems and assemblies are planned, designed, installed, tested, operated, and maintained to meet the needs of the owner. For SmartEnCity, the commissioning is a way to ensure we reach the point we want to be for the different actuations, documenting and verifying that we meet the initial objectives set in the project.

Commissioning concept encompasses the full stock of interventions as long as the equipment, systems and facilities need to be commissioned. Within this equipment, monitoring devices are one of the pillars. That is the reason why a general description about commissioning is initially described in order to further focus the commissioning process on the monitoring stages.

Ideally, commissioning should start before the design phase of a system or process, and it should extend beyond installation and for up to one year of use. This covers many activities, including defining and documenting the main requirements, supporting project objectives through design reviews, conducting field tests and verifications during construction or installation; and adjusting and fine-tuning systems for optimal further performance (continuous commissioning).

The main aim of the commissioning and test procedure is to guarantee the operability of a system in terms of performance, reliability, safety, information traceability, etc. The commissioning plan establishes the strategy to reach a fine tuning and test of the overall performance of the implemented energy conservation measures and it is necessary to analyse the situation differently depending the action we are considering. In this document the SmartEnCity action considered is the district retrofitting action (and the related equipment).

From "*Embedded Commissioning for Building Design*" by Akin&Garrett (ESL-IC-04-10-05), building Commissioning has a broad scope that extends to all phases of building delivery. We view commissioning as a building delivery embedded process that persistently verifies and validates design intent throughout the building lifecycle process.

In the building lifecycle approach (Figure 5), buildings are considered modelled through a variety of different developmental phases. In this intervention project, we use the necessary theory and tools to support the embedded commissioning process as a function of building lifecycle. Building commissioning is a multi-phase process that ensures that the interacting systems in a building are properly installed and operating. In the early phases of facility design, commissioning is concerned with whether the program and the design are delivering the tenants' desired functionality. During the construction process, commissioning is concerned with ensuring that the performance of the selected building equipment agrees with the design specifications and delivers the intended functionality. The process of building commissioning tends to generate large amounts of data, much of which needs to be shared across several delivery phases.

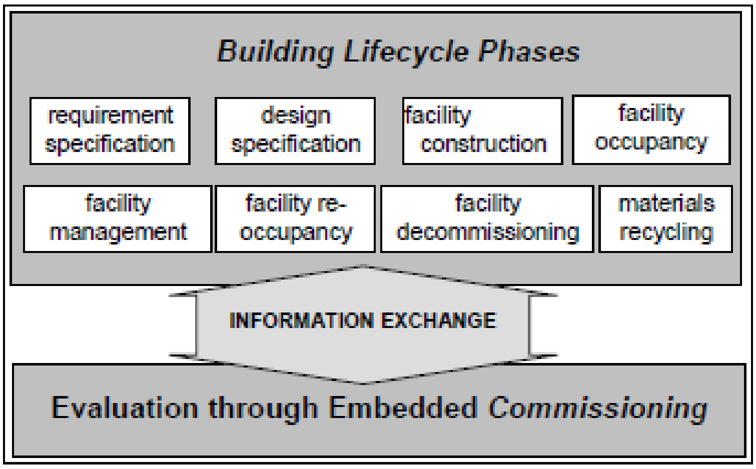

Figure 5: The Embedded Commissioning Model

Translating this concept into the monitoring equipment commissioning process, whatever the framework is the commissioning process should consider different steps:

- Design
- Initial setup
- Installation
- Commissioning & set up
- Maintenance & data collection
- Decommissioning

7.1 Design

This first stage is crucial at time of achieving a proper commissioning because it is the step where the requirements are established. Within SmartEnCity, this stage is based on the establishment of the KPIs where the needs in terms of variable to be metered so as to calculate the indicators have been set up. Additionally, other requirements are taken from the actions to be carried out. For instance, the control systems to be deployed in the demo sites require some measurements to properly manage the energy sources in an effective way.

Second part of the design phase is to identify the systems to be commissioned. Within this deliverable, this second part of the design stage is not covered. At the moment, the monitoring requirements are established, as well as the monitoring recommendations. Nevertheless, during the development of the project, resolution of tenders, etc., the specific equipment will be detailed, being documented in D7.5 about commissioning. D7.6 specifies the commissioning procedure to be followed by the lighthouse cities.

Besides, complementary to the previous paragraphs, within design, the planning and schedule of the actions is a very important aspect to be considered. Similarly, it happens with the documentation that is necessary for the installation of the equipment (e.g. electrical connections).

7.2 Initial setup

This second stage of the commissioning is related to the initial setup of the equipment, where the devices are prepared to follow a plug&play procedure. In this sense, a preliminary visual inspection is required in order to ensure that the equipment is correct and no damages are detected. After that, the equipment is pre-configured according to the monitoring needs instead of configured as default.

Moreover, the test plan is prepared in order to support the installation staff at time of testing the proper behaviour of the equipment. Then, test checklists are developed with the aim of checking the final performance.

As well, within this step, the initial assembly of the equipment (if necessary) is rendered. For instance, electrical cabinets can be pre-configured before the installation process.

Finally, initial calibrations are carried out so as to verify that the equipment is ready to set in normal operation, i.e. supply, calibration, firmware adaptation, operating system. Basically, the intention is to determine whether the equipment is prepared to be installed.

