TOWARDS SMART ZERO CO_2 CITIES ACROSS EUROPE

VITORIA-GASTEIZ ✣ TARTU ✣ SØNDERBORG

Deliverable 7.3: Evaluation protocols

WP7, Task 7.1

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[1] PU = Public

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30/01/2017	1.0	Julia Vicente (CAR)	Consolidated final version including improvements on whole document due to revisions (TEC and CEE) comments, and final inputs from partners. Document ready for submission.

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Abbreviations and Acronyms

Abbreviation/Acronym	Description
ANSI	American National Standards Institute
API	Application Programming Interface
APP	Application software
ASHRAE	American Society of Heating, Refrigeration and Air-conditioning Engineers
BEMS	Building Energy Management Systems
CDD	Cooling Degree Days
CHP	Combined Heat and Power
CIOP	Common Information Object Protocol
DEMS	District Energy Management Systems
DHW	Domestic Hot Water
ECM	Energy Conservation Measure
EN	European Norm
EPD	Environmental Product Declarations
EU	European Union
EV	Electric Vehicle
EVO	Efficiency Valuation Organization
FEV	Full Electric Vehicle
GPS	Global Positioning System
HDD	Heating Degree Days
HEMS	Home Energy Management Systems
ICT	Information and Communication Technologies
ICEV	Internal Combustion Engine Vehicle
IoT	Internet of Things
IPMVP	International Performance Measurement and Verification Protocol
ISO	International Organization for Standardization
ITU	International Telecommunication Union
KPI	Key Performance Indicators.
LCA	Life Cycle Assessment
LH	Lighthouse
M&V	Measurement and Verification

n.a.	Not applicable
NGO	Non-Governmental Organization
OECD	Organization for Economic Co-operation and Development
PMV	Predicted Mean Vote
PPD	Predicted Percentage of Dissatisfied
PV	Photovoltaic
RES	Renewable Energy Source
SCIOSS	Platform for Internet of Things
SCIS	Smart Cities Information System
SmartEnCity	Towards Smart Zero CO2 Cities across Europe
SMS	Short Message Service
ToC	Table of Content
WP	Work Package

Table 1: Abbreviations and Acronyms

0 Publishable Summary

This report compiles the holistic methodology developed for the evaluation of the performance of the interventions carried out in the three LH cities participating in SmartEnCity project. This methodology consists of 7 protocols named as Energy Assessment Protocol, ICT Protocol, LCA Protocol, Mobility Protocol, Social acceptance Protocol, Citizen Engagement Protocol and Economic Performance Protocol.

Each protocol covers the description of the objectives to be evaluated and the methods to be applied and are represented by a set of KPIs which will be used as tool for quantify the result reached after the execution of the interventions and actions in the cities of Vitoria-Gasteiz, Tartu and Sonderborg. In addition, specific plans take part of these protocols in order to describe the specific procedures to be applied in each city.

This report has been the result of the involvement of a wide number of partners. Such tight collaboration has allowed agreeing a tailored methodology for the evaluation of the performance of the interventions. Thus, the development of each protocol has been open to include some requirements from each LH but they have a common framework of evaluation for a comparison of the results reached in each city once the interventions conclude.

1 Introduction

1.1 Purpose and target group

The aim of this deliverable is the definition of a holistic methodology for the assessment of the performance achieved in the lighthouse cities which participate in SmartEnCity project after the execution of the building retrofitting, district heating, smart grid, smart mobility, ICT platforms and citizen engagement actions. This methodology, which consists of seven protocols, are based in the KPIs proposed in the previous deliverable D7.2 and will allow to measure the objectives established in each city from technical, environmental, economic and social points of view.

Tailored protocols have been designed to evaluate the effects of interventions in terms of environmental benefits (e.g. energy reduction, CO_2 saving), thermal comfort, social acceptance, economic benefits among others after the collaboration of 16 partners from the three cities which take part of the project.

Concerning other deliverables, the present deliverable becomes the stepping stone for remaining WP7 deliverables. In addition, D7.3 will be taken into account for the evaluation of baseline in WP3 (D3.2), WP4 (D4.2) and WP5 (D5.2) and will be considered in the regeneration strategy to be defined in the project (D.2.7 and D2.8).

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	Main responsible of protocols for mobility, LCA, social acceptance and citizen engagement. Content in protocols for economic performance, energy assessment and ICT
TEC	Main responsible of protocols for energy assessment and ICT. Revision of the document.
ACC	Main responsible of protocol for economic performance
VIS	Content to protocols for energy assessment, LCA, social acceptance, economic performance and citizen engagement for Vitoria-Gasteiz
CEA	Content to protocols for mobility in Vitoria-Gasteiz
MON	Content to protocols for Energy Assessment, ICT and citizen engagement in Vitoria-Gasteiz
FED	Content to protocols for mobility, social acceptance and economic performance in Vitoria-Gasteiz
CEE	Revision of the document.

ACC	Main responsible of protocol for economic performance
TAR	Content to protocols for energy assessment, ICT, LCA, mobility, social acceptance, citizen engagement and economic performance in Tartu
TREA	Content to protocols for energy assessment and ICT protocol in Tartu
ET	Content to protocols for energy assessment and citizen engagement protocol in Tartu
SONF	Content to protocols for ICT, economic performance, social acceptance, citizen engagement for Sonderborg
ZERO	Content to protocols for mobility, social acceptance, economic performance and citizen engagement for Sonderborg
PLAN	Content to protocols for energy assessment and LCA for Sonderborg.
VG	Content to protocols for ICT protocol and citizen engagement in Sonderborg

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
D7.2	This deliverables provides the evaluation framework and specifically the set of objectives and KPIs to be considered in each protocol developed in D7.3
D7.4	This report D7.4 will take into account the methodology developed in the current deliverable for the evaluation of the impacts due to interventions in the cities of Vitoria, Tartu and Sonderborg
D3.2, D4.2, D5.2	This deliverable provides the methodology for the evaluation of baseline in Vitoria (D3.2), Tartu (D4.2) and Sonderborg (D5.2)
D7.6, D7.7, D7.8	The monitoring program to be designed in these deliverables will be based in the evaluation protocols established in D7.3
D7.9	The procedure for the collection of data will be based in the procedures and KPIs defined in this deliverable D7.3
D7.13	This deliverable provides the overall description of the methodology which allows to evaluate the performance achieved in interventions in Vitoria, Tartu and Sonderborg at the end of project which will be reported in D7.13
D6.3	The platform data model will be designed to accommodate KPIs to be measured in the project

D2.7, D2.8	The methodology for evaluating the interventions will be integrated in the regeneration strategy to be defined in the project in deliverables D2.7 and D2.8

Table 3: Relation to other activities in the project

2 Objectives and expected Impact

2.1 Objective

SmartEnCity aims to contribute to create Smart Zero CO2 Cities across Europe through urban regeneration strategies, integrated urban plans and district integrated interventions.

WP7 will help to support cities for reaching this objective by providing a holistic methodology for assessing the performance achieved in the sustainable interventions and quantifying the impact generated in the cities as a result of their implementation. The task T7.1, where this report takes part, is specifically focused in the creation of an evaluation plan constructed on indicators collection process. This Deliverable D7.3 “Evaluation protocols” is contributing with the establishment of the methodology for the quantification of the performance of the demo area after the district renovation and the implementation of sustainable vehicles. This methodology covers seven protocols which will be applied for the evaluation of different issues which will be detailed along the current report.

- Energy Assessment Protocol
- ICT Protocol
- Life Cycle Analysis
- Mobility Protocol
- Social Acceptance Protocol
- Citizen Engagement Protocol
- Economic performance Protocol

Finally, it has to mention that the methodology includes the KPIs selected by representative partners of the cities involved in the project.

2.2 Expected Impact

Since this report will be public, the methodology described in this deliverable can be used not only for the three LH cities of SmartEnCity but also for any city which intends to transform into a Smart Zero City and which require to know how to evaluate the performance achieved after the execution of sustainable interventions. Thus, cities will have well described procedures for evaluating different type of interventions (e.g. district renovation, sustainable mobility actions, citizen engagement actions, etc) from a holistic point of view which includes technical and environmental improvements but also social and economic benefits.

3 Overall Approach

The content of this deliverable is structured as follows:

- Introduction, objectives and expected impacts: Previous sections introduce the purpose of the report, the relation with other tasks of the project and the contributions from the different partners.
- Section 4 describes the interventions and actions to be implemented in each city.
- Section 5 describes the process carried out for the elaboration of this document through the design of the protocols.
- Sections 6 to 12 cover the protocols which take part of the methodology where a common framework has been defined for each one as well as the specific plans of evaluation to be implemented in each city. These chapters include the objectives and KPIs to be evaluated, the target audience on which is addressed and an overview of the methods proposed and finally selected by the cities. The protocols developed are:
    - Energy Assessment Protocol
    - ICT Protocol
    - LCA Protocol
    - Mobility Protocol
    - Social Acceptance Protocol
    - Citizen engagement protocol
    - Economic Performance Protocol
- At the end of the document Annex 15 contains the templates contained on the excel files generated for the calculation of the economic KPIs.

4 Description of interventions in the three LHs

This section will introduce the interventions and district characterization in order to introduce the reader in the framework where protocols will be implemented.

4.1 Vitoria-Gasteiz

4.1.1 District description

It is expected that 750 dwellings (circa 60.000 m^2) in the Coronation district will be renovated, including full envelope insulation and having their energy systems replaced with a connection to the district heating.

This corresponds to between 30 and 50 buildings, and would affect circa 2,000 inhabitants.

Population living in this city district is amongst most aged, with highest immigration, and lowest income of Vitoria's city. The property is owned in its majority by families that occupy the dwellings and in other cases by private individuals that rent the property to tenants. There are no large tenants in the area and the decision on the refurbishment has to be made by reaching a 60% majority between the individual apartment owners in each building.

- Number of dwellings to be retrofitted

  750 dwellings.

- Number of buildings to be retrofitted

  30 to 50.

- Number of buildings to be connected to the District Heating

  30 to 50.

- Number of residents benefited by the district intervention

  Circa 2000.

- Property structure

  Individual family owners.

- Type of residents (owners/tenants) and residents profile (elder people, young families, immigrants, etc.)

  Aged population, large percentage of immigration.

4.1.2 Energy efficient district refurbishment action

Following table provides a brief description of the current situation and the ECM to be implemented on Vitoria Gasteiz.

Vitoria-Gasteiz	Before retrofitting	After retrofitting
Passive measures	Envelop insulation: Little or no insulation Roof insulation: Little or no insulation Windows (replaced some time ago, old): Mostly old, few replaced recently	Envelop insulation (type): External insulation or ventilated façade (U =0,21 W/m2k) Roof insulation (type): Depending on the building but reaching a U value of 0,21 W/m2k) Windows: Double low-e glazing
Active measures (integrated infrastructures)	The heating system consists of natural gas boilers (80% correspond with individual boilers and 20% with centralized boilers)	The renovated dwellings will be connected to the new district heating network which will be fuelled by a biomass boiler (chips)

Table 4: Current and future situation in Vitoria-Gasteiz

4.1.3 Mobility actions

Most of the mobility actions in Vitoria have been affected by cascade funding[2] so that they will be replaced by new ones.

There are currently some proposals waiting to be evaluated by the Project Officer, and they will be more accurately explained in the next related deliverable (D7.7 Mobility Action Monitoring Program). Meanwhile, a brief explanation has been included in this report.

New EV charging stations

A set of new charging points will be added to the current network, providing service to the city council fleet.

As a complement to the existing fast charging point (East part of the city), a new one will be implemented at the West part of the city. A study will be accomplished in order to determine the possibility to extend such a fast charging infrastructure by the way of using the power grid of the current tram and the planned one for the electric BRT. This way it would be possible to offer a complete opportunistic charging network, mainly focused to give support to the professional fleets (taxis, freight delivery, commercial fleets, ...), as a complement to their at-home standard charging infrastructure.

[2] The cascade funding refers to the impossibility of using Article 15 of the GA "Financial support to third parties" as financial support to 3rd parties is not allowed. According to this some actions initially foreseen had been obliged to be modified. This same issue is applicable to the three LH cities in the project.

E-Bicycle promotion for travelling to work

A total of 25 electric bicycles will be deployed along with a specific campaign to promote smart bike riding to work within the local/regional administration and in cooperation with the main local businesses and companies.

A permanent call will be launched in order to recruit the participants. Each participant will be supported by personal coaching so that they feel safe while riding to work. They will also receive support to solve any mechanical problem during the test. A two month test is provided for each user. A minimum of 250 workers will participate in the initiative.

A survey will be designed in order to properly assess the impact of this measure, during and after the participation of each user that will be supported by a specific App that will be collecting additional data.

Intelligent safe parking and bike tracking

A pilot measure dealing with safe parking and tracking supported by smart technologies will be implemented. More in detail, 4 safe smart bike parking stations would be deployed during the second year of the project and 2 more during the third one.

Testing will be done on the interaction of this infrastructure with an “electronic bicycle license plate” based on RFID or Bluetooth LE (iBeacom) technology. A small locator that will be placed on a set of bicycles will communicate with Apps’ users and with different autonomous tracking.

It must be noted that significant changes can still be applied to these measures and thus affect the associated monitoring protocols.

Additionally, 26 EV (two types) will be devoted to last mile delivery service. Required electricity will be provided by 26 dedicated charging points.

Overview: The Vehicles are bought by EMS, and FED rent them to the enterprises that will operate the services in the city.

4.1.4 Citizen engagement strategy

In the case of Vitoria-Gasteiz the process consists on increasing the level of impact of the citizens in the proposal. An information strategy was launched, followed with a Consultation for the district renovation. The target people, house owners, must be empowered and involved. Informal leaders must be detected and a leader group created to progress and create a certain “momentum” for the intervention.

The roles of the stakeholders and citizen engagers must be clearly defined before starting the process. In Vitoria-Gasteiz, the decisions about citizen engagement are validated by the General Management Board of VISESA and the Vitoria City Council urbanism department general manager. TECNALIA’s project coordinator safeguards the compromises acquired with the EU Commission and at the same time offers solutions and bridges for enabling action. Before the definitive decisions are made, the above mentioned stakeholders analyse discuss and decide on alternatives to be presented to the General Management Boards.

VISESA takes the global responsibility of promoting, managing the execution and closing contracts with the Citizens excluding the part of energy service, for which a new public private society is being created. Because of this key role, VISESA is the main interlocutor with the owners for the house refurbishing in the project.

ACEDE-CEE (H-ENEA) is responsible for analysing and making proposals regarding citizen engagement for the house renovation, which are shared with the project main coordinators from one side and contrasted with the stakeholder members from the other.

There is also a dedicated Communication Team which members are: VISESA, CEA (Vitoria-Gasteiz city council), H-ENEA and Vitoria Municipality.

During the first year, various activities have already taken place following the above mentioned approach and stakeholder structure. Neighbourhood associations were invited by letter and phone to a meeting. The second step was to directly invite the neighbours through door to door invitations. VISESA organised an exhibition so the house owners could see the refurbishing typologies depending on the initial building characteristics, and how the connection to the district heating will take place. With the help of ENSANCHE 21 (part of the municipality of Vitoria-Gasteiz), VISESA is also operating a local “on-site” office, where more concrete information about the building retrofitting features is being provided to the owners and neighbours.

The next step is to prepare specific refurbishing offers with the home owners. The 108 community of owners within the intervention area have been contacted and the first round of meetings is now finalizing.

Additional support for the citizens is expected from the ICT developments in the project. The neighbours in the focus area of the city will have energy monitoring systems installed in the dwellings. These systems will enable feedback on their energy consumption for further energy efficiency based on the behaviour.

A number of Apps for tablets and mobile phones will be developed to provide the information to the neighbours. The information will be presented both as aggregation of the dwellings participating in the action, and as specific private information for each owner. This is expected to facilitate the adoption of the services and technologies by the citizens, creating a bidirectional communication channel between the people and the city.

Also, the general pulse of the city of Vitoria-Gasteiz (open to the entire city and not restricted to the demonstrator site) is intended to be monitored and analysed via a Citizen Inbox or similar system implemented in the city’s web site. With intelligent data analysis systems, the information would be extracted and compared to that on social networks to get the feeling of the citizens.

These services are directly linked to the Urban Platform which will be developed in the project, and it is expected to provide information in the areas of energy efficiency, intelligent mobility and citizen engagement.

4.2 Tartu

4.2.1 District description

- Number of dwellings to be retrofitted:

  900 dwellings

- Number of buildings to be retrofitted:

  20 to 23

- Number of buildings to be connected to the District Heating:

  All retrofitted buildings are already connected to district heating network

- Number of residents benefited by the district intervention:

  2100 inhabitants

- Property structure:

  95% private owners

- Type of residents (owners/tenants) and residents profile (elder people, young families, immigrants, etc.):

  Dwellings occupancy: 20% tenants, 80% owner occupied (officially)

  Age profile: [0-17] ⇨ 18%, [18-64] ⇨ 65%, [over 64] ⇨ 17%

  Ethnicity profile in Tartu: Estonians 79%, Russians 17%, other 4%

4.2.2 Energy efficient district refurbishment action

Following table provides a brief description of the current situation and the ECM to be implemented on Tartu.

Tartu	Before retrofitting	After retrofitting
Passive measures	Envelope insulation poor and insufficient Roof insulation insufficient Windows (replaced some time ago, old)	Envelope insulation according to energy calculations approx. 0,15 W/m²deg Roof insulation approx. 0,1 W/m²deg Windows u-value < 0,9 W/m²deg Heat recovery ventilation system, efficiency factor > 0,8

Active measures (integrated infrastructures)	Currently houses are connected to district heating grid. The system inside buildings is usually a "one pipe" system, There are no thermostats and the system is hydraulically unbalanced which leads to uneven temperatures in different dwellings. Ventilation is originally calculated to be free flowing with fresh air coming in through insufficiently tightened windows and doors. As windows are replaced with ones of higher quality the air flow has become insufficient which has led to poor indoor air quality	Reconstructing the central heating system based on adjustability and mounting thermostatic valves with limiters to radiators Radiators and pipes are replaced with modern ones. Heating system is designed house by house and is adjusted to cooperate with specific ventilation system. Ventilation system includes heat recovery with efficiency factor no less than 80%. Ventilation will also be demand-based dwelling wise on the basis of carbon dioxide concentration in indoor air. Building integrated (mostly on rooftop) PV panels will be installed to cover electricity demand and over buildings needs produced electricity will be sent to the grid.

Table 5: Current and future situation in Tartu

4.2.3 Mobility actions

Some of the mobility actions in Tartu have been affected by cascade funding so that they will be replaced by new ones. These actions are not described in this section.

Brief description of the actions already defined

- Introducing 8 electric cars and 16 electric bikes in 4 charging points available for public use;
- Purchasing 60 new biogas buses for public transport;
- Setting up 5 new public charging points to meet the increased demand;
- Implementing a general bike sharing system;
- Developing a participatory transport planning system for increasing the efficiency of public transport;
- Re-using EV batteries for storing and using renewable energy;

In addition to above mentioned activities some ideas for activities to replace the support of purchase of electrical cars are thought.

4.2.4 Citizen engagement strategy

For the SmartEnCity project to succeed, active participation of citizens is required. All the buildings in the renovated district are privately owned and the collective decision by the owners is required for the renovation to take place. The SmartEnCity project can support this process but the final decision (including decisions about the technical design and its implementation) has to be made by the representative NGO of the private owners (building association). Because of this, the main focus of engagement is on the building associations and the main task is to include the associations into the renovation process (even if they do

not participate in the SmartEnCity project). The single most important act of engagement will be the decision to renovate, made by the housing associations. Everything in the project has to support this decision and help its realization.

In light of this, the main target groups included for citizen engagement are:

1. Pilot area residents

2. Citizens of Tartu

Pilot area residents will be addressed as a whole group but different approaches are used for the elderly and the young, for example. In Tartu, our strategy is mostly focused of informing, consulting, involving and collaborating with the citizens, and to a lesser degree empowering (however, the latter will be promoted through the SmartEnCity project activities). As house renovations and other project activities require most input from public authorities, citizens will be mostly communicated with, consulted with and they will be involved in the development of project activities and in certain decision-making processes. In some activities more collaboration and empowerment is expected, i.e. transportation planning app, choosing artworks to go on the facades of their houses, etc.). The end goal of Tartu is to have well-informed citizens who feel that they have and they can contribute to the development of Smart Tartu.

Other important aspects of engagement in Tartu are mobility (EV and electric bike rentals, tbd.) and social innovation and mutual learning - not only teaching the pilot area residents how to use new technologies but also ensuring that Tartu as a whole becomes more accepting of new technologies and innovations – this includes both the planned smart home systems and, for example, new EV technologies in mobility.

The success of the engagement activities will be later assessed with the help of several KPI's that have been developed both in cooperation with other WPs but also within the Engagement Working Group. These include, for example, numerical KPI's (how many citizens have been reached, how many participants in events, etc.) but also more abstract changes in thinking, which will be explored by UTAR and IBS in detailed randomly selected interviews with pilot area residents. More information can be found on Section 11 in this document.

ICT Urban platform will be one important mean to foster further citizen engagement into the development of Smart Tartu. Tartu ICT platform has modular and layered approach. Where lower layer stands for sensors and actuators, middle layers represent connectivity and everything related to data management and upper layer is for applications. Security is applied on top of every interaction in the architecture. Communication in-between layers is all built up on, as standardized application programming interfaces (API’s) as possible. Such approach allows to separate hardware providers and application developers. Also, applications can be developed over multiple technology and/or business domains.

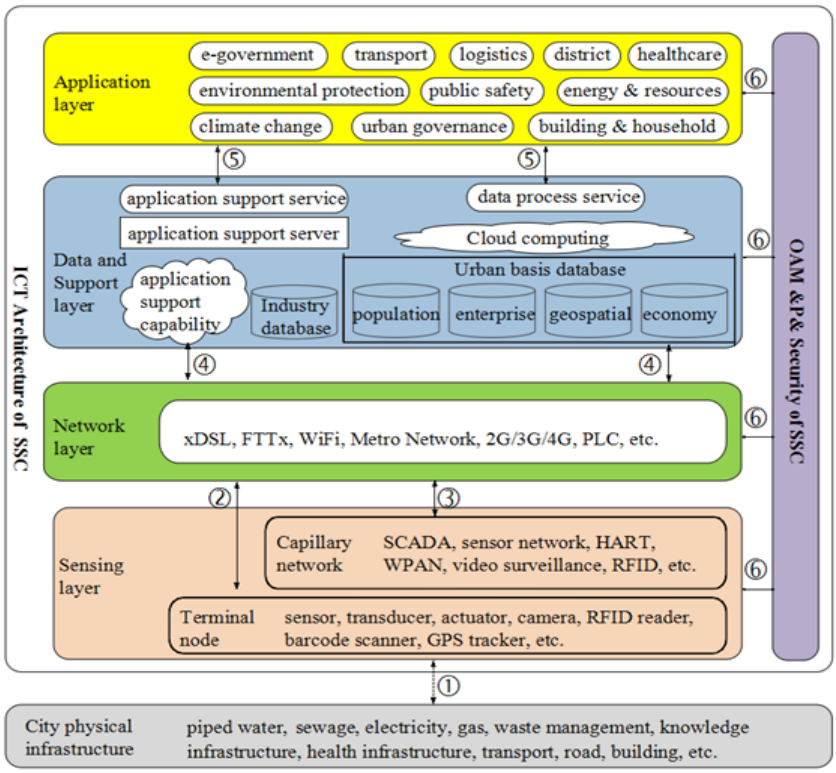

Figure 1: Architecture sample according to ITU[3]

As received feedback from Telia, in the SmartEnCity project background technology will be provided for the ICT urban platform and this will serve as platform for the third parties to build their applications and additional layers on IT. This means that in case of most of the KPI-s in this protocol we will be dependent on the information given by the third parties and have no direct access to the data by ourselves in the SmartEnCity project.

Citizen engagement strategy through ICT platform

ICT solution created in the project will enable inhabitants to monitor energy consumption (electricity, heat, water) in their dwellings and also there will be added opportunity to exchange information between of housing union and dwelling owner. ICT solution will provide owners with information from smart lighting system (temperature, traffic information).

To inform the inhabitants of the pilot area will be used the project website: www.tarktartu.ee as a main channel. To some extent information will be spread through Facebook. Press releases will be communicated through the official channels of the city.

The approximate number of citizens that will be informed about the project is 5000 citizens.

The decision making units at the neighbourhood are the formed by citizens. 100% of inhabitants must vote to take the decision of the renovation of a building.

[3] *Reference architecture sample by International Telecommunication Union (ITU), that has been explained in more detail in Deliverable 2.3 in the SmartEnCity project.

4.3 Sonderborg

4.3.1 District description

- Number of dwellings to be retrofitted:

  807-844 (with about 1,700 residents)

- Number of buildings to be retrofitted:

  45-51 (with about 66,000 m2)

- Number of buildings to be connected to the District Heating:

  All buildings are already connected to district heating

- Number of residents benefited by the district intervention:

  About 1700 directly. Apart from that 76000 (inhabitants in whole Sonderborg area) will benefit as the district interventions will bring Sonderborg closer to reach the goal to become a zero carbon community. 27500 (inhabitants in city of Sonderborg) will benefit more directly as the heat pump is set to be installed in this specific district heating area.

- Property structure:

  All of the energy efficient building retrofitting will be done in social housing building blocks with the building owners being the three leading social housing companies of Sonderborg involved. All the properties are organized as Public Housing Associations, where the tenants are members of the specific housing association.

  The tenants in each of the departments of the specific housing association elect a Department Board.

  All the department boards in the housing association form together a Representatives Forum, who elects the Executive Committee of the Housing Association.

  The Executive Committee employs the Head of the administrative staff of the Association.

- Type of residents (owners/tenants) and residents profile (elder people, young families, immigrants, etc.):

  All residents in the social housing blocks being retrofitted are tenants. The profile of the tenants is generally a mix of general population (students, elder people, immigrants, etc.) but a relatively moderate/low disposable income is a common feature.

4.3.2 Energy efficient district refurbishment action

Following table provides a brief description of the current situation and the ECM to be implemented on Sonderborg.

Sonderborg	Before retrofitting	After retrofitting
Passive measures	Envelop insulation poor or insufficient Roof insulation poor or insufficient Double panel Windows (replaced some time ago, old)	Envelop insulation improved Roof insulation improved New windows and doors New ventilation systems LED outdoor lamps
Active measures (integrated infrastructures)	All buildings are connected to Sonderborg District Heating System, which is based on renewable energy sources.	Lighting control Automatic heating control Building Integrated PV panels New large scale heat pumps in the district heating system using the sea water as heat source in order to increase heat demand with RES and heating control systems

Table 6: Current and future situation in Sonderborg

4.3.3 Mobility actions

Some of the mobility actions in Sonderborg have been affected by cascade funding so that they will be replaced by new ones. These actions are not described in this section.

The only still mobility actions to be introduced consist of 38 biogas buses and 30 charging stations.

4.3.4 Citizen engagement strategy

For the case of Sonderborg, the strategy to be followed to engage the citizens in the process will be deployed in different steps. All tenants in the tree housing associations will be invited for meetings where they will receive information about the specific plans for retrofitting and where they will be able to discuss about them. Additionally there will be information available online at the websites of the housing associations.

The final decision/approval of the retrofitting plans will be taken by the tenants living in each specific unit.

Step one	
Goal	• To build a confidential cooperation between Project Zero and the general managers of the housing associations.

The initial step will be to discuss this citizen engagement among Project Zero, the general managers from the housing associations and the consulting engineer (and soon to be SmartEnCity partner) Torben Esbensen who is associated with the retrofitting projects. They all form together the “citizen engagement partnership”.

Thereafter in the framework of collaboration between the Project Zero secretariat and students from the university in Sonderborg will be developed a program of workshops to be held with the department boards in step two

Step two	
Goal	• To prepare a team that will secure strong future contact to the tenants. • In cooperation with the team make a program for citizen engagement, as described in step three

As decided by the "citizen engagement partnership" (check step one), each of the three housing associations general managers gets in contact with two department boards in their respective housing associations.

Thus, six department boards are contacted in total and the Project Zero secretariat invites each department board for a workshop (check step one) to prepare them as a team prior to contacting the tenants.

Each team department board identifies then 5 families to participate in a project about tenant's behaviour patterns. One family can be 1-2 adults with or without children.

Step three	
Goal	• Involving 30 families to be aware of their behaviour in relation to use of energy. • To build up a basis for cooperation between the families. • To find new keypersons for the project further on

There will be 5 workshops whit the 30 families all whit different topics.

For example there will be meetings with excursions to the treatment plant, incinerator, or geothermal plant. At the different locations, there will receive information and will discuss about aspects as waste, water, waste water, energy or transport.

The families must work together and inspire each other whit ways to minimize their energy consumption.

Step four	

Goal	• Start the citizen engagement in the rest of the departments in the six involved housing associations.
	• Getting all the housing associations to make a green strategy involving the following:
	  ◦ Energy management
	  ◦ Citizen engagement
	  ◦ Procurement policy / demand to suppliers
	  ◦ Retrofitting policy
	In order to succeed with the vision of the city council becoming CO2 neutral by 2029.
	• Identifying new departments in the six housing associations in Sonderborg municipality to start retrofitting based on the lessons learned from SmartEnCity.

The experience and learnings from the 30 families will be used to make a program that the housing associations will use to start a similar process in the rest of housing departments.

In dialog whit the housing association board it will be implemented a green strategy. The head board is the one who must present it to the board of representative on their annual general assembly.

The general managers have to find the departments that are more similar to the SmartEnCity and contact the board of residents.

Up to now we have not developed leaflets or brochures. With a more direct and personal communication, we try to avoid misunderstandings and to build up a confidential relation.

The administration at the housing associations will contact the tenants through letters at their website or information in the stairwells. The members in the department boards will take contact to the tenants too.

So far and in the future, the discussions and information exchange between Project Zero, the general manager, and the department boards have been face to face, by phone or emails.

Later on it will be necessary to add to those other kind of communication channels, because the Project's citizen engagement grows and the idea will be to try reaching and involving more persons.

807 apartments are directly involved by the retrofitting project. Estimating 2.1 individuals per apartment give us an estimated overall number of 1695 citizens directly involved. The goal is that all 7069 apartments, thus an estimated number of 14845 citizens, will hear about the project in the end.

Decision making units at the neighbourhood.

Regarding the decision making units in the neighbourhood (i.e. the percentage of votes that allow to starting the works in the building and/or at district level), the decision making process is similar in all three housing associations.

1. The Administration prepares a plan for the refurbishment and discusses it with the department board.
2. When they agree the administration collects offers from contractors and make a final proposal on a resident meeting.
3. At the resident meeting, there is a vote about the refurbishment plan. It is only needed to obtain a simple majority of the attending tenants to vote in favour of the refurbishment plan for it to be approved.

5 Procedure for the design of protocols

The methodology for the evaluation of interventions described in this report has been the result of the collaboration of 16 partners which has allowed developing a common framework of evaluation but also due to the differences found among interventions and cities, which have specific needs and expectations, tailored evaluation plans have been designed for each city. Thus, the common framework of the protocols has been defined by partners that are not involved in the local projects (TEC, CAR and ACC) which have proposed the scope (e.g. objectives to be evaluated) and the methods and indicators to be used. Then, the partners involved in the deployment of local LH projects have selected the most convenient procedure which fits better with the characteristics of their projects.

The definition of each protocol that takes part of this deliverable has consisted of three stages:

1 Identification of partners to be involved in the description of each protocol.

2 Taking into account the objectives proposed in D7.2, delineation of the objectives to be evaluated in each protocol and in each city through the collaboration of partners.

3 Definition of the methodology to be implemented for the intervention performance evaluation. For some cases, the assessment requires the comparison of the final performance achieved after the end of the project with the period before the intervention, which is named as baseline. The identification of KPIs, using the list of indicators provided in D7.2, has taken part of the definition process of the methodology.

Tables below summarize each of these stages.

Protocol	Main responsible of protocol	Partners involved in Vitoria-Gasteiz	Partners involved in Tartu	Partners involved in Sonderborg
Energy Assessment	TEC, CAR	VIS, MON	TREA, TAR, ET	PLAN, ZERO
ICT	TEC, CAR	MON	TREA, TAR	SONF, VG
LCA	CAR	VIS	TAR	PLAN, ZERO
Mobility	CAR	CEA, FED	TAR	ZERO
Social acceptance	CAR	VIS, FED	TAR, IBS	ZERO, SONF
Citizen engagement	CAR	MON, VIS	TAR, IBS, ET	ZERO, VG
Economic performance	ACC, CAR	VIS, FED	TAR, IBS	ZERO, SONF

Table 7: Partners involved in each protocol

Table below compiles a summary of the potential objectives that can be achieved through SmartEnCity in each one of the three types of interventions defined in the project: district renovation, mobility actions and citizen engagement actions.

Type of intervention	Technical objectives	Environmental objectives	Social objectives	Economic objectives
DISTRICT RENOVATION: Building retrofitting Integrated infrastructures	Reduction of the energy demand of buildings Savings of energy consumptions with desired comfort in dwellings Improvement of the energy efficiency in the district Higher use of RES and self-sufficient energy consumption in the district	Savings of CO_2 emissions generated in the district Reduction of the environmental impact in the district	Improvement of the residents quality of life (thermal comfort) Higher the acceptance of the project by residents of renovated district	Reduction of the energy costs of residents Decrease in the payback of the district renovation intervention
SUSTAINABLE MOBILITY Electrical Vehicles Biogas buses City mobility planning	Reduction of the traffic congestion Improvement of the efficiency of urban transport systems Savings of energy consumption in the vehicles	Reduction of the CO_2 emissions generated in the vehicles	Improvement of the quality of life for vehicle users Higher acceptance of the project by vehicle users	Reduction of the energy costs of drivers Decrease in the payback of the mobility intervention
CITIZEN ENGAGEMENT STRATEGY Information campaigns Urban platform/Web applications	Achieve the engagement of city communities	Contribute with citizen engagement strategy to improve the environmental awareness of the citizens	Higher acceptance of the project by citizens	Contribute with citizen engagement strategy to the reduction of the energy costs of the citizens
ICT	Reduce home thermal energy consumption within desired comfort level, combining the data analysis findings with recommendations		Citizens empowerment Generate impact through the urban platform on the urban transformation	

	offered through HMI solutions. Reduce building energy consumption combining the findings for collective consumption with recommendations given to the energy provider (i.e.: thermostat set point) Evaluate the impact of the HMI and the social networks on energy consumption behaviour. Improve the existing urban platforms and generate new ICT developments and services integrated into the existing (or newly deployed) smart urban platforms.			

Table 8: Potential objectives per type of intervention

Related to KPIs, a set of potential indicators to be used for each type of objective can be found in this deliverable 7.2. Table below summarizes the number of indicators selected for each type of intervention and type of KPI.

Type of intervention	Technical KPIs	Environmental KPIs	Social KPIs	Economic KPIs
District renovation	18	7	26	8
Mobility	9	3	13	8
Citizen engagement	23	3	10	3

Table 9: Number of indicators proposed in D7.2

Those KPIs have been merged in the protocols defined:

- Energy Assessment Protocol: Technical KPIs
- ICT Protocol: Technical KPIs
- Life Cycle Analysis: Environmental KPIs
- Mobility Protocol: Technical KPIs
- Social Acceptance Protocol: Social KPIs
- Citizen Engagement Protocol: Technical KPIs
- Economic performance Protocol: Economic KPIs

6 Energy Assessment Protocol

6.1 Scope of the protocol

6.1.1 Energy Conservation Measures

The Energy Assessment Protocol will cover the effects in the district area after the building retrofitting and the implementation of integrated infrastructures actions which include the ECM's (Energy Conservation Measures) described in chapter 4 in the sections Energy efficient district refurbishment action.

6.1.2 Results expected after the implementation of ECM

City	Energy savings	Emissions reduction	Comfort
Vitoria	It is expected to achieve an energy reduction of the 30% by the planned implementation of energy efficient retrofitting measures in buildings and the new district heating network	According to the emissions reduction, it is expected to achieve a reduction close to 100% by using RES.	According to the DoA: Guarantee desired comfort at dwelling level
Tartu	It is expected the retrofitting of buildings will decrease total energy consumption at least a 30%, and heat energy consumption will be reduced more than a 50%.	The energy needs and consumption will be reduced significantly because of the planned interventions. Domestic hot water production by using natural gas and electricity will be replaced by a district heating based system which will use biomass as fuel. Installing of PV panels and production of solar energy will also reduce CO2 emissions of retrofitted buildings. In conclusion, the reduction of CO2 will be close to 50%.	According with the requirements of national level: Air indoor quality, thermal comfort.
Sonderborg	The planned implementation of energy efficient retrofitting measures in buildings will significantly decrease the energy consumption (applies only to the retrofitted buildings). The planned implementation of a large-scale heat pump in the district heating system will reduce primary energy consumption as the technology is more efficient than the existing energy system. It will also increase the use of RES in the energy system, as it will allow to integrate more RE based electricity in the heating system (applies to the energy system and all district heating consumers in the Sonderborg area).	The planned implementation of energy efficient retrofitting measures buildings will reduce CO2 emissions corresponding to CO2 emissions of the lower heating and electricity production needed to meet the demand (applies only to the retrofitted buildings). The planned implementation of a large-scale heat pump in the district heating system will reduce CO2 emissions corresponding to CO2 emissions of the less district heating production needed to meet the demand, and the substitution of fossil fuel based district heating with increasingly RE electricity based district heating (applies only to the retrofitted buildings). (applies to the energy system and all district heating consumers in the Sonderborg area).	No significant changes are expected.

Table 10: Summary table of expected results after ECMs

6.1.3 Objectives to be evaluated

Previous technologies will contribute to reduce energy demands, reduce home thermal energy consumptions with desired comfort at dwelling level and, indirectly, reduce the CO_2 emissions generated from the district. Hence, the Energy Assessment Protocol will cover the evaluation of the following objectives:

1) Energy savings achieved with the implementation of energy performance solutions in the districts due to retrofitting actions which lead to a reduction of energy demand, the efficiency gained and higher use of RES.
2) CO_2 avoided associated to the energy savings.
3) Comfort achieved.

However, this protocol will be focused in the following parameters by each city, taking into account the requirements from SmartEnCity, national laws and interest of the partners in each city.

City	Objectives to be evaluated
Vitoria	Energy savings CO_2 savings Thermal comfort by meters and by the residents' opinion
Tartu	Energy savings CO_2 savings Thermal comfort and Indoor Air Quality by the residents' opinion
Sonderborg	Energy savings CO_2 savings Thermal comfort by the residents' opinion

Table 11: Objectives to be evaluated

6.2 Assessment methods

6.2.1 Energy and CO_2 savings

Energy savings cannot be directly measured, since savings represent the absence of energy use or demand. Instead, savings are determined by comparing measured use or demand before and after implementation of a program, making suitable adjustments for changes in conditions.

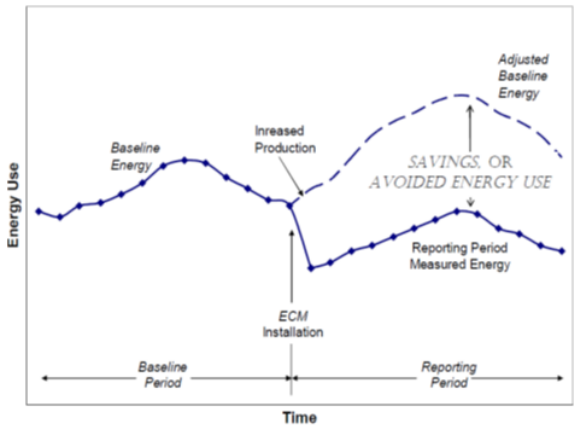

Figure 2: Energy consumption before and after the ECM installations

As an example of the savings determination process, Figure 2 shows the energy-usage history of an industrial boiler before and after the addition of an Energy Conservation Measure (ECM) to recover heat from its flue gases. At about the time of ECM installation, plant production also increased.

To properly document the impact of the ECM, its energy effect must be separated from the energy effect of the increased production. The “baseline energy” use pattern before ECM installation was studied to determine the relationship between energy use and production.

Following ECM installation, this baseline relationship was used to estimate how much energy the plant would have used each month if there had been no ECM (called the “adjusted-baseline energy”). The saving, or ‘avoided energy use’ is the difference between the adjusted-baseline energy and the energy that was actually metered during the reporting period.

Without the adjustment for the change in production, the difference between baseline energy and reporting period energy would have been much lower, under-reporting the effect of the heat recovery.

It is necessary to segregate the energy effects of a savings program from the effects of other simultaneous changes affecting the energy using systems. The comparison of before and after energy use or demand should be made on a consistent basis, using the following general equation:

Savings = (Baseline period – Reporting period ± Adjustments)

The "Adjustments" term, in this general equation, is used to re-state the use (or demand) of the baseline and reporting periods under a common set of conditions. This adjustments term distinguishes proper savings reports from a simple comparison of cost or usage before and after implementation of an Energy Conservation Measure (ECM). Simple comparisons of utility costs without such adjustments report only cost changes and fail to report the true performance of a project. To properly report “savings,” adjustments must account for the differences in conditions between the baseline and reporting periods.

The baseline in an existing facility project is usually the performance of the facility (or system) prior to modification. This baseline physically exists and can be measured before changes are implemented. In new construction, the baseline is usually hypothetical and

defined based on code, regulation, common practice or documented performance of similar facilities. In either case, the baseline model must be capable of accommodating changes in operating parameters and conditions so “adjustments” can be made.

6.2.2 Comfort

The next subsections will review different methods to assess the comfort.

6.2.2.1 Predictive Mean Vote (PMV) for thermal comfort

The predicted mean vote (PMV) is determined based on the estimated metabolic rate and the clothing insulation, and performance indicators: the measured or predicted air temperature, mean radiant temperature, relative air velocity, and air humidity. The PMV integrates the effects of the two personal parameters and the four environmental parameters on the thermal balance, and it predicts the mean thermal sensation on a seven-point thermal sensation scale.

- Metabolic rate

The metabolic rate (M) is the rate of energy production of the body by metabolism, which varies with activity. Metabolic rate can be quantified by the met unit, where 1 met is defined as the metabolic rate of a sedentary person (seated, quiet); 1 met = 58.2 W/m2, while the metabolic rate of this person is 3.4 met, or 200 W/m2 while walking on a pace of 5 km/h. The unit W/m2 refers to the area of the nude body.

- Thermal Insulation of Clothing

Clothing insulation varies between occupants in a space due to differences in clothing preferences, company dress code, season, etc. Clothing insulation can be measured with a heated thermal manikin or with human subjects, but in practice, thermal comfort estimates based on tables may be sufficiently accurate.

- Thermal Environment Parameters

Measurement of the thermal parameters of the environment should be made in the occupied zones of the building at locations where the occupants are expected to spend their time, i.e., at their workstations or in seating areas. For the determination of PMV, the thermal parameters should be measured at the centre of gravity, which is 0.6 m for sedentary occupants and 1.1 m for standing activity. The PMV is expressed as a function of the personal parameters of metabolic rate and clothing insulation and the thermal environment parameters as input variables.

$$PMV = f(M, W, p_a, t_a, f_{cl}, t_{cl}, t_r, h_c)$$

With

$T_{cl}=f(I_{cl},f_{cl},t_r,t_a)$

$h_c=f(t_{cl},t_a,v_a)$

$f_{cl}=f(I_{cl})$

where PMV is the predicted mean vote [-], M is the metabolic rate [W/m2], W is the external work (zero for most indoor activities) [W/m^2], fcl is the ratio of the clothed surface area to the nude surface area [-],Icl is the thermal resistance of the clothing [(m2K)/ W], ta is the air temperature [oC], tr is the mean radiant temperature [^oC], va is the air velocity relative to the human body [m/s], pa is the partial water vapour pressure [Pa], hc is the convective heat transfer coefficient [W/(m^2K)], and tcl is the surface temperature of the clothing [^oC].

It is recommended to use the index only for PMV values in the range -2 to +2 , metabolic rates from 0.8 met to 4 met, clothing insulation from 0 clo to 2 clo, air temperatures from 10 to 30 C, mean radiant temperatures from 10 to 40 C, and relative air velocities from 0 to 1 m/sec. In non-air-conditioned buildings in warm climates, the occupants may sense warmth as being less severe than PMV predicts[4].

Figure 3 represents the acceptable combination or air temperature and humidity values, according to the PMV/PPD method in the ASHRAE 55-2010 standard. The representation is made on a temperature-relative humidity. The comfort zone in blue represent the 90% of acceptability, which means the conditions between -0.5 and +0.5 PMV[5]

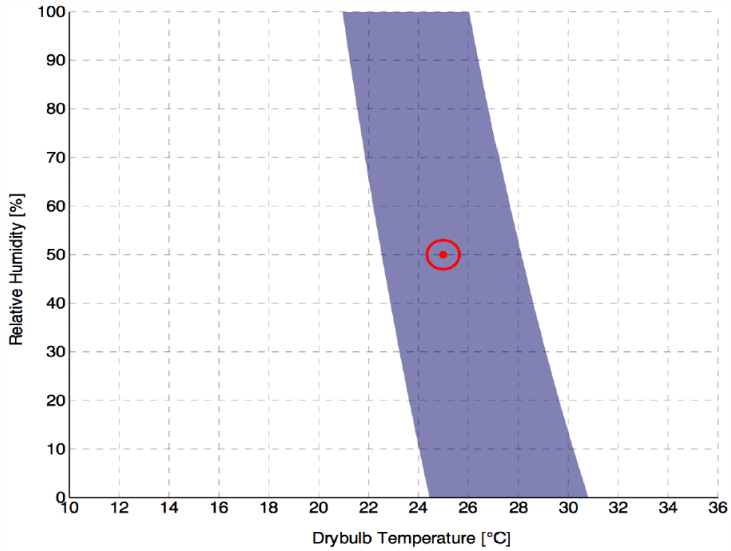

Figure 3: PMV method.

6.2.2.2 European Standard EN 15251 for Indoor Air Quality

The European standard EN 15251 stablishes four different categories of indoor environment; those categories are briefly described in the next table:

Category	Explanation
I	High level of expectation and is recommended for spaces occupied by very sensitive and fragile persons with especial requirements like handicapped, sick, very young children and elderly persons
II	Normal level of expectation and should be used for new buildings and renovations

[4] Extension of the PMV model to non-air-conditioned building in warm climates. Energy and Buildings journal (Vol. 34) Povl Ole Fanger and Jørn Toftum, Technical University of Denmark.
[5] CBE Thermal Comfort Tool for ASHRAE 55 (cbe.berkeley.edu/comforttool). Center for the Built Environment, University of California Berkeley

Category	Explanation
III	An acceptable, moderate level of expectation and may be used for existing buildings
IV	Values outside the criteria for the above categories. This category should only be accepted for a limited part of the year

Table 12: Description of the applicability of the categories used [Source: EN 15251]

According to the expected interventions in SmartEnCity; at least, categories II and III should be reached in the retrofitted dwellings.

Indeed, these categories could be used to give an overall yearly evaluation of the indoor environment by evaluating the percentage of time in each category.

In other standards like EN 13779 and EN ISO 7730 categories are also used; but may be name different (A, B, C or 1, 2, 3 etc.).

Indoor air quality depends of many parameters and sources (number of persons, emissions from activities but also from furnishing, flooring materials, cleaning products etc.). A correct ventilation rate, either natural or mechanical, maintains the indoor air quality controlled. These ventilation rates should be extracted from national regulations (EN 15251 gives default values to use in case no national regulation is available).

EN 15251 states that “Indoor air quality measurements are based on the indirect approach of measuring ventilation rates”, if the ventilation rates are assured, the indoor air quality should be reached. Specific measurements should be done only if specific complaints persist.

In residential buildings where the main pollution sources where people, the indoor air quality can be derived using CO_2 measurements. Concentration of CO_2 is not considered harmful nor a contaminant at the levels of 400 to 2000 ppm normally found in buildings. Previous versions of ANSI/ASHRAE Standard 62 set the CO_2 set point in 1000 ppm, but newer versions has deleted this reference to stablish a differential set point between inside/outside CO_2 concentration of 700 ppm in reference to a ventilation level of 7 l/s. So the measurement of CO_2 concentrations is an indirect measurement to establish if the ventilation rates are achieved in the spaces.

EN 15251 do not include an specific reference table for the differential CO_2 concentration in residential buildings which assures the ventilation rates for each category, but it is possible to use the values recommended for occupied spaces in non-residential buildings:

Category	Corresponding CO_2 concentration above outdoors in PPM	
	Typical range	Default value
I	≤400	350
II	400-600	500
III	600 – 1000	800
IV	≥1000	1200

Table 13: Differential CO_2 concentration levels

6.2.2.3 Questionnaires for thermal comfort:

They are used as tool for compiling the resident's opinion. It does not include any measured variable; but only based on the building or equipment user opinions.

6.3 SmartEnCity evaluation approach for Energy and CO_2 savings: IPMVP Protocol

Energy Assessment Protocol will follow the IPMVP (International Performance Measurement and Verification Protocol) methodology to verify the energy savings obtained thankfully to renovation activities. The International Performance Measurement and Verification Protocol (Volume 1, EVO 10000 – 1:2012) is a guidance document describing common practice in measuring, computing and reporting savings achieved by energy or water efficiency projects at end-user facilities. The IPMVP presents a framework and four measurement and verification (M&V) Options for transparently, reliably and consistently reporting a project's saving. M&V activities include site surveys, metering of energy or water flow(s), monitoring of independent variable(s), calculation, and reporting. When adhering to IPMVP's recommendations, these M&V activities can produce verifiable savings reports.

The IPMVP is not a standard and thus there is no formal compliance mechanism for this document. Adherence with the IPMVP requires preparation of a project specific M&V Plan that is consistent with IPMVP terminology. It must name the IPMVP Option(s) to be used, metering monitoring and analysis methods to be used, quality assurance procedures to be followed, and person(s) responsible for the M&V.

6.3.1 IPMVP option selection

IPMVP provides four options for determining savings (A, B, C and D). The choice among the Options involves many considerations including the location of the measurement boundary (If it is decided to determine savings at the facility level, Option C or D may be favoured). However if only the performance of the ECM itself is of concern, a retrofit-isolation technique may be more suitable (Option A, B or D):

- Option A. Retrofit Isolation: Key Parameter Measurement
- Option B. Retrofit Isolation: All Parameter Measurement
- Option C. Whole Facility
- Option D. Calibrated Simulation

Figure 4 below shows the process to select the IPMVP option based on the full set of project conditions, analysis, budgets and professional judgment.