7.3 Installation

In this case, the installation, configuration and first tests (short-term according to the test plan in the design phase) for communication and data gathering are carried out. Usually the equipment needs a configuration and calibration procedure to receive data correctly, in the expected ranges and with the necessary frequency, among other characteristics. This configuration is performed and tested during this stage. Finally, manuals and training could be required.

7.4 Commissioning and setup

The key objective during this phase is to ensure all components of the critical infrastructure, as well as the system as a whole, operate as intended and in accordance with the requirements established in the design phase. Here, the medium/long-term tests have to be completed according to the test plan established during the design stage.

Additionally, several days of continuous data gathering are run with the aim of checking data (i.e. correctly received within the envisaged features (range, frequency, etc.)) and also the communication is stable and available along time.

Besides, fine-tuning is implemented in this phase. This process takes into account the performance of all the system working together, therefore, some modifications/adjustments of the parameters could be necessary in contrast to the initial setup. Thus, the optimal performance is determined.

Last but not least, lessons learnt are extracted and documented in order to support maintenance and further installations. Moreover, the data sheets, installation schemas, etc. are also documented in this stage with the objective of keeping record of the installation in order to facilitate the maintenance.

7.5 Maintenance & data collection

Having the data sheets and operation manual established, next step is the maintenance and data collection. These two terms should not be confused. Starting with maintenance, it is related to fails, breaks and other issues that appear physically in the devices. As well, extension of the monitoring network or replacement of equipment could happen, which belong to the maintenance. Even periodic calibrations are sometimes required depending on the equipment specifications. Of course, all these changes are documented in the same way than the step before with the goal of keeping the information the most updated possible.

On the other hand, data collection is related to the continuous commissioning and gathering of data along the operative time. Ensuring data continuity, avoiding data gaps and assuring data quality are the key aspects of data collection. In fact, SmartEnCity provides the deliverable D7.9 that covers the data collection approach and the data quality.

7.6 Decommissioning

The last stage of the commissioning procedure is not always happening and it is related with dismantling the monitoring equipment. This stage should be well planned because data gathering processes should be stopped, electrical connections should be taken into consideration and water ducts could be affected. At the end, the owner or end-user must not be affected by the decommissioning process.

This phase is out of the scope of SmartEnCity project, but it is necessary to be considered within the whole commissioning procedure.

8 Deviations to the plan

No main deviations have to be reported according to the dates and content of the deliverable with respect to the intended plan.

9 Outputs for other WPs

This document provides output mainly for activities and deliverables under WP7 although also has a reflection on the activities carried out on the LH cities, as there is where the final implementations take place.

The evaluation scheme that has been drawn through the different documents delivered previously on WP7, have its continuation on D7.6, D7.7 and D7.8 monitoring programs.

The evaluation scheme started to be deployed in D7.1 and D7.2 with the definition of a strategy of evaluation consisting of a set of objectives to be reached and KPIs for their evaluation. This strategy was be validated by the local partners participating on the interventions and depicted on the evaluation plan delivered in D7.3 jointly with D7.4, where the procedures for the evaluation of the baseline and final performance of the interventions were described.

The baseline evaluation of each LH city has been included as part of D3.2, D4.2 and D5.2 respectively by applying the protocols described in D7.3 and D7.4. In parallel, the monitoring programs deliverables for the district retrofitting and integrated infrastructures actions and the data collection approach deliverable have been defined. Those documents jointly show how the data gathering and collection from the different sources (dwellings, buildings, district, vehicles, etc.) will be done to allow a final evaluation of the final performance. The final evaluation will be done under task T7.5 and the results of this assessment included on Deliverable D7.13.

Also, a final report including the detailed information of all monitoring elements and the data collection process will be done at the end of the project (D7.12).

Figure 6 below shows the process described before of the evaluation scheme in parallel to the corresponding tasks/deliverables associated:

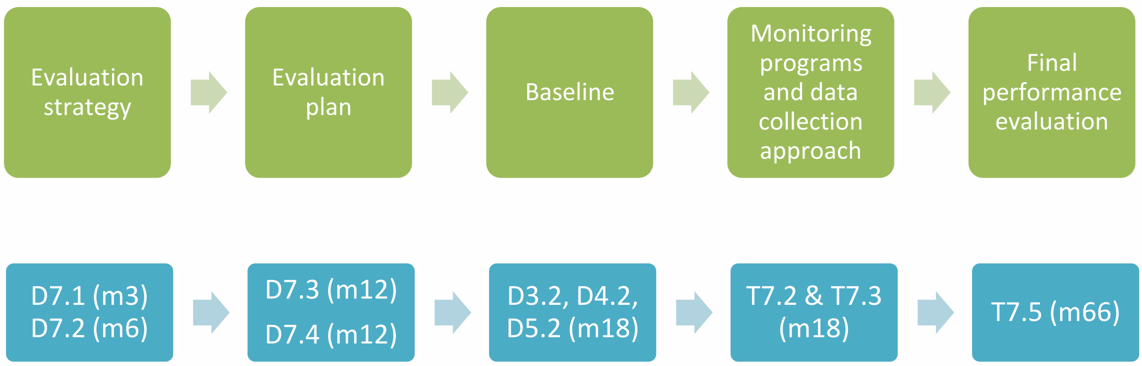

Figure 6: Deliverable D7.6 in the framework of the evaluation scheme

In Parallel a follow-up process is done to check periodically the advances of the actuations, and the implementation of the different measures, as well as the data collection process. This will be contemplated on internal periodic reports and also on the supervision of the interventions deliverables (D7.5, D7.10 and D7.11).