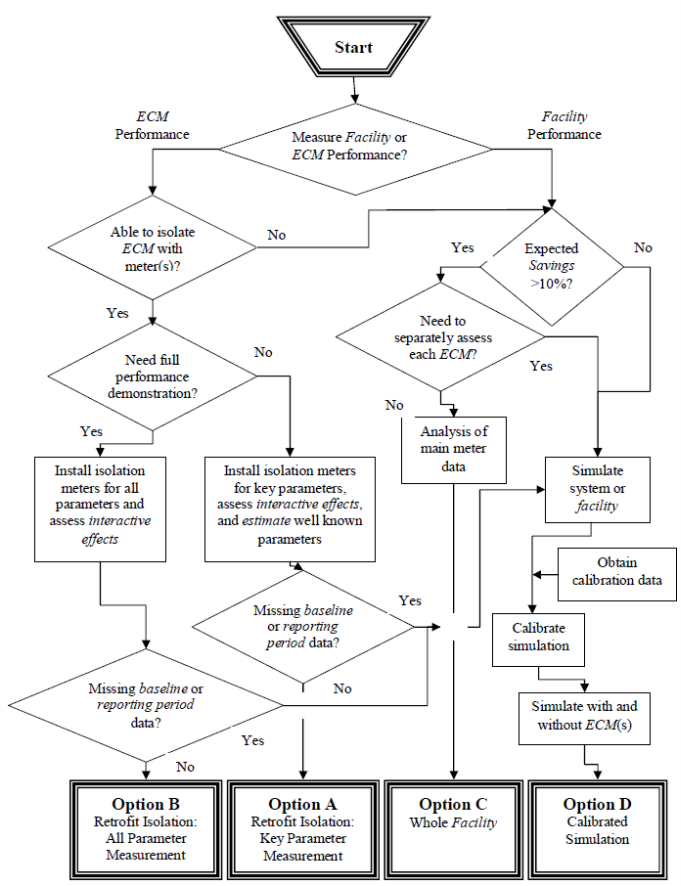

Figure 4: Option Selection Process

According to the planned interventions in every LH city in SmartEnCity, options A and B seem not to be suitable. The expected savings are expected to be greater than the 10% and some ECMs will not have available isolated meters. So option C and option D, depending on the available data prior the interventions and the needs to assess each ECM, will be chosen as IPMVP option for each city.

City	Option
Vitoria – Gasteiz	**D**
Tartu	**C**
Sonderborg	**D**

6.3.2 Measurement boundary

It is necessary to define the limits of the measurements by setting a system boundary. Figure 5 shows a general scheme of a system boundary for a building, which is a detailed system boundary modified from EN 15603:2008.

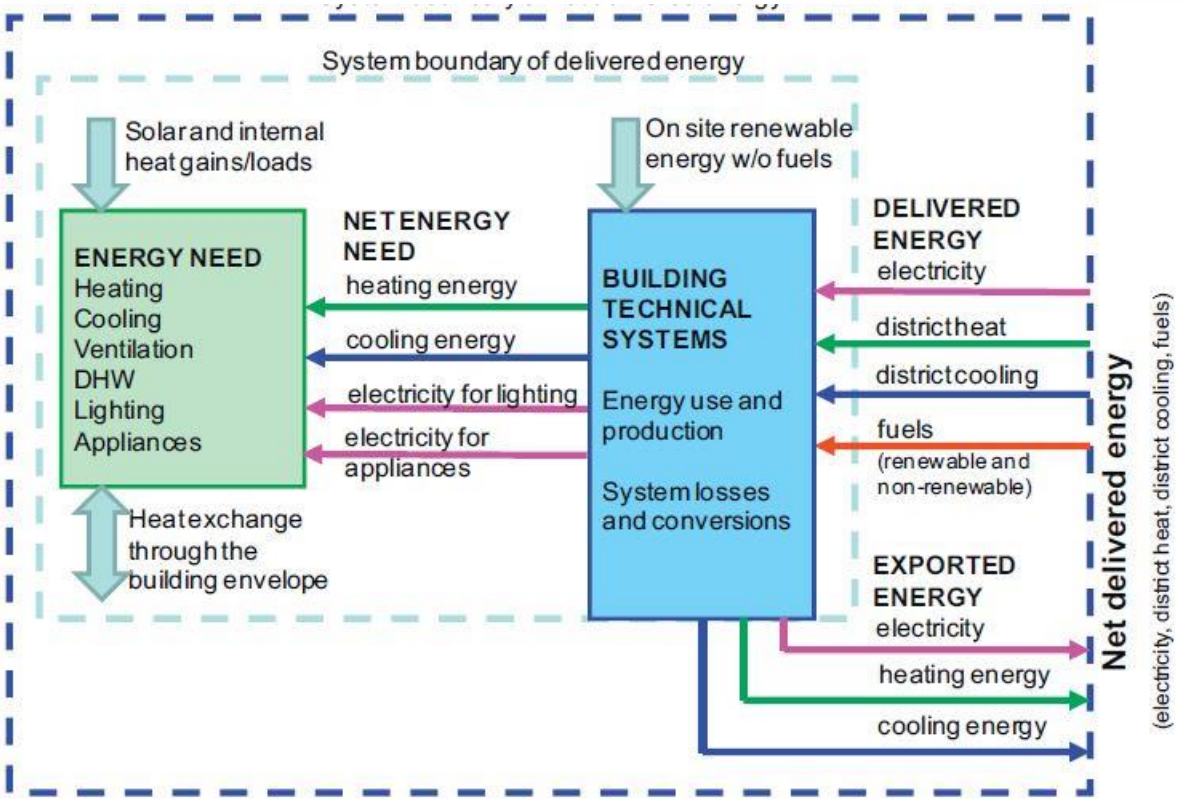

Figure 5: Building system boundary (Source: J. Kurnitski et al, 2011)

However, the boundaries needed for SmartEnCity have to be extended because of the interventions in the LH, which cover entire sites with multiple buildings and decentralized production.

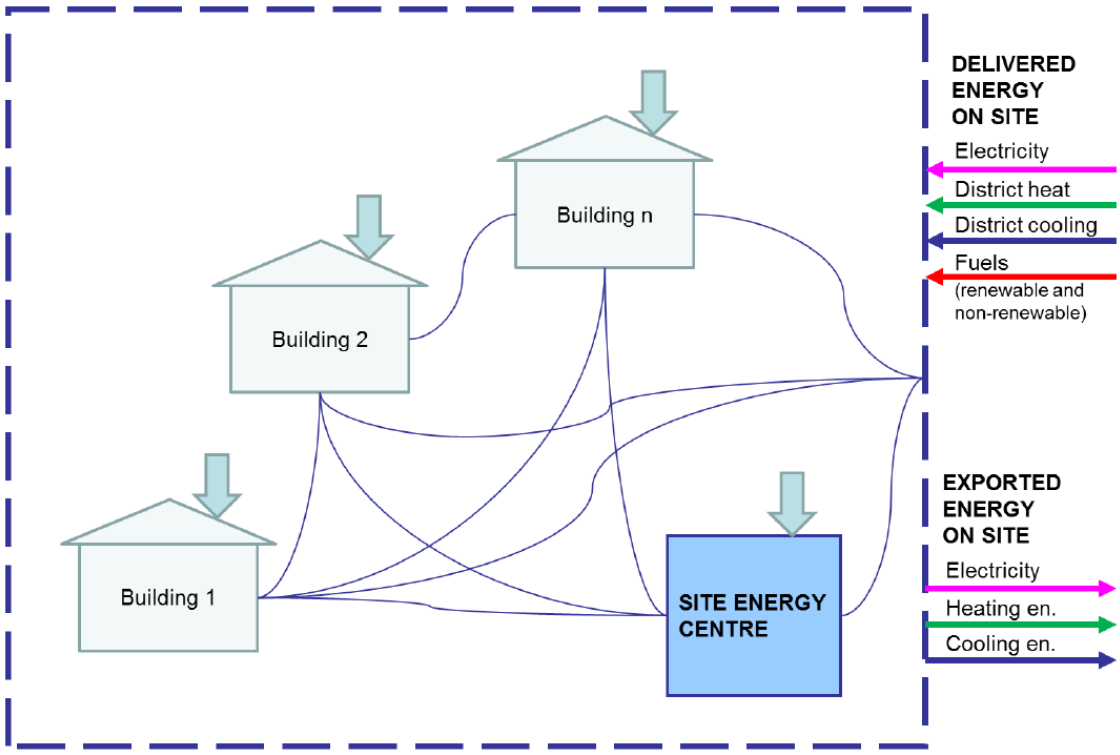

Figure 6: Extended system boundary (Source: "Final report on common definition for nZEB renovation", ZenN)

The next table shows a general overview of the measurement boundary selected for each LH depending on the covered interventions.

City	Measurement boundary
Vitoria – Gasteiz	Whole district (main heat meter)
Tartu	Building level (main heat meter)
Sonderborg	Whole district (main heat meter)

Note: Not all the KPIs for a LH have to use the same measurement boundary; this means that a KPI could use a specific boundary that should be described.

6.3.3 Baseline and reporting period

It is important to characterize the baseline and reporting periods. The interventions in SmartEnCity include equipment which will be used to measure several variables, but prior the intervention it is not guaranteed that those variables could be measured. Using the current bills is a good alternative to gather this information and calibrate the models. The next table shows the availability of bills for the different lighthouses:

City	Availability of bills
Vitoria – Gasteiz	Yes (Guaranteed from building owners undertaking the renovations)
Tartu	Yes (Metered data available for heat energy, electricity and water consumption on building level)
Sonderborg	Not guaranteed

a) Independent variables

Energy consumption is influenced by the individuals that compose the household, as well as the physical characteristics of the house and equipment stock, environmental variables, social factors, and economic conditions. A large body of research has focused on energy demand and the drivers of demand, exploring relations between various factors.

Degree days

Weather has many dimensions, but the primary driver of residential heating and cooling demand is outdoor temperature. A degree-day is a relative measure of outdoor air temperature taken at a specific location.

For normalizing heating energy consumption in different climate conditions the so-called **heating degree days** (HDD) are used and well established. However, their definition differs and two main algorithms are known: one implementing the building's threshold heating temperature alone, the other one implementing the targeted set temperature of the building additionally. Both methods calculate the sum of a temperature difference on all days, when

the heating has to be turned on (heating day). On non-heating days the temperature difference is not included into the sum.

$$HDD_{t_{ht}} = \sum_{1}^{z} (t_{ht} - t_a);\ with\ t_a < t_{ht}$$

where

$HDD_{t_{ht}}$ heating degree days for a time period with z heating days (ambient air temperature being below the heat threshold temperature t_{ht})

z number of heating days in the time period

t_{ht} heating base point temperature

t_a daily average ambient air temperature

When looking at European countries, different applications of the methodology are found, and with different threshold and different set temperatures, which hampers a unified calculation. In 1996 the European Commission asked for an assessment of climatic correction methods applied in various member states. Eurostat[6] presented the findings to the Energy Statistics Committee and the Member States in principle approved a common method for heating-temperature correction. The method is described in "Panorama of Energy"[7]. It employs the first described formula and defines 15°C as the heating threshold temperature and 18°C as the heating set temperature. The average daily temperature is defined as the arithmetic mean of the minimum and maximum air temperature of that specific day.

$$HDD_{18/15} = \sum_{1}^{z} (18℃ - t_a);\ \ with\ \ t_a = \frac{t_{min} + t_{max}}{2}$$

There is no standardized method for **cooling degree days** (CDD) available and Eurostat does not propose a procedure either. However, in literature and different projects a method has become commonly accepted. The calculation is analogue to the heating degree-days and as it is applied to air-conditioning systems very often there is no distinction between ambient air temperature and room set temperature. The supply air with a specific set temperature has to be cooled down exactly at the time when the temperature of the ambient air temperature exceeds that value. According to the common use, the base temperature is defined as 18°C.

$$CDD_{t_{st}} = \sum_{1}^{z} (t_a - t_{st});\ with\ t_a > t_{st}$$

where

$CDD_{t_{st}}$ cooling degree days for a time period with z days when ambient air temperature exceeds the cooling set temperature t_{st} (cooling days)

z number of cooling days in the time period

[6] European Commission – Eurostat, 2007

[7] European Commission – Eurostat (2007). Panorama of Energy – Energy Statistics to support EU policies and solutions, n.d

t_{st} cooling base point temperature ($t_{st} = 18$℃)

t_a daily average ambient air temperature

If the daily average temperature exceeds the reference base temperature,t_{ht}, the heating degree-day measure is set equal to zero since there is no heating requirements expected on this day. Similarly, if daily average temperature falls below t_{st}, the cooling degree-day measure is zero since there is no cooling requirements expected on this day.

b) Static factors

They are factors which do not changed with high frequency during the time such us, occupancy of the district building, heated area. This information could be obtained from the energy audit of the districts.

Vitoria

- Square meters heated: Circa 60.000 m2 expected
- Profile of occupancy in dwellings: Elderly people, young immigrant families
- Characteristic of district (number of buildings, characteristic of energy distribution system, etc.): 30 to 50 buildings fuelled by a biomass district heating system

Tartu

- Square meters heated: Circa 39.000 m2 expected
- Profile of occupancy in dwellings: 65% of residents between 18 and 65 years old
- Characteristic of district (number of buildings, characteristic of energy distribution system, etc.): There are about 100 of multi-apartment buildings in the district, 42 of them are “hruštšovka” buildings, built between 1960 and 1970. 50% of the buildings will be retrofitted. The multi-apartment buildings are connected to the district heating network, which uses biomass as fuel. Domestic hot water is produced using electricity or natural gas

Sonderborg

- Square meters heated: Circa 9.200.000 m2 (whole Sonderborg area)
- Profile of occupancy in dwellings: 20.000 one-family houses; 3.500 townhouses and 1,500 rise housing buildings
- Characteristic of district (number of buildings, characteristic of energy distribution system, etc.): There are, in total, about 66.000 buildings (30.000 of them are heated). The buildings are heated primarily through five separate district heating networks in spread out around the whole Sonderborg area

c) Reference period

It covers the period on which district will be monitored after the renovation for the calculation of the energy savings which will be at least two years.

City	Reference period
Vitoria	April 2019 – April 2021
Tartu	January 2019 – December 2020
Sonderborg	January 2019 - January 2021

d) Basis for adjustments

The adjustments term shown in equation should be computed from identifiable physical facts about the energy governing characteristics of equipment within the measurement boundary. Two types of adjustments are possible: routine and non-routine.

Routine Adjustments

For any energy-governing factor expected to change routinely during the reporting period, such as weather or production volume. A variety of techniques can be used to define the adjustment methodology. Techniques may be as simple as a constant value (no adjustment) or as complex as a several multiple parameter non-linear equations each correlating energy with one or more independent variables. Valid mathematical techniques must be used to derive the adjustment method for each M&V Plan.

Non-Routine Adjustments

For those energy-governing factors which are not usually expected to change, such as: the facility size, the design and operation of installed equipment, the number of weekly production shifts, or the type of occupants. These static factors must be monitored for change throughout the reporting period.

Examples of static factors needing non-routine adjustments are changes in the:

- Amount of space being heated or air conditioned,
- Type of products being produced or number of production shifts per day
- Building envelope characteristics (new insulation, windows, doors, air tightness),
- Amount, type or use of the facility's and the users' equipment,
- Indoor environmental standard (e.g. light levels, temperature, ventilation rate), and
- Occupancy type or schedule.

$$Savings = (Baseline\ Energy - Reporting\ period\ energy) \pm Routine\ Adjustments \pm Non\ Routine\ Adjustments$$

The adjustments terms in the previous equation are used to express both pieces of measured energy data under the same set of conditions. The mechanism of the adjustments depends upon whether savings are to be reported on the basis of the conditions of the reporting period, or normalized to some other fixed set of conditions.

e) Sampling

Due to difficult to monitoring all of dwelling of district building, it is necessary to define some sampling strategies to define which dwelling would be monitoring and that information can use for calculation the energy savings.

6.3.4 Post-retrofitting measurement

The post retrofit data campaign, as well as the baseline measurement campaign, is influenced by not-adjustable independent variables (internal/external and environmental conditions). It is necessary to measure also these variables and to associate to each campaign its environmental condition measure.

As an example, it is provided some variables from each category (not-adjustable and adjustable variables):

- Not-adjustable
  - Occupation (Air quality CO_2)
  - Air quality
  - Environmental temperature
  - Environmental humidity
  - Solar incidence
  - Wind force and direction
  - Rain
- Adjustable
  - Indoor temperature
  - Indoor humidity
  - Windows openings, shutters
  - Indoor lighting
- Energy consumptions
  - For the district/building/flat/common areas
  - Primary Energy Consumption (gas, electricity, Renewable Energy Sources, etc.)
  - For each application (heating space, Domestic Hot Water, etc.)
  - Energy for lighting, appliances

From the above list of measures, the **external temperature** has the highest influence on the ambient conditioning process and is the most responsible of variations in energy consumption. For each of the tentative parameters above it will be necessary to define which measures will be compulsory and which will be option.

6.3.5 Energy KPIs

List of KPIs proposed from the D7.2 for a posterior selection by each city. These KPIs are also extracted from the “Key Performance Indicator Guide” elaborated by Smart Cities Information System (SCIS).

List of indicators	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). 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
Delivered energy (for energy supply units)	The delivered energy of a large-scale or building-integrated energy supply unit corresponds to the energy entering the energy supply unit (e.g. energy content of light oil, electricity, district heat). To enable the comparability between energy supply units, the total delivered energy is related to the energy output of the energy supply unit (e.g. electricity, heat, cold). In case of cogeneration the input is matched to the output using an exergy based approach. This indicator represents the reciprocal efficiency of the energy supply unit. * Exergy factor: In case of polygeneration the raw energy used as input has to be allocated to the different outputs. The exergy-based approach only considers that part of energy that can be converted into mechanical work. If e.g. a CHP plant produces heat and power, the exergy of one KWh electricity is higher than the exergy of the same amount of thermal energy. Therefore the major part of the input can be assigned to the generated electricity and the smaller portion to the generated heat. This approach therefore considers how useful the forms of energy are for the final consumers.	kWhin/kWhout	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)
Primary energy (for energy supply units)		kWhin/kWhout	

List of indicators	Definition	Unit	Data source
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)
CO2 equivalent (for energy supply units)	The CO_2 emissions of a large-scale or building-integrated energy supply unit correspond to the emissions that are caused by the energy output. In different variants of this indicator the emissions caused by the production of the energy supply unit components can be either included or excluded. To enable the comparability between energy supply units, the total energy demand is related to the energy output of the energy supply unit (e.g. electricity, heat, cold). In the case of cogeneration, the input is matched to the output using an exergy-based approach.	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
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

List of indicators	Definition	Unit	Data source
Specific yield	The specific yield is the calculated or metered output energy of a supply system related to the size (capacity) of the system. It often is provided as an annual or monthly value, for closer studies a higher resolution is adequate. All energy supply units have a peak power load, heat exchangers all have a surface area, and so these are taken as the related size of the system. The system size is either described by the surface area (e.g. collector area of solar thermal systems) or the peak power (e.g. electrical power of a wind turbine).	W/(m²·K)	Estimated
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
Degree of energetic self-supply	The degree of energetic self-supply is defined as ratio of locally produced energy and the local consumption over a period of time (year). The indicators are separately determined for thermal energy (heat or cold) and electricity. Furthermore, the quantity of locally produced energy can be interpreted as by renewable energy sources (RES) produced energy or by combined heat and power (CHP) plants produced energy.	%	Estimated
Share of renewable energy	Total share of renewable energy sources in a complex energy supply system.	%	Estimated
Efficiency	Evaluation the efficiency of systems (boiler, solar collector, etc.)	%	monitored

Table 14: List of energy KPIs

KPIs selected

List of indicators	Vitoria-Gasteiz	Tartu	Sonderborg
Energy demand	YES	YES	YES
Delivered energy (for buildings)	YES	YES	YES
Delivered energy (for energy supply units)	YES	NO	NO
Primary energy (for buildings)	YES	YES	YES
Primary energy (for energy supply units)	YES	YES	YES
CO2 equivalent (for buildings)	YES	YES	YES
CO2 equivalent (for energy supply units)	YES	YES	YES
Density of energy demand	YES	YES	YES
Peak load and load profile of electricity demand	YES	YES	YES
Peak load and load profile of thermal (heating/cooling) energy demand	YES	YES	YES
Specific yield	NO	NO	NO
Degree of congruence of calculated annual final energy demand and monitored consumption	YES	YES	YES
Degree of energetic self-supply	YES	YES	YES
Share of renewable energy	YES	YES	YES
Efficiency	NO	YES	YES

Table 15: List of energy KPIs selected by the LH cities

6.4 SmartEnCity evaluation approach for Thermal comfort

6.4.1 Method selected

Considering the thermal comfort in the scope is an add-on to what is mentioned in the Grant Agreement, and each LH should decide how the will measure the impact of the interventions on it.

City	Method	Explanation
Vitoria – Gasteiz	Questionnaires and meters	Questionnaires to be distributed to the owners and tenants as part of the Social Acceptance Protocol. Internal temperatures to be gathered after the ECMs.
Tartu	Questionnaires and meters	Questionnaires to be distributed to the owners and tenants as part of the Social Acceptance Protocol. CO2 meters will be installed.
Sonderborg	Questionnaires	Questionnaires to be distributed to tenants as part of the Social Acceptance Protocol.

Table 16: Thermal comfort evaluation approach on the LH cities

6.4.2 Comfort KPIs

List of KPIs proposed from the D7.2 for a posterior selection by each city. These KPIs are also extracted from the "Key Performance Indicator Guide" elaborated by Smart Cities Information System (SCIS).

List of indicators	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
Internal relative humidity	This parameter is a percentage ratio between the quantity of vapour included in an air mass and the maximum quantity of vapour that the same air mass could include under the same conditions of temperature and pressure. This data gives information about the level of saturation of the atmospheric & vapour which value, primary for comfort conditions and ambient healthfulness, should be comprehended between 55% - 65%.	%	Meters
Internal air speed and distribution	Through this parameter it's possible to know the movement of the air inside the internal ambient. The movement of the air contributes to the healthfulness of the internal air quality level but, this same movement, in function of its speed, could also produce changes in individual comfort conditions due to the augment of the convection heat dissipation or to improper air flows.	m/s	Meters
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 17: List of comfort KPIs

KPIs selected

List of indicators	Vitoria	Tartu	Sonderborg
Internal air temperature	YES	NO	NO
Heat quantity for set point achievement	YES	NO	NO
Internal relative humidity	NO	NO	NO
Internal air speed and distribution	NO	NO	NO
Thermal comfort	YES	YES	YES

Table 18: List of comfort KPIs selected by the LH cities

6.5 Plan for the energy and comfort assessment

6.5.1 Plan for Vitoria-Gasteiz

Vitoria	
ECM	Envelope insulation and new district heating network
Objectives to be evaluated	Energy performance of the renovated dwellings and new district equipment, including energy savings and CO2 emissions reduction
Method for the evaluation of energy savings	Protocol IPMVP. Option D
Method for the evaluation of comfort	Internal temperature measurement and questionnaires
Reference period for energy assessment evaluation	April 2019 – April 2021
KPIs selected	-Energy demand -Delivered energy (for buildings) -Delivered energy (for energy supply units) -Primary energy (for buildings) -Primary energy (for energy supply units) -CO_2 equivalent (for buildings) -CO_2 equivalent (for supply units) -Density of energy demand -Peak load and load profile of electricity demand -Peak load and load profile of thermal (heating/cooling) energy demand -Degree of congruence of calculated annual final energy demand and monitored consumption -Degree of energetic self-supply -Share of renewable energy

Vitoria	
KPIs selected (continuation)	-Internal air temperature -Heat quantity for set point achievement -Thermal comfort

Table 19: Plan for the energy and comfort assessment for Vitoria-Gasteiz

6.5.2 Plan for Tartu

Tartu	
ECM	Envelope insulation and new windows Ventilation with heat recovery Heating system renovation Heat exchanger for domestic hot water PV panels
Objectives to be evaluated	Energy performance of the renovated dwellings and new district equipment, including energy savings and CO2 emissions reduction
Method for the evaluation of energy savings	Protocol IPMVP. Option C
Method for the evaluation of comfort	Questionnaires and CO_2 meters
Reference period for energy assessment evaluation	January 2019 – December 2020
KPIs selected	-Energy demand -Delivered energy (for buildings) -Primary energy (for buildings) -Primary energy (for energy supply units) -CO2 equivalent (for buildings) -CO2 equivalent (for supply units) -Density of energy demand -Peak load and load profile of electricity demand -Peak load and load profile of thermal (heating/cooling) energy demand -Degree of congruence of calculated annual final energy demand and monitored consumption -Degree of energetic self-supply -Share of renewable energy -Efficiency -Internal air temperature -Heat quantity for set point achievement -Thermal comfort

Table 20: Plan for the energy and comfort assessment for Tartu

6.5.3 Plan for Sonderborg

Sonderborg	
ECM	**Building renovation actions**: • Roof insulation • Retrofitting of existing windows and doors • LED outdoor lamps • Building Integrated PV panels • New heating control systems • New ventilation systems • New windows • Attic insulation • Facade insulation **District heating actions**, currently new large scale heat pumps in the district heating system using the sea water as heat source in order to increase heat demand with RES and heating control systems
Objectives to be evaluated	Primary energy consumption, end use energy demand, renewable energy consumption, CO2-emissions from energy production/consumption (all in the perspective of the whole Sonderborg area)
Method for the evaluation of energy savings	Protocol IPMVP. Option D
Method for the evaluation of comfort	Questionnaires
Reference period for energy assessment evaluation	January 2019 - January 2021
KPIs selected	-Energy demand -Delivered energy (for buildings) -Primary energy (for buildings) -Primary energy (for energy supply units) -CO2 equivalent (for buildings) -CO2 equivalent (for supply units) -Density of energy demand -Peak load and load profile of electricity demand -Peak load and load profile of thermal (heating/cooling) energy demand -Degree of congruence of calculated annual final energy demand and monitored consumption -Degree of energetic self-supply -Share of renewable energy -Efficiency -Thermal comfort

Table 21: Plan for the energy and comfort assessment for Sonderborg

6.5.4 Comparative Summary of the Plans for energy assessment performance

Table 22 below summarizes comparatively the plans that will be deployed regarding the energy assessment performance.

	Vitoria	Tartu	Sonderborg
Actions	Building renovation actions New district heating network	Building renovation actions PV panel integration District heating network upgrade	Building renovation actions PV panel integration District heating production equipment upgrade
Method for the evaluation of energy savings	Protocol IPMVP. Option **D**	Protocol IPMVP. Option **C**	Protocol IPMVP. Option **D**
Method for the evaluation of comfort	Internal temperature and questionnaires	Questionnaires and CO_2 meters	Questionnaires
Reference period for energy assessment evaluation	Apr 2019 – Apr 2021	Jan 2019 – Dec 2020	Jan 2019 – Jan 2021

Table 22: Comparative summary on energy assessment for the three LH

7 ICT Protocol

7.1 Scope of the protocol

The ICT protocol aims the evaluation of the final deployed ICT tools in the cities, including the urban platform. Having this in mind, it will establish a common evaluation framework based on indicators through which the effectiveness of these tools could be analysed.

7.1.1 Actions to be evaluated

ICT tools are one of the main enablers for the cities, as well as one of the main contributors for urban transformation. Multiple technologies are, or will be, developed for the integration of services at the urban level. That is the reason why the applicability of them is pivotal for ensuring the urban transformation strategy and, hence, their performance via different pillars needs to be evaluated.

First of all, it is necessary to recall the interventions that are being taken into consideration within the SmartEnCity project. Depending upon the actions carried out, the analysis and evaluation vary according to the strategy. In this way, it is remarkable that the main objective is the improvement of the existing urban platforms, if any. In summary, in SmartEnCity, the main interventions are related to:

- Implementation of an ICT urban platform, which holds urban services for the smart city transformation.
- Installation of monitoring equipment in order to gather useful information. It is notable that there are multiple monitoring devices that will be installed, but, it is not necessary that all of them are integrated into the urban platform. However, the ICT evaluation protocol does not care about it, but the final situation regarding the monitoring equipment integrated into the platform.
- Development of added value services that provide smart solutions for the citizens, decision-makers, etc. These services are also integrated into the urban platforms at top level.
- Smart solutions, named Home/Building/District Energy Management Systems (from now on HEMS, BEMS, DEMS), are also defined in order to manage the energy flows over the network.

7.1.2 Objectives to be evaluated

Depending upon the actions carried out, the analysis and evaluation vary according to the strategy. In this way, it is remarkable that the main objective is the improvement of the existing urban platforms, if any.

Once the interventions related to ICT are defined, the objectives are the following:

O1. To evaluate the improvements of the existing urban platforms themselves.
O2. To evaluate the new ICT developments and services carried out under the SmartEnCity umbrella and integrated into the existing (or newly deployed) smart urban platforms.
O3. To assess the ICT services' features, in terms of performance, such as response time, scalability and extensibility.

O4.To assess the impact that the urban platform has over the urban transformation.

It is important to distinguish objectives O1 and O2 taking Figure 7 into consideration. O1 is related to the low part of the picture, where the data acquisition systems, interfaces, harmonization layer and APIs are included. Secondly, O2 represents the upper part of the picture where the added value services are deployed.

Figure 7: Urban platform vs services

Note that the services' features are extensive, however, some of them are out of the scope of the SmartEnCity project. In other cases, it is important to highlight that are covered in other pillars. For instance, one of the main features taking the citizens into account is the usability of the services. Nevertheless, as the citizen is the focus, the usability of the ICT tools is defined within the Citizen Acceptance assessment protocol

7.2 Assessment method

One of the major concerns in the ICT tools is the lack of a standard procedure for the assessment, although several software metrics exist, which will be helpful within SmartEnCity project. In this way, a minimum set of software metrics (both direct (speed, cost, etc.) and indirect measures (quality, functionality, reliability, efficiency, maintainability, etc.)) to be measured and the measurement methods have to be established. Besides that, the desirable range of values for each measure/metric should be defined depending on the characteristics of the specific software, the place on which it will be used, etc. In that sense, under the Eurostat[8], statistical office of the European Union, had published a set of indicators related to ICT tools, as illustrated into Figure 8, where diverse areas of interest are covered where the ICT tools have impact.

1. Economic development	4. Public Health	7. Management of natural resources
2. Poverty and social exclusion	5. Climate change and energy	8. Transport
3. Ageing society	6. Production and consumption patterns	9. Good governance
Tab. 3.2 Eurostat renewed EU sustainable development indicators (Gothenburg 2001, renewed June 2006, revised by the end of 2007)		10. Global Partnership

Figure 8: Eurostat related indicators

The way Eurostat establishes the evaluation is through the digital agenda scoreboard for measuring the progress of digitalization and ways of success under the aforementioned

[8] http://ec.europa.eu/eurostat/web/sdi/indicators

pillars. That is to say how the ICT tools are contributing to these points. Of course, this number is large but not all are applicable in the SmartEnCity context. All these assets are behind policy actions that SmartEnCity translates into developments. The assets are based on the multiple indicators, such as presented on the article "Appropriate Evaluation Methods for ICT Initiatives" [9], which also defines more indicators to be taken into consideration. Apart from these resources, SmartEnCity itself has determined a set of indicators from the ICT experts' point of view, which are documented in D7.2. Additionally, the Organization for Economic Co-operation and Development (OECD) collects 15 ICT indicators that are drawn from various publications and databases produced by the OECD's Directorate for Science, Technology and Innovation[10]. As observed, most of them are already considered from the SmartEnCity perspective, although defined in a slightly modified way.

7.3 SmartEnCity evaluation approach

Having explained the aforementioned methods, SmartEnCity will follow the same strategy as the references. That is to say:

- Definition of a list of assets
- Definition of indicators for each one of the assets
- Definition of the score methodology

Additionally, it is envisaged the evaluation of the improvements regarding the urban platform in comparison with the current situation. In this way, similar to energy performance assessment, two periods are defined: baseline and post-intervention. For ICTs, the concept of baseline refers to the current status of the technology development, that could not be a numerical value, meanwhile post-intervention means the status of the platform after the deployment (both qualitative and quantitative). Also, it needs to be taken into consideration that not all the indicators are comparable between two seasons, but simply assess the features of an ICT tool. For instance, although it will be detailed below, a quantitative possibility would be the comparison between elements connected into the urban platform before and after the development. On the other hand, an example about non-comparable results would be the scalability of the platform, which is not quantifiable, but qualitative. Anyway, each of the cities decides which will be the comparable and non-comparable indicators.

According to this approach, the following categories are established in order to fulfil the objectives and developments:

- Urban development, where the improvements and performance of the urban platforms will be determined.
- Management, where the equipment integrated into the urban platforms is assessed.
- Society, where the service developments are evaluated.

7.3.1 Baseline and post-intervention design

For this protocol we will try to establish a baseline which will characterize the capabilities of the current platform in each LH. If there is no current platform, the values for the indicators will be zero. Then, after first interventions (in this case, the core intervention will be the

[9] Appropriate Evaluation Methods for ICT Initiatives B. Shadrach and Ron Summers. Loughborough University, UK. http://www.iimahd.ernet.in/egov/ifip/apr2002/article1.htm
[10] http://www.oecd.org/internet/broadband/oecdkeyictindicators.htm

deployment of the platform in each LH), the indicators will be evaluated every year (during two years) to show how the capabilities of the platforms increase along the deployment interventions.

7.3.2 KPIs

Then, having collected the indicators from previous deliverables and experiences, the total set of KPIs per category is as follows:

Category	Objectives	Indicators
Urban development	O3. To assess the ICT services' features, in terms of performance, such as response time, scalability and extensibility. O4. To assess the impact that the urban platform has over the urban transformation	Response time Scalability Extensibility Storage capacity Hours of maintenance Operating hours Non-expected hours off-line
Management	O1. To evaluate the improvements of the existing urban platforms themselves.	Number of HEMS equipment connected Number of BEMS equipment connected Number of DEMS equipment connected Number of EV connected Number of mobility equipment connected Total amount of data generated Types of measurements Percentage of equipment connected Recharging points equipment connected Smart lighting equipment connected
Society	O2. To evaluate the new ICT developments and services carried out under the SmartEnCity umbrella and integrated into the existing smart urban platforms. O4. To assess the impact that the urban platform has over the urban transformation	Number of services deployed Types of services (related to society) Percentage of dwellings connected Percentage of buildings connected APIs integrated Open data-sets available

Table 23: KPIs per category for ICT

Once the indicators and procedure are defined, the next step is to customize the whole process in each one of the cities. Then, next sections cover the customization of the aforementioned method, where the final indicators for each city are set up, as well as the way to obtain them.

7.4 Plan for the ICT assessment

In this section, the plan for the ICT assessment methodology in each city is highlighted, where three points are covered.

- Applicability of the procedure into the demo according to the current status and the further implementation of the urban platforms.
- Selection of the KPIs, where the list of "available" KPIs will be the basis for the decision. Here, the applicable and most interesting indicators will be selected.
- Finally, how the indicators will be measured. That is to say, if they are directly taken from the urban platform or any other source is required. Besides this, the units are also determined in order to set up a comparable framework.

7.4.1 Plan for Vitoria-Gasteiz

As it was noticed above, the starting point for the cities may differ. In the case of Vitoria-Gasteiz there are no ICT systems in place directly linked to the ICT interventions specified in the project. The main interventions in Vitoria-Gasteiz are related to energy efficiency, mobility and citizen engagement. It is in this last one where the city has some ICT systems on line to receive information and proposals from the citizens as a citizen inbox, but the evaluation and analysis of its content is human processed. Therefore, and taking into consideration future citizen engagement Apps for the city, it is difficult to envisage an equivalence.

Having said that, it would be not too far from reality to affirm that there is no place for an initial measurement of a baseline for the city in terms of ICTs. Thus, the focus will be in how to measure the results of the ICT interventions in the neighbourhood through the new developments under SmartEnCity.

In the previous section, a series of KPIs was proposed to measure ICTs, which, in the case of Vitoria-Gasteiz, most of them apply. Fortunately enough, because we are talking ICTs, the concept of data and indicator is inherent to the technology. Extracting numbers, indicators and making comparisons should be simple enough, as the information is contained in the system. Interpreting could be more hassle, in particular if comparisons were to be performed across cities with different systems, organisations, suppliers and priorities.

For the development, integration and deployment of the CIOP, the indicators proposed are:

KPI	Description	Measure
Response time	Measure the time the requests take to provide the information to the user (citizen or other system). Data may be taken from database engine or framework	time
Scalability	This indicator will give information on the how well the ICT systems will be replicated. The data will be obtained by counting the times each class is instantiated	Number of instances per service/class
Extensibility	Increase of sensors managed (note that currently this number is 0). Number of services implemented. This data will be a count of services and classes in the system	Number of newer services or classes implemented
Storage Capacity	As ICTs are deployed and host the data captured from sensors and operations, the storage needs will be incremented. The increase in storage need will provide information on how much the system is connected and integrated to the physical world. Calculated from the storage needs.	disk/cloud storage space
Hours of maintenance	Expressed as the time needed to upgrade the system, this information provides an insight on how much the system needs to provide newer services (demanded by users) or increase the functionality by connecting	time

	to other existing or newer systems. The data is related to the number of additional developing hours for new services	
Non-expected hours off-line	This is a measure of the down time of the system, which should be kept closest to zero. The data is the number of hours the system is not operative	time

Table 24: development, integration and deployment of the CIOP indicators proposed in Vitoria-Gasteiz

If a look is taken to the number of elements managed with the ICT systems,

KPI	Description	Measure
# of HEMS connected	This is related to the number of sensing systems installed in the dwellings and integrated into the urban platform. It can be easily obtained from the instances declaration in the Platform	Units
# of BEMS connected	Number of systems installed per building, related to common operations (not dwellings), integrated in the platform. It can be easily obtained from the instances declaration in the Platform	Units
# of EV connected	Electric vehicles integrated the platform. Could be further enhanced with vehicle class definition (cars, bikes, etc.) Measure the number of classes and number of instances of each in the platform declarations	Units (per class)
# of mobility equipment connected	Other equipment integrated to the platform and also related to mobility. Measure the number of classes and number of instances of each in the platform declarations	Units (per class)
Total amount of data generated	This will measure the amount of data generated. Obtained from the storage used.	Disk/cloud storage space
Types of measurements	This relates to the magnitude definition of the data (temperature, energy, speed, etc.) It will be obtained from the magnitudes of the data definitions in the city data model	Units
Percentage of equipment connected	This relates to the degree of achievement of the intervention to existing system. This data will be obtained from the number of elements managed with the platform comparing to the total number of candidate elements.	Percentage
Recharging points equipment connected	This relates to the number of EV post installed in the City. Count of instances of this class.	Units
Smart lighting equipment connected	This relates to the number of streetlights installed in the City and managed with the platform. Count of instances of this class.	Units

Table 25:KPIs for the elements managed with the ICT systems in Vitoria-Gasteiz

Finally, for the elements related to the application of ICTs for the citizen, the evaluation protocol should implement the following:

KPI	Description	Measure
Number of services developed	Relates to the amount of services based on ICTs to offered citizens and third parties. The KPI will be the count of services implemented	Units
Types of services	The services will be classified by area (mobility, engagement, energy efficiency, management, etc.). The count of services deployed for each area will be measured.	Classification/ units
Percentage of dwellings connected	This relates to the success of the system deployment throughout the project implementations. The KPI will be calculated considering how many are on-line out of the number considered in the actions	Percentage
Percentage of Buildings connected	This relates to the number of buildings with common systems connected. The KPI will be calculated considering how many are on-line out of the number considered in the actions	Percentage
APIs integrated	This will measure the ease of connectivity for third parties to provide services through the ICT system. The measure will be the number of APIs developed for interoperability	Units
Open-Data sets available	This indicates the availability of data for citizens and third parties for evaluation and service building. The sets considered will be related to the services defined before.	Units

Table 26: KPIs to evaluate the application of ICTs for the citizen in Vitoria-Gasteiz

The next steps in the implementation of this methodology will be developed under D7.9, where, after collecting data, the aforementioned KPIs will be analysed. This final analysis will compare the current situation in contrast to the new developments with the aim of evaluating the improvements carried out for the ICT implementation. Nevertheless, in Vitoria-Gasteiz, as no platform is already deployed, the assessment will consist in determining the final KPIs and these will be directly the improvement.

7.4.2 Plan for Tartu

At the current status, Tartu does not have any city information platform that gathers energy related data from buildings and districts. Due to that fact, the current status of estimation for the indicators is “0”. However, further developments according to the design within WP6 will be implemented in order to automatically gather information by CIOP platform and, in this way, determine a set of KPIs that indicate the performance. This will support the automatic calculation of some of the selected KPIs that are detailed below. However, some other indicators (for example: open data-sets available, number of services deployed, types of services (related to society), response time, scalability, extensibility, storage capacity, hours of maintenance, operating hours, non-expected hours off-line) will be calculated manually based on the information from ICT platform.

In short, the ICT solution will be based on IoT (Internet of Things) technologies that gather information from a number of various sensors. The real-time sensor data is gathered

centrally in a secured distributed cloud platform where it can be analysed. The sensors are deployed at various levels such as the city and city block (for example traffic monitoring), one house (building energy consumption) and a single apartment (controlling each radiator etc.). These levels are important from data aggregation, comparison and reporting perspective (how is one building doing compared to another) as well as authorization (for example access to city block aggregated data can be public but individual apartment data is not).

Having explained the status and methodology, the next step is the decision of the indicators, which are remarked in the table below.

KPI	Description	Measure
Response time	Measurement of time during which the system conforms to the request from outside the system. Data will be taken from database engine.	Time
Scalability	This indicator will give information on the how well the ICT systems will be replicated. The data will be obtained by counting the times each class is instantiated	Number of instances per service/class
Extensibility	Number of sensors and services integrated. Data will be taken from the platform itself.	Number of services or classes integrated
Storage Capacity	Total storage space in use needed to service the system. Data will be taken from the platform itself.	Disk/cloud storage space
Hours of maintenance	Time needed to upgrade and development of the system due to integration of new services and classes. Data will be calculated on basis of information from system.	Time
Non-expected hours off-line	The number of hours the system is not in operation. Data will be taken from the platform itself.	Time
KPI	Description	Measure
# of HEMS connected	Number of sensing systems installed in the dwellings and integrated in the CIOP. Data will be taken from the platform itself.	Units
# of BEMS connected	Number of sensing systems installed per building and integrated in the CIOP. Data will be taken from the platform itself.	Units
# of EV connected	Number of electric vehicles integrated to the system. Data will be taken from the platform itself.	Units (per class)
# of mobility equipment connected	Number of other mobility related equipment integrated to the system. Data will be taken from the platform itself.	Units (per class)
Total amount of data generated	The amount of data generated by the system. Data will be taken from the platform itself.	Disk/cloud storage space
Recharging points equipment connected	The number of EV recharging units installed in the pilot area and integrated into the CIOP. Data will be taken from the platform itself.	Units

Smart lighting equipment connected	The number of streetlights installed in the pilot area and managed by the system. Data will be taken from the platform itself.	Units
KPI	Description	Measure
Number of services developed	The amount of services based on ICTs offered to citizens and third parties. Data will be gathered manually using information from the system and questionnaires.	Units
Types of services	The services will be classified by area (mobility, engagement, energy efficiency, management, etc.). Data will be gathered manually using information from the system and questionnaires.	Classification/units
Percentage of dwellings connected	The percentage of dwellings of pilot area connected to the system. Data will be gathered from the platform itself.	Percentage
Percentage of Buildings connected	The percentage of dwellings of pilot area connected to the system. Data will be gathered from the platform itself.	Percentage
Open-Data sets available	Available number of data sets for citizens and third parties for evaluation and service building. Data will be gathered from the platform itself.	Units

Table 27: KPIs for the ICT evaluation plan in Tartu

Regarding the calculation of these indicators, the number of equipment connected is very simple because is simply counting, but there are more abstract indicators (e.g. response time) that need further analysis about how to deal with them, as well as alignment with the other demos so as to provide a comparable framework. This will be determined according to the developments in WP6, as well as D7.9 where the evaluation will take place.

In addition, in case of current status, it must be evaluated at M18 and it must provide all the details for the procedure for collecting data.

7.4.3 Plan for Sonderborg

In Sonderborg, the platform will be based on SCIOSS, which is shortly described here. SCIOSS is the platform for Internet of Things. Many concepts today are powered by SCIOSS. The SCIOSS platform has 4 main areas:

- Security - to control security and access rights.
- Interoperability - to share data with other systems.
- Interconnection - to gather data from devices and other systems.
- Services - to send data and information.

SCIOSS is a well-known system running for more than 15 years. In the earlier days simple web pages were showing data from devices using old fashioned data line communication. Today it is known as IoT and every device is on the Internet and all is cloud based. The SCIOSS backend system consists of more than 15 services running on 12 virtual machines.

Interoperability

SCIOSS is built to share data among different systems and to connect to a range of manufacturers. The range of standard APIs supported in SCIOSS;

- RoadPrint - data from vehicles and tasks.
- VMS - data from any logged data.
- ProPower - billing data for accountant (to be decided).
- SmartEnCity - data from energy sources.

Interconnection

The IoT Gateway devices are constantly monitored and online. Any sensor, signal or meter can connect and communicate. The IoT Gateways have 3 focus areas:

- Stationary - for wall or cabinet mounting. In general used in the industry or in private locations. The purpose is to monitor processes and log data.
- Mobile - for mounting in vehicles of any kind. Purpose is to track vehicles and interconnected data form signals.
- Charger - is for charging electrical vehicles intelligent.

Services are a range of helpers to fetch external information into the system. For example, prices for electricity are daily fetched form Nordpool. IoT devices can intelligently use this information so for example a pump only runs during the 20 cheapest hours pr. day.

Services

Different services are accessible for the users:

- Get alarms or warning as SMS or E-mail.
- Download data.
- Send GPS data to the Danish road directorate.
- Range of APPs

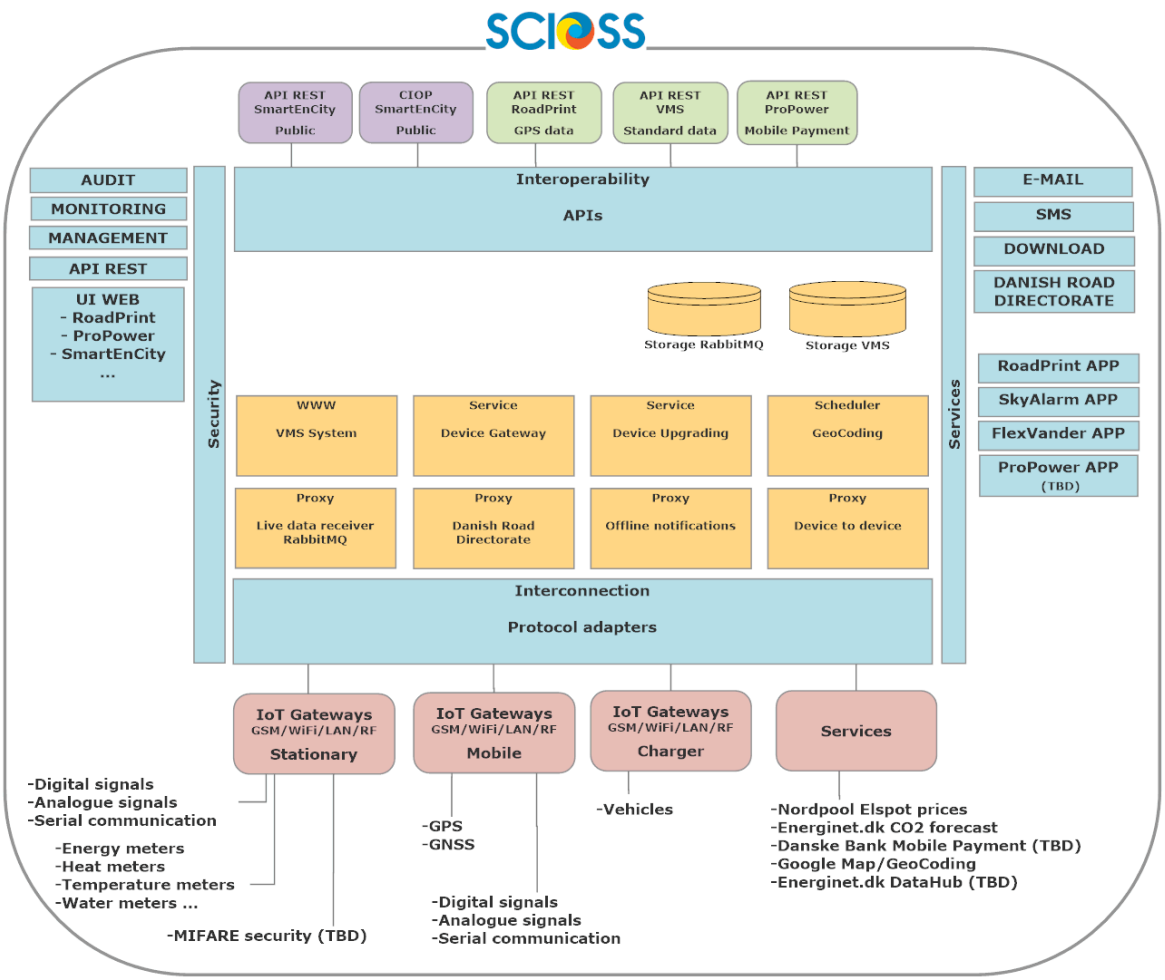

Figure 9: Schema for the SCIOSS platform

According to the aforementioned framework that will base the development of the urban platform in Sonderborg, a set of KPIs can be selected to evaluate the final situation. This list is detailed below.

KPI	Description	Measure
Response time	Depending on request type	Time
Scalability	SCIOSS Scalability is defining SCIOSS horizontal and vertical scaling. SCIOSS support horizontal scaling (scale out/in): - Add new nodes such as adding new blade (computer). - Scaling out from x Web Server systems to more Web systems on more nodes. SCIOSS support vertical scaling (scale up/down): - Virtualization technology is used. - Single node scale up such as increase CPU power, memory or storage.	Number of instances per service/class
Extensibility	SCIOSS interoperability is the ability to share data with other systems and support for sensors by different manufactures.	Number of services or classes integrated

	The physical IoT gateway device support drivers for a range of sensors and meters by different manufactures. The physical Web Services support open standards for data exchange with other systems.	
Storage Capacity	Extendable – cloud based	Disk/cloud storage space
Hours of maintenance	Time to keep system running and patch-up	Time
Non-expected hours off-line	The number of hours the system is not in operation.	Time
KPI	Description	Measure
# of HEMS connected	Number of sensing systems installed in the dwellings and integrated in the CIOP.	Number
# of BEMS connected	Number of sensing systems installed per building and integrated in the CIOP.	Number
# of EV connected	Number of electric vehicles integrated to the system.	Number (per class)
# of mobility equipment connected	Number of other mobility related equipment integrated to the system.	Number (per class)
Total amount of data generated	The amount of data generated by the system.	Disk/cloud storage space
Recharging points equipment connected	The number of EV recharging units installed in the pilot area and integrated into the CIOP.	Number
Smart lighting equipment connected	The number of streetlights installed in the pilot area and managed by the system.	Number
KPI	Description	Measure
Number of services developed	The amount of services based on ICTs offered to citizens and third parties.	Number
Types of services	The services will be classified by area (mobility, engagement, energy efficiency, management, etc.).	Classification/units
Percentage of dwellings connected	The percentage of dwellings of pilot area connected to the system.	Percentage
Percentage of Buildings connected	The percentage of dwellings of pilot area connected to the system.	Percentage
Open-Data sets available	Number of web service functions.	Number

Table 28: KPIs for the ICT evaluation plan in Sonderborg

The next steps in the implementation of this methodology will be developed in D7.9, where the KPIs will be analysed. This final analysis will compare the current situation in contrast to the new developments with the aim of evaluating the improvements carried out for the ICT implementation. Nevertheless, in Sonderborg, as no platform is already deployed, the assessment will consist in determining the final KPIs and these will be directly the improvement.

The current status will be evaluated in M18 and must provide all the details for the procedure for collecting data.

7.4.4 Comparative Summary for the Plans for evaluating ICT solutions

This section simply summarizes the content in terms of KPIs to be calculated in the three demos with the aim of having in a single table the KPIs and determine very easy the KPIs that are common between all the developments.

City	Objectives	KPIs	
Vitoria - Gasteiz	O1	Response time	Types of measurements
	O2	Scalability	Percentage of equipment connected
	O3	Extensibility	Recharging points equipment connected
	O4	Storage Capacity	Smart lighting equipment connected
		Hours of maintenance	Number of services developed
		Non-expected hours off-line	Types of services
		# of HEMS connected	Percentage of dwellings connected
		# of BEMS connected	Percentage of Buildings connected
		# of EV connected	APIs integrated
		# of mobility equipment connected	Open-Data sets available
		Total amount of data generated	
Tartu	O1	Response time	# of mobility equipment connected
	O2	Scalability	Total amount of data generated
	O3	Extensibility	Recharging points equipment connected
	O4	Storage Capacity	Smart lighting equipment connected
		Hours of maintenance	Number of services developed
		Non-expected hours off-line	Types of services
		# of HEMS connected	Percentage of dwellings connected
		# of BEMS connected	Percentage of Buildings connected
		# of EV connected	Open-Data sets available
Sonderborg	O1	Response time	# of mobility equipment connected
	O2	Scalability	Percentage of equipment connected
	O3	Extensibility	Recharging points equipment connected
	O4	Storage Capacity	Smart lighting equipment connected
		Hours of maintenance	Number of services deployed
		Operating hours	Types of services (related to society)
		# of HEMS equipment connected	Percentage of dwellings connected
		# of BEMS equipment connected	Percentage of buildings connected
		# of DEMS equipment connected	APIs integrated
		# of EV connected	

Table 29: Comparative summary of the ICT evaluation plans for the three LH

8 LCA Protocol

Life Cycle Assessment (LCA) is an environmental tool that allows the compilation and evaluation of the inputs, outputs and the potential environmental impacts of a product system throughout its life cycle (ISO 14040:2006).

The LCA methodology is clearly described by the following international standards:

- ISO 14040:2006. Environmental management. Life Cycle Assessment. Principles and framework.
- ISO 14044:2006. Environmental management. Life Cycle Assessment. Requirements and guidelines.

The LCA methodology is structured in four steps, as it can be seen in Figure 10.

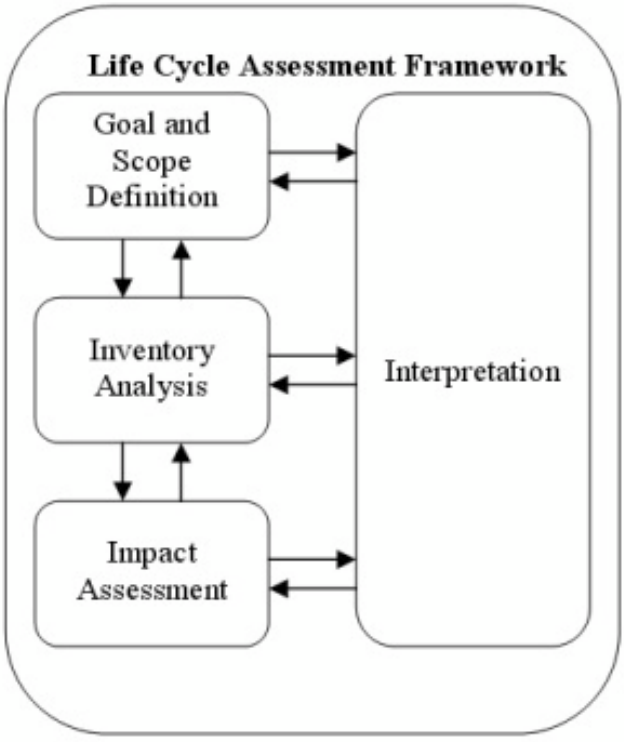

Figure 10: Life Cycle assessment framework

1. - Goal and scope:

The first stage of the LCA methodology defines why the assessment is developed, which the target audience is, and some important decisions, among others, as:

- Functional unit selection
- System boundaries
- Impact indicators selection

2. - Inventory analysis:

In this stage, the complete information about the system studied is collected, including energy and material inputs and outputs, as well as emissions to air, soil and water. Special attention must be paid to the data quality and the acquisition methods.

3. - Impact assessment:

After inventory compilation, classification and characterization are developed in this stage, in order to sort the inventory according to the effect on the environment and the multiplication by a factor in order to evaluate its contribution to that effect. Depending on the indicators selected, other stages (normalization or weighting are optional).

4. - Interpretation:

The final conclusions of the study are obtained in order to select strategies to improve the environmental performance of the system evaluated.

In this section, a simplified protocol for the LCA development in the framework of the project SmartEnCity will be developed and will be applied in the three demonstration cities, in order to determine the sustainability of the activities of the project considering the whole life cycle of the retrofitting action and the building performance.

8.1 Scope of the protocol

8.1.1 Objectives to be evaluated

Some of the SmartEnCity objectives which are persuaded are closely related to the sustainability, including:

- To achieve a sustainable, smart and resource-efficient urban environments
- Reduce the environmental impact in the district
- Keep city carbon footprint and energy demand to a minimum

Therefore, as potential objectives to be evaluated, the LCA Protocol could be focused on:

- The reduction of environmental impacts due to the district intervention
- The reduction of environmental impacts due to the mobility action.

Although Life Cycle Assessment (LCA) is an environmental tool commonly used to evaluate products, processes and services, it seems quite complex to include the whole activities to be developed under the framework of the Project SmartEnCity. Thus, taking into account that the project only intends to apply a LCA analysis for the district intervention, the mobility action will not be evaluated.

All the partners involved have agreed that ***EN 15978:2011***. *"Sustainability of construction works. Assessment of environmental performance of buildings. Calculation method"* is the most adequate standard to follow, because, according to the proposal, it has been stated that the methodology for the LCA evaluation should be very simple due to the complexity of the intervention, and must be based on existing standards methods.

Following the EN 15978:2011, the consortium will be able to assess the present situation of the buildings, but also will obtain information about the potential improvements after the retrofitting actions, accounting the environmental impacts of the retrofitting but also the environmental benefits of the potential energy savings and efficiency in the building.

8.1.2 Actions to be evaluated

In this case, the LCA approach will be developed for the *District intervention*, focusing on:

- the building retrofitting actions,
- the infrastructures involved,
- the energy consumption (including thermal and electricity).

A summary of the actions to be evaluated is shown in table 8.1. This table includes the main actions developed in each demo, as well as the main infrastructures involved before and after the retrofitting actions. Thermal and electricity energy is also included as the main input during the using phase of the building.

	Vitoria-Gasteiz	Tartu	Sonderborg
Energy conservation measures in building retrofitting actions	Envelop insulation Roof insulation New windows	Envelop insulation Roof insulation New low energy windows Heat recovery ventilation system Reconstructing the central heating system based on adjustability and mounting thermostatic valves with limiters to radiators	Envelop insulation Roof insulation Retrofitting of existing windows and doors New ventilation systems LED outdoor lamps Lighting control Building Integrated PV panels Solar thermal panels
Integrated infrastructures	**Before district actions,** the heating system consists in natural gas boilers (80% correspond with individual boilers and 20% with centralized boilers) **After district actions**, the heating system will be a new biomass district heating network (chips)	**Before district actions**, the heating system is based on district heating networks (cooling plant) working with wood chips. Hot water is produced with individual boilers using electricity **After district actions**, the heating system will be according to the installation of solar panels in the cooling plant for the plant's own energy needs but also heat exchangers will be upgraded to improve the efficiency of plant and produce hot water for the buildings	**Before district actions**, the heating system consists on a district heating system working with RES (solar thermal, geothermal and waste-cogeneration) and fossil fuels. **After district actions**, new large scale heat pumps in the district heating system using the sea water as heat source in order to increase heat demand with RES and heating control systems
Energy	Thermal and electricity consumption	Thermal and electricity consumption	Thermal and electricity consumption

Table 30: Actions to be evaluated in each city

Actions to be considered in each city are detailed in table below

City	Actions to be evaluated
Vitoria	Building retrofitting actions Integrated infrastructures Energy
Tartu	Building retrofitting actions Integrated infrastructures Energy
Sonderborg	Building retrofitting actions Energy

Table 31: Actions to be considered in each LH city

8.2 Assessment methods

As it has been previously reported, existing methodologies, according to the corresponding standards, will be used during the LCA study (table 8.2).

Methodology	Standard
Life Cycle Assessment	ISO 14040:2006. Environmental management. Life Cycle Assessment. Principles and framework. ISO 14044:2006. Environmental management. Life Cycle Assessment. Requirements and guidelines.
Sustainability assessment in buildings	EN 15978:2011. Sustainability of construction works. Assessment of environmental performance of buildings. Calculation method.

Table 32: Assessment methods and standards

Working under the framework of the Life Cycle Assessment methodology, covered by ISO 14040 and ISO 14044, the LCA deployment will be developed according to the EN 15978 scheme.

The four previous stages of the LCA methodology (Goal and scope, Life cycle inventory, Life cycle impact assessment and Conclusions) will be articulated according to the following seven main stages reported in the EN 15978:

1. - Objective of the study

Objective: A clear definition of what are the main objectives of the LCA study must be detailed, as a sum of the objectives of the three demos involved in the Project. It would be aligned with the type of KPIs selected.

2. - System definition

Functional unit: According to the ISO 14044 standard, the functional unit should be defined as the reference unit through which a system performance is quantified in a LCA. This should be a measurable unit for describing the function of the assessed object; serving as basis to relate the obtained results of the analysis. It must be the same for the baseline and the Project scenario.

Reference study period: Definition of the time to be reported in the environmental assessment. It must be the same for the baseline and the Project scenario.

System boundaries: The definition of what is included and what excluded for assessment. Key steps in the process. For example, energy for heating will be included in both scenarios, but whereas individual heating boilers could take part of baseline scenario the project scenario could consist of district heating using biomass.

Building modelling (physical): Determination of what materials/structures will be included considering that the project studies a retrofitting action.

3. - Description and configuration of scenarios for the baseline and project scenarios

Building modelling: It includes the processes that can be included in the analysis, depending on the time selected for the assessment such as maintenance, replacement, repair, etc

Life cycle stages: It consists of the stages to be included in the analysis (e.g. product stage, construction process stage, use stage and end-of life stage).They take part of the Modules A, B and C from the scheme of the building assessment information.

Life cycle stages scenarios: To be modelled according to the scope selected.

Environmental advantages beyond the system boundaries: To be established in Module D separately.

4. - System quantification. The quantification of all materials and products are determined based on the intended description of the evaluation object or with the actual quantities and scenarios for each life cycle module of the evaluation object.

Net amount: It correspond with the net units of products, components, materials and elements of the building.

Gross amount: This coincides with the previous value but including also the losses.

Type of data: Different types of data can be collected, depending on the Life Cycle Stage, availability, geographical sources, suppliers' sources, real values, estimated values, generic data, proxy data, selection and preferences.

5. - Environmental data selection (for the baseline and the project scenarios).

EPD use: Use of Environmental Product Declarations (EPD) when they are available. It is a document that provides quantified and verifiable information on the environmental performance of a product, material or service.

Other info use: Selection and identification of other required information.

Data quality and consistency: Current data, geographical, annual average, technological validity, etc., in order to have robust data for the assessment.

6. - Environmental calculation (for the baseline and the project scenarios)

Environmental aspects and impacts: To be decided by the consortium.

Evaluation methods: To be decided by the consortium.

7. - Reporting and communication.

General information & Evaluation results: According to EN 15978, section 12.6.

On the other hand, EN 15978 covers a list of indicators that are included in the table below. Such list has been provided to the representative partners of the cities for this protocol for the selection of the most convenient indicators.

Type of indicator	Code	Indicator	Unit
Environmental impact	EI_1	Global warming potential	kg CO_2 eq
	EI_2	Depletion potential of the stratospheric ozone layer	kg CFC 11 eq
	EI_3	Acidification potential of land and water	kg SO_2 eq
	EI_4	Eutrophization potential	kg PO_4^{-3} eq

	EI_5	Formation potential of tropospheric ozone photochemical oxidants	kg C_2H_2 eq
	EI_6	Abiotic resources depletion potential of elements	kg Sb eq
	EI_7	Abiotic resources depletion potential of fossil fuels	MJ
Resources use	RU_1	Use of renewable primary energy excluding energy resources used as raw material	MJ
	RU_2	Use of renewable primary energy resources used as raw material	MJ
	RU_3	Use of non-renewable primary energy excluding energy resources used as raw material	MJ
	RU_4	Use of non-renewable primary energy resources used as raw material	MJ
	RU_5	Use of secondary material	kg
	RU_6	Use of renewable secondary fuel	MJ
	RU_7	Use of non-renewable secondary fuel	MJ
	RU_8	Net use of fresh water	m^3
Waste categories	WC_1	Hazardous wastes disposed	kg
	WC_2	Non-hazardous wastes disposed	kg
	WC_3	Radioactive waste disposed	kg
Output flows	OF_1	Components for re-use	kg
	OF_2	Materials for recycling	kg
	OF_3	Materials for energy recovery (not being waste incineration)	kg
	OF_4	Exported energy	MJ

Table 33: List of indicators proposed to the LH cities

8.3 SmartEnCity evaluation approach

In this section, some of the main decisions taken by the partners involved in this protocol are collected and explained, in order to develop the LCA study according to the methodology selected, which were described in the section before.

Functional unit

The functional unit will be 1 m^2 * yr, considering the specific building type, occupancy and usage characteristics that will be specified by the three cities.

Although data collection may be carried out considering gross building values, the final results will be expressed in terms of the functional unit selected.

Reference study period

The reference study period is an important decision to be taken. Considering that the main objective is to compare the baseline scenario vs. the project scenario of each district, and also considering that each district has its own characteristics, it has been decided that each district will be responsible of the selection of the reference study period, which must be clearly justified.

In the table 8.3 it can be seen the reference study period selected by each district.

	Vitoria-Gasteiz	Tartu	Sonderborg
Reference study period	50 years	30 years	30-40 years (still to be decided)

Table 34: Reference study period

Data will be collected considering this reference study period. Nevertheless, the final results could be expressed in 1 year basis, so “similar time period” results will be available.

System boundaries

The systems boundaries will include the following actions:

- the building retrofitting actions,
- the infrastructures involved,
- the energy consumption (including thermal and electricity).

They are explained in detail in table 8.1.

Regarding to the infrastructures involved in the project scenario, the partners have agreed to be considered them as optional, taking into account that the objective of the LCA study is focused on renovation actions and that a simplify approach has been selected.

Nevertheless, each partner will justify why the infrastructure is in or out of the scope.

In order to clarify the scope of the study and the system boundaries, EN 15978 provides a scheme of the building assessment information (Figure 11).

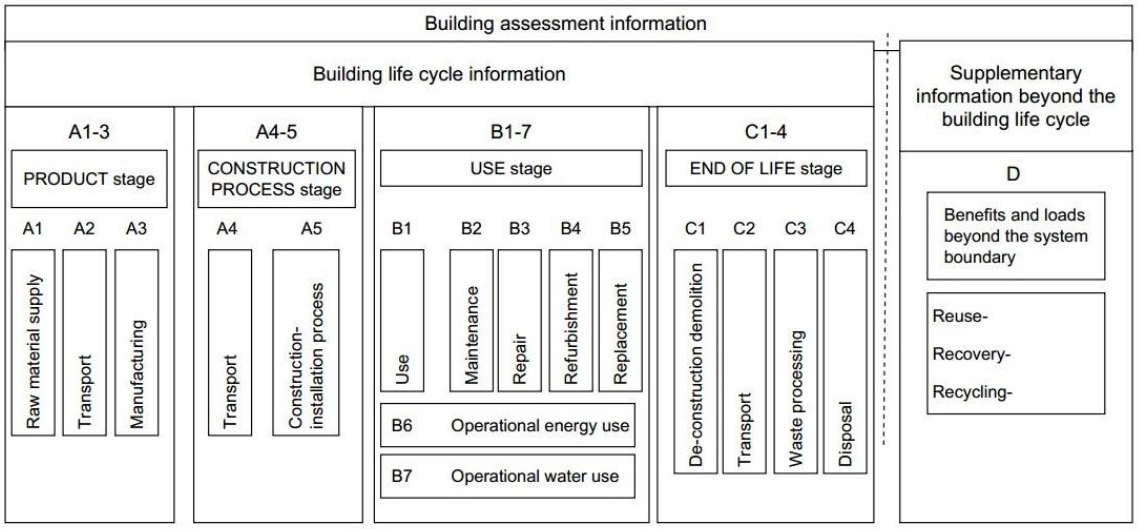

Figure 11: Building assessment information according to EN 15978:2011

This scheme will be adopted by the three cities, in order to develop the same approach in the three of them.

Baseline scenario and project scenario

Two scenarios in each city will be assessed, following the EN 15978:2011

Baseline scenario	The baseline scenario includes the district performing according to the current district situation.
Project scenario	The project scenario includes the district performing during the reference study period including the actions involved in the project (retrofitting, infrastructures and energy consumption).

Considering that this study is not related to the construction of a new building, a first assumption can be made including only the project intervention measures (along their life cycle) and the energy consumption. The rest of the building will be out of the scope, as well as water consumption.

Working this way will allow the consortium to focus on the relation between the energy conservation measures, the integrated infrastructures, and the improvement in energy consumption and efficiency.

Key performance indicators

The indicators selected for the cities are presented in table 8.4, extracted, most of them, from the CEN TC 350.

Type of indicator	Code	Indicator	Unit
Environmental impact	EI_1	Global warming potential	kg CO_2 eq
	EI_2	Ecological footprint	ha
Resources use (*)	RU_1	Use of renewable primary energy excluding energy resources used as raw material	MJ
	RU_2	Use of renewable primary energy resources used as raw material	MJ
	RU_3	Use of non-renewable primary energy excluding energy resources used as raw material	MJ
	RU_4	Use of non-renewable primary energy resources used as raw	MJ
Waste categories	WC_1	Hazardous wastes disposed	kg
	WC_2	Non-hazardous wastes disposed	kg
Output flows	OF_1	Exported energy	MJ

(*) *The four indicators of the "Resources use" can be calculated with the Cumulative Energy Demand*

Table 35: Key Performance indicators selected form EN 15978

The definition of each indicator is described in the table below.

Indicator	Description
Global warming potential	Index that attempts to integrate the overall climate impacts of a specific action. It relates the impact of emissions of a gas to that of emission of an equivalent mass of CO2. The duration of the perturbation is included by integrating radiative forcing over a time horizon (e.g., standard horizons for IPCC have been 20, 100, and 500 years). The time horizon thus includes the cumulative climate change and the decay of the perturbation. 100 years has
Ecological footprint	The Ecological Footprint is defined as the area of productive land and water ecosystems required to produce the resources that the system needs and assimilate the wastes generated.
Use of renewable primary energy excluding energy resources used as raw material	For this four indicators, using the environmental indicator Cumulative energy demand, it will be able to separate the primary energy in renewable and non-renewable, as well as energy used for raw material and other uses
Use of renewable primary energy resources used as raw material	
Use of non-renewable primary energy excluding energy resources used as raw material	
Use of non-renewable primary energy resources used as raw material	
Hazardous wastes disposed	Amount of hazardous and non-hazardous wastes disposed during the life cycle of the district intervention according to the current European legislation. Directive 2008/98/EC and Annex III to Directive 2008/98/EC
Non-hazardous wastes disposed	
Exported energy	Energy that is produced in the context of the district studied that can be exported from the system to other use out of the systems boundaries.

Table 36: Key Performance indicators description

8.3.1 Baseline design

In this section, the procedure for the baseline scenario LCA study will be developed. The project will follow the building assessment information scheme according to EN 15978:2011.

The baseline will provide the reference values in order to validate, from the environmental point of view, the actions developed in the SmartEnCity project.

The baseline scenario is assumed to consider the current district performance, in order to be studied during the reference study period selected by each city, and considering the use stage, end of life and energy consumption of the building. This implies that no retrofitting actions are considered.

A short description of the categories described in figure 8.2 will be elaborated for the baseline scenario, as a general approach, that must be interpreted by each city in its particular context during the LCA development.

A1-A3. PRODUCT stage

In this stage the raw material supply, transport and manufacturing of the components of the retrofitting materials and the integrated infrastructures are considered.

A1	Raw material supply	This category includes all the materials used in the retrofitting components and the integrated infrastructure	As no retrofitting or integrated infrastructure actions are developed in the baseline scenario, this stage is not included in the LCA
A2	Transport	This category covers the flow of materials from the raw material source to the manufacturing plant	
A3	Manufacturing	This category refers to the manufacturing process of the retrofitting components and integrated infrastructure	

Table 37: Product stage for the baseline scenario

A4-A5. CONSTRUCTION PROCESS stage

In this stage, the transportation from the manufacturing plant to the district is considering, as well as the incorporation of the materials to the district.

A4	Transport	This category includes the transportation of the materials from the manufacturing place to the district.	As no retrofitting or integrated infrastructure actions are developed in the baseline scenario, this stage is not included in the LCA
A5	Construction – installation process	This category incorporate the activities related to the installation of the retrofitting and integrated infrastructures in the district	

Table 38: Construction process stage for the baseline scenario

B1-B7. USE stage

All the activities developed by the district are considered in the use stage, including energy consumption and actions related to the building or district structure or components, including repair, retrofitting, substitution, etc.

B1	Use	Impacts and aspects from the existing components of the building, considering that no intervention is developed.	E.g. Emissions from façade, floors, cover, other surfaces… In some cases info may not be available
B2	Maintenance	Maintenance operations for the building considering no project intervention (only for the elements selected. i.e., the equivalents to those included in the project scenario)	E.g.: Production and transportation of auxiliary material necessary for maintenance, cleaning processes (inside and outside the building), maintenance operations for technical and functional performance of the equipment of the building. Each city must identify the maintenance operations for the different components and infrastructures in the existing building.
B3	Repair	Repair operations for the building considering no project intervention (only for the elements selected. i.e., the equivalents to those included in the project scenario)	E.g.: Repair of components, including production, transportation of new components, installation and remove process, transportation and end of life of eliminated components due to reparation process. Each city must identify the repair operations for the different components and infrastructures in the existing building.
B4	Refurbishment	Refurbishment operations for the building considering no project intervention (only for the elements selected. i.e., the equivalents to those included in the project scenario)	E.g.: Substitution of components, including production, transportation of new components, installation and remove process, transportation and end of life of eliminated components due to substitution process. Each city must identify the refurbishment operations for the different components and infrastructures in the existing building.
B5	Replacement	Replacement operations for the building considering no project intervention (only for the elements selected. i.e., the equivalents to those included in the project scenario)	E.g.: Production of the new components of the building, transportation and construction actions. Waste and end of life products management Each city must identify the replacement operations for the different components and infrastructures in the existing building.
B6	Operational energy use	Energy use for the building considering no project intervention	E.g.: Energy use by the systems integrated in the building during its operation, including heating, sanitary hot water, conditioned air, ventilation, illumination, auxiliary energy for pumps, controls, etc. Elevators, mechanical stairs, security systems, communication, must be communicated in a separate section. Please consult EN 15978 for energy exports The energy protocol will be involved in this category
B7	Operational water use	Water, including drinking water, sanitary water, hot sanitary water, etc.	The partners decided to exclude this category, because there is no strength relation with the objectives of the project

Table 39: Use stage for the baseline scenario

C1-C4. END OF LIFE stage

In this stage, the end of life will be considered, assessing the impacts divided in the following categories

C1	De-construction demolition	Deconstruction-demolition only for the elements selected in the baseline scenario	Each scenario must clarify if the deconstruction of the whole building / district is considered. In a first approach, only the equivalents elements to the project scenario should be considered.
C2	Transport	Transportation for final destination only for the elements selected in the baseline scenario	Each city should identify the final flows location
C3	Waste processing	Waste processing (recycling, reuse, energy recovery, etc…) for final destination only for the elements selected in the baseline scenario.	Just in case that the wastes needs processing for the final disposal
C4	Disposal	Include loads for final disposal.	Final disposal must be identified

Table 40: End of life for the baseline scenario

D. Loads and benefits beyond the system stage

The partners involved in LCA protocol have agreed to exclude this section, which will be only considered if a very clear case occurs.

8.3.2 Post-intervention design

In this section, the procedure for the project scenario LCA is developed. In the same way as the baseline scenario, the project will follow the building assessment information scheme according to EN 15978:2011.

Considering that this study is not related to the construction of a new building, a first assumption can be made including only the project intervention measures (along their life cycle) and the energy consumption. The rest of the building will be out of the scope, as well as water consumption.

Working this way will allow the consortium to focus on the relation between the energy measures and the improvement in energy consumption and efficiency.

A short description of the categories described in figure 8.2 will be illustrated for the project scenario, as a general approach, that must be interpreted by each city in its particular context during the LCA development.

A1-A3. PRODUCT stage

In this stage the raw material supply, transport and manufacturing of the components of the retrofitting materials and the integrated infrastructures are considered.

A1	Raw material supply	This category includes all the materials in the retrofitting components and the integrated infrastructure	Each city will have to develop a clear description of the components involved in the retrofitting actions and the infrastructure involved. Apart from composition, transport and manufacturing of the components must be addressed
A2	Transport	This category covers the flow of materials from the raw material source to the manufacturing plant	
A3	Manufacturing	This category refers to the manufacturing process of the retrofitting components and integrated infrastructure	

Table 41: Product stage for the project scenario

A4-A5. CONSTRUCTION PROCESS stage

In this stage, the transportation from the manufacturing plant to the district is considering, as well as the incorporation of the materials to the district

A4	Transport	This category includes the transportation of the materials from the manufacturing place to the district.	The retrofitting components and the infrastructures transportation to the district must be considered, as well as the installation
A5	Construction – installation process	This category incorporate the activities related to the installation of the retrofitting and integrated infrastructures in the district	

Table 42: Construction process stage for the project scenario

B1-B7. USE stage

All the activities developed by the district are considered in the use stage, including energy consumption and actions related to the building or district structure or components, including repair, retrofitting, substitution, etc. Some assumptions will have to be considered.

B1	Use	Impacts and aspects from the existing components of the building, considering that no intervention is developed.	E.g. Emissions from façade, floors, cover, other surfaces… In some cases info may not be available
B2	Maintenance	Maintenance operations for the building considering the project intervention (only for the elements included in the project scenario)	E.g.: Production and transportation of auxiliary material necessary for maintenance, cleaning processes (inside and outside the building), maintenance operations for technical and functional performance of the equipment of the building. Each city must identify the maintenance operations for the

			different components and infrastructures in the project scenario.
B3	Repair	Repair operations for the building considering the project intervention (only for the elements included in the project scenario)	E.g.: Repair of components, including production, transportation of new components, installation and remove process, transportation and end of life of eliminated components due to reparation process. Each city must identify the repair operations for the different components and infrastructures in the project scenario.
B4	Refurbishment	Refurbishment operations for the building considering the project intervention (only for the elements included in the project scenario)	E.g.: Substitution of components, including production, transportation of new components, installation and remove process, transportation and end of life of eliminated components due to substitution process. Each city must identify the refurbishment operations for the different components and infrastructures in the project scenario.
B5	Replacement	Replacement operations for the building considering the project intervention (only for the elements included in the project scenario)	E.g.: Production of the new components of the building, transportation and construction actions. Waste and end of life products management Each city must identify the replacement operations for the different components and infrastructures in the project scenario.
B6	Operational energy use	Energy use for the building considering the project intervention	E.g.: Energy use by the systems integrated in the building during its operation, including heating, sanitary hot water, conditioned air, ventilation, illumination, auxiliary energy for pumps, controls, etc. Elevators, mechanical stairs, security systems, communication, must be communicated in a separate section. Please consult EN 15978 for energy exports The energy protocol will be involved in this category
B7	Operational water use	Water, including drinking water, sanitary water, hot sanitary water, etc.	The partners have decided to exclude this category, cause there is no strength relation with the objectives of the project

Table 43: Use stage for the project scenario

C1-C4. END OF LIFE stage

In this stage, the end of life will be considered, assessing the impacts divided in the following categories

C1	De-construction demolition	Deconstruction-demolition only for the elements selected in the project scenario	Each scenario must clarify if the deconstruction of the whole building / district is considered. In a first approach, only the equivalents elements to the project scenario should be considered.
C2	Transport	Transportation for final destination only for the elements selected in the project scenario	Each city should identify the final flows location

C3	Waste processing	Waste processing (recycling, reuse, energy recovery, etc…) for final destination only for the elements selected in the project scenario.	Just in case that the wastes needs processing for the final disposal
C4	Disposal	Include loads for final disposal.	Final disposal must be identified

Table 44: End of life for the project scenario

D. Loads and benefits beyond the system stage

The partners involved in LCA protocol have agreed to exclude this section, which will be only considered if a very clear case occurs.

8.4 Comparative Summary of the Plans for assessing LCA

The three cities have a common framework but also tailored procedures adapted to the needs as it can see in the table below.

City	Objectives	Actions	KPIs	Reference study period	Other info
Vitoria - Gasteiz	Evaluation in terms of LCA for -Building retrofitting actions -Integrated infrastructures -Energy	Described in Table 30	Described in Table 36	50 years	n.a.
Tartu	Evaluation in terms of LCA for -Building retrofitting actions -Integrated infrastructures -Energy			30 years	n.a.
Sonderborg	Evaluation in terms of LCA for -Building retrofitting actions -Energy			30-40 years	n.a.

Table 45: Comparative summary of the LCA evaluation plans for the three LH

The partners in charge of the collection of data required for the LCA and the evaluation of the indicators selected will share the progress done in order to verify that the protocol is being followed correctly.

There will be four moments in which the progress done will be assessed and compared by the three cities:

- Definition of baseline scenario and the evaluation of KPIs
- Life cycle inventory
- Definition of post-intervention scenario and evaluation of KPIs
- Final reporting

9 Mobility Protocol

This report includes only a preliminary version of the mobility protocol. At this stage there are too many uncertainties affecting both the actions to be implemented in the three LH cities and the monitoring equipment to be installed in the vehicles and related infrastructure. Thus, now we can only estimate the kind of data we can expect to collect in order to calculate the KPIs that will allow us to evaluate the effects of the mobility interventions. A more detailed description will be provided in D7.7 Mobility action monitoring program (m18).

9.1 Scope of the protocol

9.1.1 Actions to be evaluated

Each LH city will deploy a set of interventions intended to achieve high clearly measurable impacts in energy efficiency and CO_2 savings. These interventions were defined at proposal preparation stage and since then some changes have been introduced and are still depending on the resolution of an amendment which hasn't started yet (there's a first amendment on-going but the mobility actions will be included in a second one). There will be changes affecting public related interventions and also those ones addressing private service (e.g. promotion of EVs acquisition through grants from the public administrations) that must be changed in order to avoid cascade funding. In this sense, next table shows the preliminary list of potential actions to be deployed in the three LH cities as they were included in the Description of Work.

Vitoria	Tartu	Sonderborg
26 EVs (two types) devoted to last mile delivery service 26 Charging points devoted to last mile delivery service 10 e-bikes within a multimodal bike-hub 22 EV taxis 6 Charging points devoted to taxis 10 e-motorcycles 15 private EVs 20 charging points for private use	8 EV and 16 e-bikes available for public use 4 charging points available for public use 60 biogas buses for public transport 5 public charging points 1 general bike sharing system Participatory transport planning system Re-use of EV batteries for storing and use of renewable energy 14 EV taxis 15 EV cars for private use	38 biogas buses devoted to public transport 18 EVs 30 charging points

Table 46: Mobility actions as described in the Description of Work (DoA)

By the time the current report is being written there are some uncertainties regarding the final actions that will be finally implemented.

In the case of **Vitoria**, it is highly likely that all the actions related to public vehicles will be changed to a great extent. This will affect: taxis, e-motorcycles, private EVs and related charging points.

As regards last mile delivery, the final number of last mile delivery vehicles and their related charging points might change.

E-bikes might be more than initially planned, with several bike hubs (to be approved by amendment). Check section 4.1.3 of the current report.

In **Tartu** there will be only the 8EVs intended for a rental car service. The rest (taxis and private ones) will be removed.

In **Sonderborg**, the 18 EV initially planned won't be deployed in order to avoid cascade funding.

9.1.2 Objectives to be evaluated

Mobility interventions in SmartEnCity project have been defined to achieve a set of impacts which are directly connected with technical, environmental, social and economic objectives.

Type of intervention	Technical objectives	Environmental objectives	Social objectives	Economic objectives
Sustainable mobility Electric Vehicles Biogas buses Bikes sharing City mobility planning	Reduce the traffic congestion Improve the efficiency of urban transport systems Decrease energy consumption in urban transport	Reduce the CO_2 emissions associated to urban transport	Improve the quality of life and the acceptance of the project by drivers	Reduction of the energy costs of drivers Decrease the payback of investment intervention

Table 47: Objectives to be achieved through the interventions

Technical and environmental objectives

- **Decrease of energy consumption in urban transport**
  Through the deployment of a fleet of electric vehicles, the SmartEnCity project aims to reduce the energy expenditure in urban transport. Since electric vehicles are more efficient than equivalent performance ICE (Internal Combustion Engine) vehicles (except in the range aspect), a global energy saving can be expected from their introduction in the urban vehicle fleet.
- An extended use of bikes, together with an efficient public transport service (buses) may lead to a decrease of private vehicles use, and therefore might have an effect on **traffic congestion reduction**.
- The introduction of new EVs and the replacement of traditional buses with biogas ones will help to improve air quality through a **reduction of emissions** in general and CO_2 in particular, but won't have any effect on traffic flow.

- The replacement of old vehicles with more efficient ones (EVs) will contribute to **decrease energy consumption**. Additionally, a potential increase of public transport use (as an alternative to private one) may have an influence on the energy consumed.
- The introduction of efficient last mile delivery services will lead to a better quality of service that comes in consequence of the **reduction of delivery times**.
- **Reduction of the CO_2 emissions associated to urban transport:** EVs have zero emissions and that's already an advantage when compared to ICEs. However, the electricity generated during the charging process comes from a mix of energy, which is clean as long as it is generated by renewable energy sources. In most cases, there will be a balance between fossil and renewable energy sources (this will differ depending on the country). Regarding biogas buses, combustion of biogas, like natural gas, produces carbon dioxide (CO_2), a greenhouse gas. However, the carbon in biogas comes from plant matter that fixed this carbon from atmospheric CO_2. Thus, biogas production is carbon-neutral and does not add to greenhouse gas emissions. Further, any consumption of fossil fuels replaced by biogas will lower CO_2 emissions.
- **Increase the efficiency of public transport:** An efficient public transport in terms of timely arrivals and departures and enough coverage with as many stops and vehicles as required to cover citizens' needs will lead to a natural preference for public transport instead of private one. In the end, traffic congestion will be reduced and air quality will be improved.
- **Increase the efficiency of freight delivery:** An efficient freight delivery service leads to a reduction in delivery time delays. Shorter delivery times mean less traffic flow and in the end less traffic congestion.

Social and economic objectives

- The introduction of EVs and biogas buses can increase the **social acceptance** of drivers towards this type of vehicles due to the environmental related advantages, as well as the reduction in the operation cost.
- Finally, as a consequence of the access to a better price (for EVs) or a cheaper fuel (in the case of biogas buses), the payback of investment for this type of vehicles might decrease. As cascade funding is not an option anymore, **alternative financial means** will have to be considered in order to make EV prices more appealing (e.g. national grants).
- Bike parking stations offer a safe and convenient parking that will probably favour the use of bikes (either conventional or electric).

9.2 Assessment methods

The assessment of the effects of these interventions will be performed by means of a protocol that will be based on a set of KPIs from the tentative list provided in D7.2. Part of them will be commonly adopted by the three cities; while there will also be others specific for each of the cities. This strategy should make sense as the mobility interventions differ from one city to another.

This protocol will detail the way in which the final performance of the mobility interventions will be evaluated, by comparing with the period immediately previous to the interventions, which is called “baseline”.

Data collected to calculate the KPIs and feed the evaluation protocol will come mainly from two sources:

- Data registered by sensors & monitoring equipment installed in the vehicles or available at traffic platforms. These will be used mainly to calculate technical and environmental KPIs.
- Information coming from surveys. These will be useful to evaluate the social and economic KPIs, which will be addressed by other protocols (Social Acceptance and Economic Performance protocols).

9.2.1 Methodology description

There is no unified verification protocol to guide the evaluation process to quantify and validate the improvements achieved with urban mobility interventions in the specific terms of SmartEnCity project general objectives. Therefore, an ad-hoc protocol will be defined, based on IPMVP principles (this protocol is commonly used for building retrofitting).

A common list of KPIs was agreed in D7.2. Based on that, the three LH cities will select and adapt these indicators depending on their specific mobility interventions and the available monitoring equipment.

Specific KPIs that will be finally adopted by each LH will be provided in section 9.4. In some cases it is not clear whether or not some data will be registered in a way that KPIs can be easily calculated, as the monitoring equipment specifications to be installed in the vehicles haven’t been properly defined yet.

Type	Action	General objective	Category	List of indicators
Technical indicators	**Implementation of mobility actions** *(Last mile vehicles, bikes, city mobility planning)*	Reduce the traffic congestion	Logistic indicators	Traffic flow by vehicle type - peak
				Traffic flow by vehicle type - off peak
				Flow (at a specific reference point)
				Average vehicle speed (peak / off-peak)
				Average time for a reference distance
				Average occupancy
	Implementation of mobility actions in freight *(Last mile vehicles)*	Increase the efficiency of freight deliveries	Logistic indicators	Accuracy of timekeeping for freight

	Implementation of mobility actions in public transport *(Electric taxis, biogas buses)*	Increase the efficiency of public transport		Accuracy of timekeeping for public bus
	Replacement of old vehicles with more efficient vehicles *(EVs)* **and an increase of use of public services** *(Taxis, buses, bikes)*	Decrease energy consumption	Energy performance indicators	Energy consumption
				Vehicle fuel efficiency
Environmental indicators	**Use of high performance green vehicles** *(EV, biogas buses, public transport)*	Reduce the CO_2 emissions	Emissions indicator	CO_2 emission by travelled distance
			Use of cleaner vehicles	Total number of recharges per year (biogas and EV)
				Total kWh recharged in the EV charging stations (biogas and EV)

Table 48: KPIs proposed for evaluating sustainable mobility actions (from D7.2)

Agreed KPIs will be calculated preferably from direct measures (real sensors, dataloggers, etc.). However, depending on the availability of measurement equipment, in some cases estimations will be used.

In the specific case of traffic congestion reduction, the effects of the interventions will be measured at city level (impacts evaluation) and won't be included in the current protocol, which is focused on the mobility interventions at demo site level.

For each of the relevant KPIs a baseline will be calculated and used as a reference for comparison with the value observed after the physical implementation of the interventions.

The methodology followed will consist in adapting the Measurement & Verification (M&V) option A of the IPMVP for the mobility interventions deployed in the three LH cities.

The M&V Plan will include the specific measurements, collecting sources and adjustments for each particular scenario, taking into account the interventions that will be performed, and also the available sensors that will gather the measurements for the evaluation. The M&V Plan will be structured as follows:

- Formulation of mobility-related general objectives
- Selected IPMVP Option and Measurement Boundary

- Baseline design
- Post-intervention measurements and collecting sources
- Analysis
- Reporting Period

9.3 SmartEnCity evaluation approach

IPMVP offers four different Measurement and Verification options (refer to section 6.3.1 for a more detailed explanation), but only option A can really be applied to the mobility scenario, given that it is impossible to measure the city as a whole and isolate the effects of the mobility actions from other possible interferences, and it is not possible either to measure all different parameters that might affect the formulation of mobility-related general objectives within reasonable cost constraints.

Option A is the Partially Measured Retrofit Isolation, in which savings are determined by partial field measurement of the energy use of the element(s) to which the formulation of each mobility-related general objective was applied, separate from the energy use of the rest of the system. The monitored parameters are followed on a continuous basis or a high rate, and the rest of variables are fixed as stipulations.

We will use available statistics (such as average fuel consumption, vehicles adoption rates or emissions per litre of fuel) in order to make the stipulations as accurate as possible to the real values.

The measurement boundary for the evaluation will be the set of vehicles deployed within SmartEnCity interventions, and the network of charging stations (electric and biogas), as well as the bike parking stations which are expected in the case of Vitoria-Gasteiz (depending on the amendment final resolution). To determine the EV adoption rate, local (city-level) statistics will be used.

9.3.1 Baseline design

The mobility baseline period chosen should be one year. This is suitable since some of the parameters, such as vehicle purchases statistics are released on a yearly basis, and vehicle monitored data for distances and energy can be aggregated along this period.

Regarding the scope of the baseline in terms of energy savings, an equivalent number and typology of internal combustion vehicles will be chosen as reference for the ones introduced by the mobility interventions.

Scope of the Intervention	Baseline
# E-bikes	# Conventional bikes
# Electric vehicles	# (gasoline / diesel vehicles)
# Biogas buses	# diesel buses
# Last mile delivery EVs	# (gasoline / diesel last mile delivery vehicles)

# Bike-hubs	# Current existing infrastructure for conventional bikes
# New charging points	# Current existing charging points (previous to SmartEnCity project)
# New biogas stations	# Diesel stations previously devoted to old diesel buses refuelling

Table 49: Baseline scope

The schedule of the project does not accommodate for the time to gather baseline data for a full year, so already available statistical information about internal combustion vehicles energy usage, CO_2 emissions or the current charging infrastructure will be used to provide a baseline.

Additionally, historic values from freight delivery services and public buses actual timekeeping along one year previous to the interventions implementation will be used as far as possible.

Decrease of energy consumption in urban transport

Given the fact that FEV are more efficient than ICEs, it is foreseen to save several MW worth of energy during the lifetime of the project.

Though 1 year would be desirable to set up the baseline, there's no time to accommodate such time period, during which we should be measuring the energy consumption of an equivalent fleet of ICE vehicles. We will estimate it from:

- The travelled distance of the vehicles of the intervention, assuming the ICE vehicles would be used to provide an equivalent service.
- In the case of Vitoria-Gasteiz a remarkable number of bikes are expected to be deployed. We can consider they will be substituting ICEs, but also public transport, and walking. The travelled distance by bikes may be registered through an app with a smartphone. Some assumptions will have to be made in order to estimate the energy consumption saved through the use of bikes.
- The average fuel consumption per distance travelled for the vehicle type (car, bus, diesel or gasoline)
- The energetic value of a litre of fuel: of 8.79 kWh per litre of gasoline and a value of 9.98 kWh per litre of diesel.
-

Therefore, the baseline for energy consumption of vehicles is[11]:

[11] Sources: Instituto para la Diversificación y Ahorro de Energía for average new car fuel consumption, US Energy Information Administration for energetic values of a litre of fuel

$$Baseline\ for\ energy\ consumption =$$

$$Total\ km\ travelled\ by\ buses \cdot 0.6762 \frac{l\ diesel}{km} \cdot 9.98 \frac{kWh}{l\ diesel} + Total\ km\ travelled\ by\ electric\ cars\ \cdot (0.47\ gasoline\ car\ ratio \cdot 8.79 \frac{kWh}{l\ gasoline} \cdot 0.055 \frac{l\ gasoline}{km} + 0.51\ diesel\ car\ ratio\ \cdot 9.98 \frac{kWh}{l\ diesel} \cdot 0.047\ \frac{l\ diesel}{km})$$

Reduction of CO_2 emissions in urban transport

CO_2 emissions cannot be measured directly, but they can be estimated from the spent fuel or the distance travelled per vehicle type, either as a factor of the distance, or as a factor of the spent fuel, which is in direct relation with the distance.

Using information about emissions provided by the US Energy Information Administration, the Atmospheric Chemistry and Physics Journal and the UK Vehicle emission curves for the National Transport Model, assuming modern ICE vehicles fitted with particle filters (since the intervention vehicles would be replacing newly acquired vehicles) and discarding re-suspension, as it would be similar for both ICEV and EV, we can calculate the baseline CO_2 emissions as:

$$Baselilne\ for\ CO2\ emissions = Total\ km\ travelled\ by\ buses\ \cdot 0.6762\ \frac{l\ diesel}{km} \cdot \frac{2.68\ Kg\ CO2}{l\ diesel} + Total\ km\ travelled\ by\ electric\ cars\ \cdot (0.47\ gasoline\ car\ ratio \cdot \frac{2.35\ Kg\ CO2}{l\ gasoline} \cdot 0.055\ \frac{l\ gasoline}{km} + 0.51\ diesel\ car\ ratio \cdot \frac{2.68\ Kg\ CO2}{l\ diesel} \cdot \frac{0.047\ l\ diesel}{km})$$

Increase the efficiency of public transport

Public transport efficiency will be ideally assessed from timekeeping historic values, registered along one year previous to the implementation of the new biogas buses fleets. Indicators assessing the punctuality of the old buses will be calculated. They will be based on the deviations from the theoretical arrival and departure times.

Increase the efficiency of freight delivery

The only city deploying last mile delivery actions is Vitoria-Gasteiz. Last mile delivery efficiency would be ideally assessed from delivery delays historic values, registered along one year previous to the implementation of the new freight delivery fleets. These data would be retrieved (as far as possible) from similar fleets, providing similar services.

If there were no registers of delivery delays historic values, estimations would be made to calculate a reasonable baseline.

According to a recent study on last mile delivery solutions for Vitoria-Gasteiz[12] in the short to medium term, a logistics delivery system has been proposed, based on not allowing the

[12] Definición de un nuevo modelo logístico de distribución urbana (Definition of a new logistic model for urban distribution). Developed by DHL for Vitoria-Gasteiz.

entrance of delivery vehicles further to a set of non-attended reception points (packstations). Traffic congestion and CO_2 emissions would be reduced as a result of this procedure.

9.3.2 Post-intervention design

Key parameters to be monitored during the intervention are the same that constitute the baseline, although the information will come or will be derived from the installed monitoring devices. At this stage the monitoring equipment specifications are not fixed in general for any of the LH cities. These specifications depend to a great extent on the final mobility actions to be deployed. More information on this will be provided in D7.7 Mobility action monitoring program.

- **Energy expenditure:** Sensors installed in the electric vehicles for battery levels and recharges, as well as sensors in the charging stations will provide the energy expenditure information required, so we will measure real data rather than estimations. Given that some electric vehicle models may not provide energy expenditure information, the reported expenditure per distance will be used along with the travelled distance to provide estimation (as a worst case scenario).
- Biogas consumption by buses will be measured with specific on-board equipment as long as possible. Otherwise, estimations will be used. It must be noted, however, that in the case of Sonderborg, there's not much information (by the time this report is being written) on the kind of data that will be registered from new biogas buses. More information will be available in June 2017, when the buses are delivered and put in service. Moreover, on weekends, these buses will be used for other services further to ordinary public transport. This will be taken into consideration regarding the registered data.

- **CO_2 emissions:** Given that it is hard to get accurate measures for CO_2 emissions on vehicles, particularly for electric vehicles (as the emission takes place where the energy is generated and unrelated to the electric vehicle location), we will use the consumed kWh and multiply it by the factor of CO_2 emissions per generated Kilowatt of the particular electric generation mix in each country. In Spain this factor is 0.203 Kg/KWs, which may be also valid for Denmark.

- **Electric vehicle recharges**: Number and KWh recharged yearly. This information will be measured directly in the charging stations

- **Biogas bus refuelling**: Number and litres recharged yearly. This information will be measured directly in the biogas stations.

- **Timekeeping** registers from biogas buses and freight delivery vehicles

9.4 Plan for the mobility assessment

A list of actions and related KPIs from the three cities is shown below. It must be noticed that they might change significantly. More accurate information will be provided in D7.7

City	Actions	KPIs
Vitoria-Gasteiz	26 EV (two types) devoted to last mile delivery service 26 Charging points devoted to last mile delivery service New EV charging stations 25 e-bikes 6 smart e-bike parking stations E-Bicycle promotion for travelling to work Intelligent safe parking and bike tracking	Average vehicle speed (peak / off-peak) Accuracy of timekeeping for freight Energy consumption CO_2 emission by travelled distance Total number of recharges per year (biogas and EV) Total kWh recharged in the EV charging stations (biogas and EV)
Tartu	8 EV and 16 e-bikes available for public use 4 charging points available for public use 60 biogas buses for public transport 5 public charging points 1 general bike sharing system Participatory transport planning system Re-use of EV batteries for storing and use of renewable energy	Average occupancy (EVs) Accuracy of timekeeping for public bus CO_2 emission by travelled distance Total number of recharges per year (EV) Total kWh recharged in the EV charging stations (EV)
Sonderborg	38 biogas buses devoted to public transport 30 charging points	Accuracy of timekeeping for public bus Vehicle fuel efficiency Total number of recharges per year (biogas and EV) Total kWh recharged in the EV charging stations (biogas and EV)

Table 50: foreseen actions and KPIs for the mobility evaluation plans of the three LH

Next steps:

Procedure for collecting data for the final performance will be done in D7.9.

Define tentative partners' roles for the implementation of protocol in the evaluation of baseline and final performance.

10 Social Acceptance Protocol

10.1 Scope of the protocol

SmartEnCity interventions will achieve not only to improve the environment of the cities in terms of energy savings and CO_2 emissions but also to increase the social acceptance on this type of actions and the life quality of citizens from the LH cities. In this section, it will describe the objectives to be evaluated under this protocol which are aligned with the type of actions and the target audience that is involved in the project.

10.1.1 Actions to be evaluated

Within SmartEnCity many actions will be accomplished on district renovation (building retrofitting and integrated infrastructures), sustainable mobility (electric vehicles, e-bikes, biogas buses, etc.), ICT actions (urban platform) or dissemination actions. The target audience that can be beneficiary of these actions to be implemented in the city are the residents living in the district to be retrofitted, the agents that are affected by the new sustainable vehicles to be implemented in the cities and the citizens that can be recipients of the improvements obtained in the cities. Consequently, actions that can affect to the target audience and which will be considered in this protocol are the district renovation, the sustainable mobility, the urban platform and the dissemination activities. A well description of these interventions and actions can be found in section 4.

10.1.2 Objectives to be evaluated

Taking into account the previous premises, the social acceptance protocol will be focused in the evaluation of the social acceptance of the interventions carried out in the three LH cities as well as the quality of life of the beneficiaries of these interventions.

Table 51 below summarizes all the potential objectives that can be evaluated, considering the different types of interventions, actions and target audience that take part in this complex project.

Type of intervention/action	Social objectives for being evaluated	Target audience
DISTRICT RENOVATION Building retrofitting Integrated infrastructures	➢ Evaluate the acceptance of residents living in the district to be retrofitted on SmartEnCity solutions after the district renovation which include the retrofitting of buildings, the deployment of District Heating with RES and the ICT solutions (e.g. sensors, apps developed for energy services). ➢ Evaluate the quality of life of residents due to gains in comfort conditions with the district	Owners Tenants

	renovation and a reduction in the energy bills after the diminution of energy consumption and/or a better fuel energy price.	
SUSTAINABLE MOBILITY Electric Vehicles e-Bikes Biogas buses	➢ Evaluate the acceptance on SmartEnCity mobility actions by owners and users of vehicles involved in the project once EV, e-bikes and biogas buses are circulating in the cities and the ICT solutions focused in mobility have been implemented (e.g. apps deployed for vehicle users). ➢ Evaluate the quality of life of agents involved in the mobility actions due to a reduction of the operation costs with the new vehicles and other improvements achieved	Agents involved in the mobility actions such as vehicles owners and vehicle users
FULL SMARTENCITY ACTIONS/ INTERVENTIONS District renovation Sustainable mobility Urban platform Dissemination actions	➢ Evaluate the acceptance on SmartEnCity actions and interventions by citizens after the implementation of district retrofitting, mobility and ICT solutions and the information provided in urban platforms and dissemination actions in the city due to a better image of the city and feel involvement in this process of city transformation ➢ Evaluate the quality of life of citizens due to the better aesthetical of district, reduction of pollutants in the city and the improvement of the economy in the city	Citizens

Table 51: Potential objectives for the evaluation of the social acceptance

Table above describes which is understood as gains in quality of life in the framework of SmartEnCity. Concerning, social acceptance, we understand this term as a positive attitude towards a technology which can be measured as the satisfaction with technical solutions, costs and intervention phases as suitable information received about the project, among others.

From this starting point with generic objectives, the different demo sites of SmartEnCity project have identified their own objectives of interest.

Firstly, in terms of how to proceed with the evaluation of the social acceptance and quality of life:

– Option 1: to evaluate this protocol in two stages. This requires launching the tools of evaluation (e.g. questionnaires/interviews) before and after the interventions are concluded in order to known the difference found among these stages. It will be required to involve the same persons or same profile of residents (e.g. residents in the same age interval, same educational level, etc). Consequently, social acceptance is defined as the improvement achieved after the implementation of interventions.

- Option 2: to evaluate this protocol in one stage. This requires launching the tools of evaluation (e.g. questionnaires/interviews) once the interventions have been ended. Therefore, only the final performance will be evaluated without any comparison with a

previous situation. Consequently, social acceptance is the final acceptance of the project by the agents involved in the evaluation and the quality of life obtained after the implementation of interventions.

All the demosites partners selected the option 2 due to the difficulties to involve target audience in an evaluation process.

Secondly, the local team identified the target audience to be involved in this protocol.

Table below reflects the objective to be evaluated in each city after their selection by the local teams.

City	Objectives
Vitoria-Gasteiz	Evaluation of the acceptance of owners and tenants living in the district on SmartEnCity solutions implemented in the district renovated Evaluation of the acceptance of the agents involved in the last mile vehicles (manager of the company that buys the vehicles, manager of the companies that operate the vehicles and vehicle users) on EV acquired Evaluation of the gains in life quality of owners and tenants living in the district retrofitted Evaluation of the gains in life quality of the agents involved in last mile vehicles (manager of the company that buys the vehicles, manager of the companies that operates the vehicles and the vehicle users) after the acquisition of EV vehicles
Tartu	Evaluation of the acceptance of owners and tenants living in the district on SmartEnCity solutions implemented in the district renovated Evaluation of the acceptance on EV by users of rented EV and e-bikes Evaluation of the acceptance on actions implemented in SmartEnCity project by citizens Evaluation of the gains in life quality due to the project in owners and tenants from district, users of rented EV and e-bikes and citizens of Tartu
Sonderborg [13]	Evaluation of the acceptance of tenants living in the district and in other districts of the city (citizens) on SmartEnCity solutions implemented in the district renovated Evaluation of the gains in life quality of tenants living in the district retrofitted and in other districts of the city (citizens)

Table 52: Objectives to be evaluated on social acceptance in each LH city

[13] The decision to include mobility actors in Sonderborg will be postponed until the actions affected by cascade funding are defined and approved by the Commission. In this case, the protocol will be updated in the corresponding deliverable to be submitted at M18.

10.2 Assessment methods

The evaluation of positive attitude of citizens towards a technology has been done in different projects and studies (which we understand as social acceptance), being the surveys the main procedures to gather the subjective opinion of the people involved in the studies. But also, there are other methods which allow evaluating the social acceptance from objective points of view.

In this section, three methods are described as potential means to be considered in the evaluation of the social acceptance in SmartEnCity:

- ***Survey method:*** It is based on a question/answer process for gathering the subjective perspective of the respondent to specific questions. In this case, this method allows gathering the opinion from the main agents which have been affected by the technologies. Specifically, this method can be applied in order to ask about the gains in life quality and social acceptance with the district renovation, with the mobility action and with the whole actions carried out in the city.

However, it has as inconvenient the requirement of investing big efforts in order to design a suitable tool which allows knowing the key aspects under study and a long period for achieving the participation of the agents. In addition, it is needed to have a significant sample of interviewees or to involve key agents in order to have trusty data, which can be also solved through the implementation of objective methods in order to contrast the information. The information obtained will be then post-processed through a statistical analysis and reporting according to the structure agreed.

There are three possible alternatives of surveys to be applied in SmartEnCity:

- A **questionnaire** to be distributed in the framework of information campaigns, workshops, door to door, etc. to a representative sample of the end users of the analysed technologies. This has as advantage the possibility to collect the opinions of a wide number of people. However, the need to engage the participation of persons takes more time respect to interviews due to the higher sample size.
- **Focus group interview** consists of semi structural interviews where a group of users raise their opinion and expectations regarding the elements and factors of the service that are presented to them throughout the session under the direction of a moderator. This method is very useful for gathering opinions in depth, searching for common points and generalized opinions regarding the expectations of the services and when it is not easy to involve a high number of people in questionnaires. Its development requires the management of an expert in the field and takes about half a day. The interview starts with an introduction of all participants. Next, an introduction to the project and the focus of the intervention to be analysed is made by the organizer in order to make understand the context to the participants. The rest of the meeting is dedicated to discussions to identify the aspects under study (e.g. evaluation of the improvement of quality of life after the intervention and social acceptance of the intervention). On the other hand it is good to give the time needed to fully explore interesting aspects (solve doubts or problems if this proceed).

  Research shows that a focus group should not be less than four people, while a focus group with more than six people can form subgroups, or that not all participants have a

possibility to express their opinion. The number of groups depends on the number of participants, but three may be suitable. In the case of less than four persons have been identified as potential participants, it is better to use individual interviews as described below.

Each focus group should always have a moderator. The moderator will be well prepared and familiar with the topic/issues to be discussed. To help the moderator with documentation of the discussion an assistant will also be present. The room should be furnished in a half circle in order for the participants to see each other and the board where documentation is made during the discussions. After the discussions in focus groups (if more than one focus group) the moderator and assistant present the key conclusions from the discussions to the whole group.

After the workshop the moderator and assistant summarize the discussions according to topic/issue and make some overall conclusions. The summary could preferably be presented in an intermediate version to the participants of the workshop in order to verify that the participants recognize their opinions in the summary as well as to keep their engagement in the topic while materials are processed. It will also encourage their further involvement in future discussion on the topic. Finally the summary will be translated into English to be integrated in the corresponding deliverable. All the answers received will be post-processed.

- **Individual interviews** are guided interviews with few open questions where it is required to involve representative end users of the analysed technologies. Its main interest is due to the collection of the viewpoint in depth regarding the service, being an appropriate tool to discover the motivations and attitudes of the interviewees. They are suitable when it is not easy to involve a high number of people in questionnaires or if it is hard to arrange a focus group interview for practical reasons. This type of procedure usually requires the experience and training of an expert.

  To conduct an interview takes about an hour and can be made by phone or face to face. The interview starts with a short introduction to the project and the focus of the intervention to be analysed. The rest of the interview is dedicated to identify the aspects under study (evaluation of the improvement of quality of life after the intervention and social acceptance of the intervention). After the interviews a summary is written of the discussions according to topic/issue with some overall conclusions. The summary could preferably be presented in a draft version to the interviewees in order to verify that the participant recognizes their opinions in the summary as well as to keep the engagement in the topic. Finally the summary from each interview will be translated into English and reported in the corresponding deliverable. All the answers received will be post-processed.

- ***Log book:*** This objective method consists of a record of important events in the management and operation of the action and it could be applied for the retrofitting action and mobility actions for the identification of technical problems before, throughout and after the renovation process and the acquisition of the vehicle. Each individual entry can be studied, setting up its impact level whether the problem is solved (or at least solvable) and their consequences. Then, the social acceptance and the gains in life quality (e.g. thermal

comfort) could be considered as achieved if no high-impact technical issues have been gathered, or, if any, they have been solved.

- ***Data measurement:*** This method can be applied for district renovation and mobility action for measuring parameters which affect the comfort conditions, cost savings, energy consumption, etc. in order to complete the social acceptance with another point of view. Thus, the data from the monitoring system can be used for assessing real parameters, providing the comparison of both survey and measurement methods a better knowledge of the real situation than each of them individually considered.

10.3 SmartEnCity evaluation approach

From all the methods of assessment, each local team from LH projects has selected those methods which fit better with the specific circumstances from their cities and the preferences of the partners involved in the local project to engage the target audience selected.

Table below shows the methods to be used in each city and the target group to be involved.

City	Method	Target group
Vitoria-Gasteiz	Questionnaire Data measurement Log book	Owners and tenants from district
	Individual interview which includes questions defined in the Log books Data measurement	Last mile vehicle owners and users (company managers, operation managers and vehicle users)
Tartu	Questionnaire Individual interview Focus group interview [14] Data measurements	Owners and tenants from district
	Questionnaire Data measurements	EV rental users
	Questionnaire	Citizens
Sonderborg	Questionnaires Data measurement Log books[15]	Tenants
	Questionnaire	Citizens (tenants from other districts)

Table 53: Methods of assessment of social acceptance selected by the LH cities

[14] This type of interview could be done in order to discuss some specific issues with residents. This is a decision to be taken in the future in the city of Tartu.

[15] Log book has been dismissed to be a tool to be used for measuring the social acceptance in Sonderborg since partners there do not expect to be able to receive any complaints from tenants. However, in case that any complains can be collected; they will be reported in the corresponding deliverable.

Once the methods have been selected in each city, some guidelines have been defined by CAR in order to achieve a common framework of evaluation. Thus, different proposals have been provided to the local team participating in social protocol for the design of the tools to be used in the assessment of social acceptance (i.e. questionnaire/interviews and log book) and for the definition of how to proceed in the process of implementation of the tools and their posterior reporting and evaluation of the information collected.

- For the case of surveys methods, these guidelines include aspects to be considered in the design of questionnaires and interviews (e.g. topics to be evaluated and format of the questions which allow to obtain a level of satisfaction in the topics launched), aspects to be contemplated in the posterior implementation of these surveys (i.e. agents to be involved and means needed for the distribution of questionnaires and performing of surveys) and some specifications about how to process the data collected and report the social acceptance. These guidelines contribute to provide a common structure of evaluation for the three cities and to setting the basis for the future deploy of protocols in each city.
- For the case of log book, guidelines have been focused in the possible issues to be evaluated, frequency to fill this tool and procedure for processing the data collected.
- For the case of data measurements, giving the difficulty to take a conclusion at this moment about which data are measured at the same time by meters and by questionnaires, interviews and log books, this method will be concluded in a posterior deliverable from WP7 to be submitted at M18.

10.3.1 Survey methods

Structure of questionnaires/surveys

The structure of questionnaires/surveys will be based in the selection of dimensions and elements by local partners from a set of issues to be evaluated, corresponding KPIs with these elements. These dimensions and elements have been selected from different studies.

- Acceleration of clean technology deployment within the EU: the role of social acceptance. 1st POLIMP Policy Brief on Public Acceptance. Background paper to the 1st Policy Brief (June 2014).
- Assessing the social acceptance of hydrogen for transportation in Spain: An unintentional focus on target population for a potential hydrogen economy. Iribarren, D. et al. International journal of hydrogen energy 41 (2016) pages 5203-5208
- Researching social acceptability of renewable energy technologies in Finland. Moula, Md. et al. International Journal of Sustainable Built Environment (2013) 2, pages 89-98
- Social problems of green buildings: from the humanistic needs to social acceptance. Zhao, D. et al. Renewable and Sustainable Energy Reviews 51(2015), pages 1594–1609
- Deliverable 3.2. Questionnaires for the general public and selected stakeholders. Project Hydrogen acceptance in the transition phase (2016)

This structure can be applied for the three types of surveys to be deployed:

- Questionnaire for measuring the social acceptance from residents in the district to be retrofitted in Vitoria, Tartu and Sonderborg, from users of rental EV in Tartu and citizens in Tartu and Sonderborg.
- Interview for measuring the social acceptance from residents in the district to be retrofitted in Tartu and from agents involved in the last mile vehicles in Vitoria.
- Individual interview for measuring the social acceptance from citizens of Tartu.

Dimensions suggested as responsible of influencing in the social acceptance are the following:

- Social background
- Environmental background
- Individual perception of residents
- Economic value of the solutions
- Technical value of the solutions

Related to the type of question to be included in questionnaires, the option provided consist of closed questions based in a scale of satisfaction whereas information collected in surveys must be translated into this scale of satisfaction. Table below is an example of the possible structure of the questionnaires.

ELEMENT	Score*				
Economic value	1	2	3	4	5
Satisfaction with the investment costs	1	2	3	4	5
Satisfaction with the access to financing	1	2	3	4	5
Satisfaction with the payback period	1	2	3	4	5
Satisfaction level with the reduction in the energy bills.	1	2	3	4	5
Willingness to invest in further energy projects	1	2	3	4	5
Technical value	1	2	3	4	5
According with the information selected in next section					

** Extremely (5) – Very (4) – Moderately (3) – Slightly (2) – Not at all (1)*

Once introduced the main aspects to be considered in the design of survey methods, following pages are addressed to a deep description of the topics to be analysed in this protocol in each target group: residents from district to be retrofitted, agents involved in mobility actions and citizens living in the LH cities.

a) Issues to be evaluated in the survey methods for residents (owners and tenants).

- Social background

This dimension includes the characteristics of the residents and the buildings to be retrofitted whose information is required in order to understand some opinions collected from respondents in the surveys.

- Characteristics of the resident: age, education level, nationality, income, etc.
- Characteristics of the dwelling: type of building, dwelling size, ownership, accommodation time, etc.

- Environmental background

Awareness and knowledge of residents on environmental problems (global environmental problems and specific problems in the city) and clean technologies can affect also the information collected from this type of method. Hence, to collect some background on this topic can help to explain the result of the survey. For example, residents can be asked if they have heard about a list of different environmental problems and a list of energy efficient solutions and their benefits.

KPIs that can be included in this dimension are proposed below:

- Knowledge and environmental awareness on different global environmental problems (e.g. climate change) and environmental problems in the city (air pollution in the city) and the link with the use of energy sources.
- Knowledge and benefits of the solutions implemented in energy efficient retrofit projects.

- Individual perception of residents

The evaluation of the energy efficient retrofit project can be affected by the way on how residents see the decision-making process. Procedures are considered by residents to be fair when they are open and transparent, they have a voice in decisions, and these inputs are given consideration by the decision makers. In addition, the acceptance of interventions for district renovation with energy efficient solutions can be influenced with the trust in decision makers as competent people.

Therefore, residents can be asked about the following information.

- Fairness and inclusiveness in the decision-making process in terms of satisfaction with the project, with the level of information received, with the involvement degree.
- Trust in decision makers and other relevant stakeholders in terms of suitable time plan for the execution of actions and the communication and dialogue with decision makers.

- Economic value of the solutions

Social acceptance of an energy efficient retrofit project by residents will depend on a subjective assessment of its costs, benefits and potential risks since they do not have complete knowledge and information. Consequently, their opinion is based in the information provided by the project developer and the reduction detected in the energy bill after the intervention.

Therefore, residents can be asked about the following information.

- Satisfaction with the investment costs
- Satisfaction with the access to financing
- Satisfaction with the payback period
- Satisfaction level with the reduction in the energy bills
- Willingness to invest in further energy projects

- Technical value of the solutions

Friendly environment technologies are well-accepted by the general public, however, individual projects usually face resistance from the local community since they have fear for a loss of quality of life or a lack of trust for the quality of materials. Hence, for evaluating the social acceptance, residents will be asked for:

- Satisfaction with the solution implemented as a whole
- Satisfaction with the solution in terms of comfort and energy savings achieved
- Satisfaction from aesthetic perception

b) Issues to be evaluated in the survey methods for mobility actors

- Social background

This dimension includes the characteristics of the mobility actors and the vehicles currently used before the implementation of SmartEnCity mobility actions whose information is required in order to understand some opinions collected from respondents in the surveys.

- Characteristics of the vehicle users: age, gender, education level, nationality, years as vehicle user
- Characteristics of the vehicle replaced: years

- Environmental background

Awareness and knowledge of vehicle users on environmental problems (global environmental problems and specific problems in the city) and clean technologies can affect also the information collected from this type of method. Hence, to collect some background from this topic can help to explain the result of the survey.

Agents involved with the mobility action can be asked if they have heard about different environmental problems and a set of energy efficient solutions and their benefits. Therefore, KPIs that can be included in this dimension are proposed below:

- Knowledge and environmental awareness on different global environmental problems (e.g. climate change) and environmental problems in the city (air pollution, traffic jam) and the link with the use of energy sources
- Knowledge and benefits of the mobility solutions implemented in the project.

- Individual perception of vehicle users

The evaluation of the mobility action can be affected by the way on how mobility users see the decision-making process. Procedures are considered by users to be fair when they are

open and transparent, they have a voice in decisions, and these inputs are given consideration by the decision makers.

Therefore, EV users can be asked about the following information.

- Fairness and inclusiveness in the decision-making process in terms of satisfaction with the project, with the level of information received, with the involvement degree.

- Economic value of the solutions

Social acceptance of a mobility action by vehicle users will depend on a subjective assessment of its costs, benefits and potential risks since they do not have complete knowledge and information. Consequently, their opinion is based in the information provided by the project developer and the reduction of operating costs detected.

Therefore, users can be asked about the following information.

- Satisfaction with the investment costs
- Satisfaction with the access to financing
- Satisfaction with the payback period
- Satisfaction level with the reduction in the operation costs
- Willingness to purchase/invest in new EV

- Technical value of the solutions

Friendly environment technologies are well-accepted by the general public, however, individual projects usually face resistance from the local community since they have fear for a loss of quality of life or a lack of trust in the solution. Hence, for evaluating the social acceptance, vehicle users will be asked for:

- Satisfaction with the solution implemented as a whole
- Satisfaction with the solution in terms of comfort due to change in the type of energy source vehicle
- Satisfaction with the solution in terms of cost savings due to change in the type of energy source vehicle

c) Issues to be evaluated in the survey methods for citizens

- Social background

This dimension includes the characteristics of the citizens who participate in the surveys in order to understand some opinions collected.

- Characteristics of the resident: age, education level and nationality, project involvement degree, etc.

- Environmental background

Awareness and knowledge of citizens on environmental problems (global environmental problems and specific problems in the city) and clean technologies can affect also the information collected from this type of method. Hence to collect some background can help to explain the result of the survey.

Citizens can be asked if they have heard about different environmental problems and a set of energy efficient solutions and their benefits. Therefore, KPIs that can be included in this dimension are proposed below:

- Knowledge and environmental awareness on different global environmental problems (e.g. climate change) and environmental problems in the city (air pollution, traffic jam) and the link with the use of energy sources
- Knowledge and benefits of the solutions implemented in energy efficient retrofit projects and mobility actions.

- Individual perception of citizens

The evaluation of the acceptance of project by the citizens not involved directly in energy efficient retrofit or mobility actions can be affected by the way on how residents see the decision-making process in the city (procedures are considered by citizens to be fair when they are open and transparent) as well as how competent they see the stakeholders working in this type of actions.

Therefore, citizens can be asked about the following information.

- Fairness and inclusiveness in the decision-making process in terms of satisfaction with the project and with the level of information received.
- Trust in decision makers and other relevant stakeholders in terms of suitable time plan for implementing the actions in the city and the confident in decision makers and stakeholders involved in this project as well as in others similar projects.

- Economic value of the solutions

Social acceptance of an energy efficient retrofit project or sustainable mobility actions by citizens will depend on a subjective assessment of its costs, benefits and potential risks since they do not have complete knowledge and information.

Therefore, citizens can be asked about the following information.

- Satisfaction with the investment costs of this type of interventions to be assumed by the municipality and beneficiaries (district renovation, EV and biogas buses)
- Satisfaction with the access to financing for this type of interventions for the beneficiary (district renovation and EV)
- Satisfaction with the payback period for this type of interventions for the beneficiary (district renovation and EV)
- Satisfaction level with the expected reduction in the energy bills and operation costs for municipality and beneficiary (district renovation, biogas buses, EV)
- Willingness to invest in further energy projects (district renovation and EV)

- Technical value of the solutions

Friendly environment technologies are well-accepted by the general public, however, individual projects usually face resistance from the local community. Hence, for evaluating the social acceptance, residents can be asked for:

- Satisfaction with the solutions implemented in the city as a whole (e.g. aesthetic perception, energy savings).

- Satisfaction with the solution implemented in terms of personal benefits (comfort with new mobility actions, reduction of pollutants in the city).

Aspects to be considered in the implementation of survey methods

This section tries to describe the requirements that need to be considered in the implementation of surveys methods.

Table below summarizes the materials, agents and means that need to be identified for the deployment of each of the survey methods to be used in SmartEnCity project in reference to the evaluation of the social acceptance.

Method	Materials (what)	Agents to involve (who)	Means (how)
Questionnaire for residents	Questionnaire template: issues to be evaluated and type of question	A representative sample of residents (tenants, owners)	Channels of distribution as partner involved in citizen engagement process through activities carried out during this process (e.g. information campaign, workshops, office of information, door to door), by mail, phone, through websites, etc.
Questionnaire for agents involved in mobility actions	Questionnaire template: issues to be evaluated and type of question	A representative sample of agents involved in the mobility action (e.g. vehicle owner, vehicle users, etc.)	Channels of distribution as partners involved with mobility action through activities made in the project addressed to mobility actors (e.g. workshop, information campaigns), in the own office for rental vehicles, website, etc.
Questionnaire for citizens	Questionnaire template: issues to be evaluated and type of question	A representative sample of citizens	Channels of distribution as partners involved in the project in events carried out in the framework of SmartEnCity or other events made in the city
Individual interviews for residents, agents involved in mobility actions or citizens	Interview template Material for introduction of the project to the interviewer (e.g. ppt) Interview guide with information to be considered by interviewers in case it	A representative sample of residents, vehicle owners, vehicle users and citizens. This can be also housing association as representative of residents. In addition, other people involved	Interviewer Mediatory in case it is not possible to contact directly with interviewer (i.e. in the case of rental vehicle user not involved in the project, citizens)

	is not involved in the project	in the project can be interviewed to extend the point of view (e. g. energy and building companies involved in the project, rental vehicle companies involved in the project)	Means: phone or face to face
Focus group interview for residents, agents involved in the mobility actions and citizens	Interview template Material for introduction of the project to the interviewee (e.g. ppt) Interview guide with information to be considered by interviewers in case it is not involved in the project	A representative sample of residents, vehicle owners, vehicle users and citizens. This can be also housing association as representative of residents. In addition, other people involved in the project can be interviewed for extend the point of view (e. g. energy and building companies involved in the project, rental vehicle companies not involved in the project)	A moderator and assistant by each group interview

Table 54: Materials, agents and means for the deployment of the survey methods

Aspects to be considered in the evaluation process

The information obtained from questionnaires and surveys will be post-processed through a statistical analysis. Following it is described some specifications about how to process the data collected and report the social acceptance according to the scale of satisfaction gathered from the solutions and life quality gains.

Two options have been suggested:

Option 1: The social acceptance is evaluated as average score for each dimension analysed.

The social acceptance will be reported by each element and dimension in a range and then three ranges of social acceptance will be considered. I.e. Low (1-2), medium (3-4) and high (5)

Table 55 below is an example for a better understanding of this option.

Dimensions	Elements (KPIs)	Average score in each element (1-5)	Social acceptance pattern scale Average score in each dimension (1-5)
Individual perception of residents	Fairness and inclusiveness in the decision-making process: satisfaction with the project	**3**	**3.6**
	Fairness and inclusiveness in the decision-making process: satisfaction with the level of information received	**5**	
	Fairness and inclusiveness in the decision-making process: satisfaction with the involvement degree.	**4**	
	Trust in decision makers in terms of suitable time plan for the execution of actions	**4**	
	Trust in decision makers in terms of suitable communication and dialogue with decision makers.	**2**	
Economic value of the solutions	Satisfaction with the investment costs	**2**	**2.75**
	Satisfaction with the access to financing	**2**	
	Satisfaction with the payback period	**2**	
	Satisfaction level with the reduction in the energy bills	**5**	
	Willingness to invest in further energy projects	**4**	**4.2**
Technical value of the solutions	Satisfaction with the solution implemented as a whole	**4**	
	Satisfaction from the energy perspective (comfort)	**4**	
	Satisfaction from the energy perspective (energy savings satisfaction)	**4**	
	Satisfaction from aesthetic perception	**5**	

Table 55: Example of social acceptance evaluated through average score

Option 2: The social acceptance is evaluated as % for each element analysed

The social acceptance can be reported as suitable satisfaction for those elements in which a percentage (e.g. 75%) of people selected the two highest scores of social acceptance. In the example provided in the Table 56 below, the social acceptance for this element scored is not achieved (55%) in the case that scores 1 and 2 were the highest level of satisfaction.

Dimensions	Elements (KPIs)	Score obtained
Individual perception of residents	Fairness and inclusiveness in the decision-making process: satisfaction with the project	**1: 40%** **2: 15%** **3:20%** **4: 10%** **5: 15%**
	Fairness and inclusiveness in the decision-making process: satisfaction with the level of information received	
	Fairness and inclusiveness in the decision-making process: satisfaction with the involvement degree.	
	Trust in decision makers in terms of suitable time plan for the execution of actions	
	Trust in decision makers in terms of suitable communication and dialogue with decision makers.	
Economic value of the solutions	Satisfaction with the investment costs	
	Satisfaction with the access to financing	
	Satisfaction with the payback period	
	Satisfaction level with the reduction in the energy bills	
	Willingness to invest in further energy projects	
Technical value of the solutions	Satisfaction with the solution implemented as a whole	
	Satisfaction from the energy perspective (comfort)	
	Satisfaction from the energy perspective (energy savings satisfaction)	
	Satisfaction from aesthetic perception	

Table 56: Example of social acceptance evaluation as % for each element analysed

10.3.2 Log books

Structure of log books

As it was introduced in the section previous, this method consists of a record of important events in the management and operation of the actions for the identification of technical problems before, throughout and after the renovation process and the acquisition of the vehicle. Each individual entry can be studied, setting up its impact level whether the problem is solved (or at least solvable) and their consequences. Then, the social acceptance and the gains in life quality (e.g. thermal comfort) could be considered as achieved if no high-impact technical issues have been gathered, or, if any, they have been solved.

a) ***Log books in districts***

It is a common practice for logging the incidences and deteriorations in refurbishment projects. In this case, the log book will collect the problems detected by technicians and users so as to keep record of any occurrence.

The dimensions and elements suggested for being evaluated are compiled in the table below. They correspond with technical and economic issues.

Dimensions (problems)	Elements (KPIs)
Technical	Complains of residents with the time plan before the starting of works
	Complains of residents with the aesthetic of buildings before retrofitting
	Complains of residents with the time plan due to delays
	Complains with the persons working in the district
	Complains due to failure of heating system
	Complains due to aesthetical of the buildings
Economic	Complains of residents with the investment cost before works
	Complains of residents with the payback before works
	Complains of residents with the financial scheme before works
	Complains of residents with the energy savings after retrofitting since they do not respond to expected results (low impact in energy bills)
	Complains due to investment costs significantly higher
	Complains with the operating expenses after the retrofitting (higher than expected)

Table 57: Elements suggested for evaluation on a log book for refurbishment

b) ***Log books in mobility actions***

The dimensions and elements suggested to be collected are compiled in the table below. They correspond with technical and economic issues.

Dimensions (problems)	Elements (KPIs)
Technical	Complains due to failures in the vehicle
	Complains due to the time dedicated for recharging EV

Economic	Complains due to lack of recharger infrastructures
	Complains with the maintenance of operation costs
	Complains with the maintenance requirements
	Complains due to costs for the payment of the electricity consumed is higher than expected

Table 58: Elements suggested for evaluation on a log book for mobility

Aspects to be considered in the implementation of log books

This section tries to describe the requirements that need to be considered in the implementation of log books methods.

- Phases where to collect data for feeding the log books: before, throughout and after the execution of the intervention
- Frequency to collect this information
- Responsible of log books; before, during and after the works (e.g. company involved in the retrofitting, Energy Company, etc.).

10.4 Plan for the social acceptance assessment

Once the cities received some guidelines to be considered in the future evaluation of social acceptance, some decisions have been taken by partners involved in this protocol in terms of:

- Target audience to be involved in the evaluation
- Objectives to be evaluated and tools to be used.
- Main structure of the tools used
- Channels of distribution of these tools (in some cases)
- Pattern scale of satisfaction with the topics evaluated
- Post-processing process of the data collected

However, not all the decisions have been taken since the project is in an early stage (e.g. sample to be chosen). These decisions will be taken in a posterior stage of the project and will be reporting in the corresponding deliverable.

Specific details for plan of evaluation in each city are described in following sections.

10.4.1 Plan for Vitoria-Gasteiz

Table below summarizes the objective, methods and target groups to be involved in the evaluation of social acceptance in the city of Vitoria-Gasteiz

Vitoria-Gasteiz		
Objective	Method	Target group
Evaluation of the acceptance of owners and tenants living in the district on SmartEnCity solutions implemented in the district renovated Evaluation of the gains in life quality of owners and tenants living in the district retrofitted	Questionnaire Data measurement Log book	Owners and tenants from district
Evaluation of the acceptance of the agents involved in the last mile vehicles (manager of the company that buys the vehicles, manager of the companies that operate the vehicles and vehicle users) on EVs acquired Evaluation of the gains in life quality of the agents involved in last mile vehicles (manager of the company that buys the vehicles, manager of the companies that operates the vehicles and the vehicle users) after the acquisition of EV vehicles	Individual interview which includes questions defined in the log books Data measurement	Agents involved in the last mile vehicle (company managers, operation managers and vehicle users)

Table 59: Objective, method and target groups for the evaluation of social acceptance in Vitoria Gasteiz

10.4.1.1 Social acceptance in the district renovated

The tool to be used are questionnaires and log books which will include the questions selected in the tables below.

Dimensions	Elements (KPIs)	Vitoria-Gasteiz (YES/NOT)
Social background	Characteristics of the resident: age, education level, nationality and income	YES
	Characteristics of the dwelling: type of building, dwelling size, ownership, accommodation time	YES
Environmental background	Knowledge and environmental awareness on environmental problems	YES
	Knowledge and benefits of the solutions implemented in energy efficient retrofit projects	YES

Individual perception of residents	Fairness and inclusiveness in the decision-making process: satisfaction with the project, with the level of information received, with the involvement degree.	YES
	Trust in decision makers in terms of suitable time plan for the execution of actions and the communication and dialogue with decision makers.	YES
Economic value of the solutions	Satisfaction with the investment costs	YES
	Satisfaction with the access to financing	YES
	Satisfaction with the payback period	YES
	Satisfaction level with the reduction in the energy bills	YES
	Willingness to invest in further energy projects	YES
Technical value of the solutions	Satisfaction with the solution implemented as a whole	YES
	Satisfaction from the energy perspective (comfort)	YES
	Satisfaction from the energy perspective (energy savings satisfaction)	YES
	Satisfaction from aesthetic perception	YES

Table 60: Type of questions to be included in refurbishment questionnaires for Vitoria-Gasteiz

Dimensions (problems)	Elements (KPIs)	Vitoria-Gasteiz
Technical	Complains of residents with the time plan before the starting of works	X
	Complains of residents with the aesthetic of buildings before retrofitting	X
	Complains of residents with the time plan due to delays	X
	Complains with the persons working in the district	X
	Complains due to failure of heating system	X
	Complains due to aesthetical of the buildings	X
Economic	Complains of residents with the investment cost before works	X
	Complains of residents with the payback before works	X
	Complains of residents with the financial scheme before works	X
	Complains of residents with the energy savings after retrofitting since they do not respond to expected results (low impact in energy bills)	X
	Complains due to investment costs significantly higher	X
	Complains with the operating expenses after the retrofitting (higher than expected)	X

Table 61: Type of items to be collected in refurbishment log books for Vitoria-Gasteiz

The sample size of residents to be reached for measuring the social acceptance through survey methods, the channel of distribution of questionnaires and the post-processing process of the data collected will be decided in a posterior stage of the project. Will have to be defined:

- Phases where to collect data (e.g. before, throughout or after the renovation process).
- Frequency to collect this information (e.g. per month).
- Responsible before the works.
- Responsible during the works (e.g. the retrofitting company, the energy company, etc.).
- Responsible after the work.

10.4.1.2 Social acceptance in the mobility actions related to last mile vehicles

The tool to be used are interviews and log books which will include the questions selected in the tables below.

Dimensions	Elements (KPIs)	Vitoria-Gasteiz (YES/NOT)
Social background	Characteristics of the vehicle users: age, gender, education level, nationality and years as vehicle users	YES
	Characteristics of the vehicle replaced: years	YES
Environmental background	Knowledge and environmental awareness on environmental problems	YES
	Knowledge and benefits of the benefits of the mobility solutions implemented in the project	YES
Individual perception of residents	Fairness and inclusiveness in the decision-making process: satisfaction with the project, with the level of information received, with the involvement degree.	YES
Economic value of the solutions	Satisfaction with the investment costs	YES
	Satisfaction with the access to financing	YES
	Satisfaction with the payback period	YES
	Satisfaction level with the reduction in the operation costs	YES
	Willingness to purchase/invest in new EV	YES
Technical value of the solutions	Satisfaction with the solution implemented as a whole	YES
	Satisfaction with the solution in terms of comfort due to change in the type of energy source vehicle	YES
	Satisfaction with the solution in terms of cost savings due to change in the type of energy source vehicle	YES

Table 62: Type of questions to be included in mobility questionnaires for Vitoria-Gasteiz

Dimensions (problems)	Elements (KPIs)	Vitoria-Gasteiz
Technical	Complains due to failures in the vehicle	YES
	Complains due to the time dedicated for recharging EV	YES
Economic	Complains due to lack of recharger infrastructures	YES
	Complains with the maintenance of operation costs	YES
	Complains with the maintenance requirements	YES
	Complains due to costs for the payment of the electricity consumed is higher than expected	YES

Table 63: Type of items to be collected in mobility log books for Vitoria-Gasteiz

These questions included in the log book will be asked to the company manager during the interviews, which will be performed in the facilities of the people to be interviewed once the vehicles are circulated, being the expected sample size of agents to be involved for measuring the social acceptance the following:

- Manager of the company which purchase the EV.
- Manager of each company which operates the EV.
- 2-3 drivers of the EV

Finally, the reporting of the social acceptance could be under the option 2 described previously which consists of reporting each element in terms of % of satisfaction achieved.

10.4.2 Plan for Tartu

Table below summarizes the objective, method and target group to be involved in the evaluation of social acceptance in the city of Tartu.

Tartu		
Objective	Method	Target group
Evaluation of the acceptance of owners and tenants living in the district on SmartEnCity solutions implemented in the district renovated Evaluation of the gains in life quality due to the project in owners and tenants from district	Questionnaire Individual interview Focus group interview Data measurements	Owners and tenants from district
Evaluation of the acceptance on EV by users of rented EV and e-bikes Evaluation of the gains in life quality due to the project in users of rented EV and e-bikes	Questionnaire Data measurements	EV rental users

Evaluation of the acceptance on actions implemented in SmartEnCity project by citizens Evaluation of the gains in life quality due to the project in citizens of Tartu	Questionnaire	Citizens

Table 64: Objective, method and target groups for the evaluation of social acceptance in Tartu

10.4.2.1 Social acceptance in the district renovated

The tools to be used are questionnaires and interviews which will include the questions selected in the tables below.

Dimensions	Elements (KPIs)	Tartu (YES/NOT)
Social background	Characteristics of the resident: age, education level, nationality, income, etc.	YES
	Characteristics of the dwelling: type of building, dwelling size, ownership, accommodation time	YES
Environmental background	Knowledge and environmental awareness on environmental problems	YES
	Knowledge and benefits of the solutions implemented in energy efficient retrofit projects	YES
Individual perception of residents	Fairness and inclusiveness in the decision-making process: satisfaction with the project, with the level of information received, with the involvement degree.	YES
	Trust in decision makers in terms of suitable time plan for the execution of actions and the communication and dialogue with decision makers.	YES
Economic value of the solutions	Satisfaction with the investment costs	YES
	Satisfaction with the access to financing	YES
	Satisfaction with the payback period	YES
	Satisfaction level with the reduction in the energy bills	YES
	Willingness to invest in further energy projects	YES
Technical value of the solutions	Satisfaction with the solution implemented as a whole	YES
	Satisfaction from the energy perspective (comfort)	YES
	Satisfaction from the energy perspective (energy savings satisfaction)	YES
	Satisfaction from aesthetic perception	YES

Table 65: Type of questions to be included in refurbishment questionnaires and interviews for Tartu

Aspects to be considered in the implementation of survey methods:

- Sample: Local partners have some ideas about how many residents can be involved, however the exact size has not be decided yet. Still to be decided whether it will be used random or quota sample.
- The distribution of questionnaires and the performance of interviews can make use of an activity related to citizen engagement addressed to residents and also by dedicated mailing list, through post or through websites. The most probably is the combination of all simultaneously. In case of quota sample the representatives from each housing associations will distribute the questionnaire in their house according to the pre-given quotas (e.g. x number of students, x number of elderly etc.).

Finally, the reporting of the social acceptance could be under the option 2: it is evaluated as % for each element analysed.

10.4.2.2 Social acceptance about mobility actions

The tool to be used is questionnaires which will include the questions selected in the tables below.

Dimensions	Elements (KPIs)	Tartu (YES/NOT)
Social background	Characteristics of the vehicle users: age, gender, education level, nationality and years as vehicle users	YES
	Characteristics of the vehicle replaced: years	YES
Environmental background	Knowledge and environmental awareness on environmental problems	YES
	Knowledge and benefits of the benefits of the mobility solutions implemented in the project	YES
Individual perception of residents	Fairness and inclusiveness in the decision-making process: satisfaction with the project, with the level of information received, with the involvement degree.	YES
Economic value of the solutions	Satisfaction with the investment costs	NO
	Satisfaction with the access to financing	NO
	Satisfaction with the payback period	NO
	Satisfaction level with the reduction in the operation costs[16]	YES
	Willingness to purchase/invest in new EV	YES
Technical value of the solutions	Satisfaction with the solution implemented as a whole	YES
	Satisfaction with the solution in terms of comfort due to change in the type of energy source vehicle	YES
	Satisfaction with the solution in terms of cost savings due to change in the type of energy source vehicle	YES

Table 66: Type of questions to be included in mobility questionnaires for Tartu

[16] Reduction of the costs for users that rent an EV in comparison with users that rent other type of vehicle, as the payment for fuel consumed (e.g. oil) is reduced compared to the electricity consumed.

Aspects to be considered in the implementation of survey methods:

- Sample: Still to be decided.
- Means for distribution of the questionnaires are:
    - SmartEnCity local dissemination events
    - Workshops
    - Thematic free-time activities for the target group
    - In case of thematic exhibition questionnaires can be part of this activity
    - Distributed by the operator to its users (mail, website, on paper)

Finally, the reporting of the social acceptance could be under the option 2: it is evaluated as % for each element analysed.

10.4.2.3 Social acceptance about whole project by citizens

The method to be used in this case are questionnaires which will include the questions selected in the tables below.

Dimensions	Elements (KPIs)	Tartu (YES/NOT)
Social background	Characteristics of the resident: age, education level and nationality and project involvement degree, gender, income, employment, type of dwelling, city district	YES
Environmental background	Knowledge and environmental awareness on environmental problems	YES
	Knowledge about the benefits of the solutions implemented in energy efficient retrofit projects	YES
Individual perception of residents	Fairness and inclusiveness in the decision-making process in terms of satisfaction with the project and with the level of information received.	YES *We would like to explore, whether the project has inspired residents to think or act along the promoted way*
	Trust in decision makers and other relevant stakeholders in terms of suitable time plan for implementing the actions in the city and the confident in decision makers and stakeholders involved in this project as well as in others similar projects.	YES
Economic value of the solutions	Satisfaction with the investment costs	YES *(but depending of the sample selected)*
	Satisfaction with the access to financing	
	Satisfaction with the payback period	
	Satisfaction level with the reduction in the energy bills and operation costs	
	Willingness to invest in further energy projects	

Technical value of the solutions	Satisfaction with the solution implemented as a whole	YES
	Satisfaction from the energy perspective (comfort and energy savings satisfaction)	NO
	Satisfaction from aesthetic perception	YES

Table 67: Type of questions to be included in general questionnaires for Tartu

- Sample: The size cannot be estimated at this moment although the local group has some ideas about that. Will be probably required having different samples since it is desired to explore both energy retrofitting and mobility part in total. These target groups among the citizens may not be equally suitable for questionnaires in these different areas. As we are dealing with integrated solutions and district wide measures, the idea is to try to compose a sample in such a way that all issues can be explored, however depending on the actual mobility actions to be launched in the project, the citizen sample to survey the acceptance of some mobility actions may be slightly different. It is very likely that will be added questionnaires/interviews with associations of citizens from different fields as well. During the project it is already being a cooperation with such organisations, and it is planned to continue such cooperation as much as possible. This gives us also feedback from the opinions of citizens.
- Questionnaire will be distributed through the web channels of the city of Tartu and SmartEnCity project. Another option is to approach the people “on the street” and/or use thematic events. The means may be more targeted dependent on the final composition of the sample of citizens.
- Finally, the reporting of the social acceptance could be under the option 2: it is evaluated as % for each element analysed.

10.4.3 Plan for Sonderborg

Table below summarizes the objective, method and target group to be involved in the evaluation of social acceptance in Sonderborg.

Sonderborg		
Objective	Method	Target group
Evaluation of the acceptance of tenants living in the district on SmartEnCity solutions implemented in the district renovated Evaluation of the gains in life quality of tenants living in the district retrofitted	Questionnaires Data measurement	Tenants
Evaluation of the acceptance of tenants living in other districts of the city (citizens) on SmartEnCity solutions implemented in the district renovated	Questionnaire	Citizens (tenants from other districts)

Evaluation of the gains in life quality of tenants living in other districts of the city (citizens)		

Table 68: Objective, method and target groups for the evaluation of social acceptance in Sonderborg

10.4.3.1 Social acceptance in the district renovated and in other potential districts

The method to be used in Sonderborg is the use of questionnaires which will include the questions selected in the tables below. These issues will be asked to tenants from district to be renovated in the SmartEnCity project as well other tenants (citizens) from the city.

Dimensions	Elements (KPIs)	Sonderborg (YES/NOT)
Social background	Characteristics of the resident: age, education level, nationality and income	YES
	Characteristics of the dwelling: type of building, dwelling size, ownership, accommodation time	YES
Environmental background	Knowledge and environmental awareness on environmental problems	YES
	Knowledge and benefits of the solutions implemented in energy efficient retrofit projects	YES
Individual perception of residents	Fairness and inclusiveness in the decision-making process: satisfaction with the project, with the level of information received, with the involvement degree.	YES
	Trust in decision makers in terms of suitable time plan for the execution of actions and the communication and dialogue with decision makers.	NO
Economic value of the solutions	Satisfaction with the investment costs	YES
	Satisfaction with the access to financing	NO
	Satisfaction with the payback period	NO
	Satisfaction level with the reduction in the energy bills	YES
	Willingness to invest in further energy projects	YES
Technical value of the solutions	Satisfaction with the solution implemented as a whole	YES
	Satisfaction from the energy perspective (comfort)	YES

	Satisfaction from the energy perspective (energy savings satisfaction)	YES
	Satisfaction from aesthetic perception	YES

Table 69: Type of questions to be included in refurbishment questionnaires for Sonderborg

Aspects to be considered in the implementation of survey methods on Sonderborg are:

- The sample size of residents to be reached for measuring the social acceptance through survey methods will be decided in a posterior stage of the project.
- Channel of distribution of questionnaires: Questionnaire will be distributed through website to the tenants from the district to be retrofitted and by phone to those tenants from other districts to be involved in the social acceptance evaluation.
- Post-processing process of the data collected: Will have to be defined on meetings with the tenants.

10.4.4 Comparative summary of the Plans for assessing social acceptance

This protocol is a tailored protocol adapted to the objectives to be evaluated in each city.

City	Actions	Objectives	Target groups
Vitoria	District renovation Sustainable mobility actions	Evaluation of the social acceptance, in terms of satisfaction, on SmartEnCity solutions in the target groups of the project Evaluation of the life quality improvements due to the project in the target groups of the project	Owners and tenants from district renovated Agents involved in the acquisition of EVs (companies and users)
Tartu			Owners and tenants from district renovated Users of rented EVs Citizens from the city of Tartu
Sonderborg			Tenants from district renovated Tenants from other districts of the city (citizens)

Table 70: Comparative summary of the social acceptance evaluation plans on the three LH cities

The scale of social acceptance measured through surveys methods used in the three cities will be: *Extremely (5) – Very (4) – Moderately (3) – Slightly (2) – Not at all (1).*

In those cases which are using log books (applied only for Vitoria), the social acceptance and the gains in life quality (e.g. thermal comfort) could be considered as achieved if no high-impact technical issues have been gathered, or, if any, they have been solved.

11 Citizen engagement protocol

11.1 Scope of the protocol

A citizen engagement strategy will be designed in each city as basis to build a specific plan which defines the actions to be executed, the target audience and the means/channels to be used to guarantee the implementation of the SmartEnCity interventions. Both engagement processes will be the result of collaboration between actors involved in the project and the target audience which allow to co-designing the citizen engagement activities.

11.1.1 Actions to be evaluated

Actions which take part of citizen engagement are described in section 4 in the subsections devoted to the Citizen engagement strategy. Table below summarizes the main features of these activities in each city.

City	Vision of citizen engagement strategy			
	Objective	Target audience	Means	Actors/Decision makers
Vitoria-Gasteiz	To communicate with the citizens, owners, and tenants so they understand the benefits of the building retrofitting and the implementation of a DH. Organize a communication campaign, including various events, meetings, materials and channels to inform, involve and empower the house owners through the decision making process.	Mainly home owners, but also tenants and citizens	Letters, phone and door to door invitations Open exhibitions to all the residents Printed materials and web page for the intervention Local information office about the intervention Round of meetings with presidents of each building	VISESA as coordinator of the actions in Vitoria-Gasteiz and main interlocutor with home owners CEE as specialist on citizen engagement actions TECNALIA as research and innovation entity with a perspective from similar processes in other cities Municipality of Vitoria-Gasteiz as main interlocutor with citizens MONDRAGÓN as technology provider for solutions.
	To provide services to the dwelling owners to improve the thermal comfort in the houses	Owners from dwellings	ICT services accessible via Internet and smart devices	MON, MTEL, MU and other service providers
	Acquire the general feeling of the citizens	All citizens in Vitoria-Gasteiz	Citizen Inbox and data mining & intelligent analysis of social networks	Municipality as host and user of the information MON, MTEL, ETIC and others as ICT developers

Tartu	To have well-informed citizens who can and want to contribute to the development of Smart Tartu	Two target groups: pilot area residents and the citizens of Tartu	Various media channels, direct contact (incl. organizing thematic events and workshops) and ensure project visibility in traditional media as well	The local SmartEnCity communication and engagement working group (IBS, UTAR, TAR, SCL, TREA)
Sonderborg	Getting involved all housing associations to make a green strategy involving energy management, citizen engagement, procurement policy / demand to suppliers, retrofitting policy in order to succeed with the vision of the city council becoming CO2 neutral by 2029. Identifying new departments in the six housing associations in Sonderborg municipality to start retrofitting based on the lessons learned from SmartEnCity.	Mainly the demo area residents but also rest of citizens of Sonderborg	Various media channels and website, direct contact (incl. meetings, workshops thematic excursions, phone calls or e-mails) and leaflets and brochures	The local SmartEnCity communication and engagement working group for Sonderborg and the "citizen engagement partnership" (ZERO, the general managers from the housing associations and the consulting engineer associated with the retrofitting projects). The final decision/approval of the retrofitting plans will be taken by the tenants living in each specific unit

Table 71: Actions to be evaluated on the citizen engagement protocol

11.1.2 Objectives to be evaluated

Citizen engagement protocol has as main purpose to evaluate the level of successful of the project objectives as a result of the influence of the citizen engagement strategy and posterior actions as main tools for achieving the fully implementation of interventions in the city in the terms established in the Grant Agreement.

Potential objectives to be evaluated have been considered the following:

- Evaluate the citizen engagement strategy implemented in each city
- Evaluate the citizen engagement action plan implemented in each city (e.g. level of attendance to information campaigns and other type of events and the use of urban platform/web application in the city)
- Evaluate the successful of the project objectives

Therefore, the connection among citizen engagement actions and objectives to be evaluated are as follows:

Citizen Engagement Actions	Objectives
Citizen engagement strategy	Evaluate the citizen engagement strategy

Citizen engagement action plan	Evaluate the level of attendance of target audience to information campaigns and events held in the city as part of the citizen engagement actions
	Evaluate the use of urban platform/web application (apps, added value services, social media and website) as part of citizen engagement actions
Citizen engagement strategy vision & Citizen engagement action plan	Evaluate the successful of the project objectives

Table 72: Citizen engagement actions vs. objectives

Concerning the target groups that can take part of the citizen engagement actions in the cities are the following:

- District intervention: owners and tenants
- Mobility action: vehicles owners and vehicle users from EV
- Citizen engagement actions: citizens

Since the processes for citizen engagement will be different in each LH due to the citizen engagement conditions are not the same (target audience, governance, administrative structures and decision makers), the objectives to be evaluated in each city will be aligned with their own citizen engagement process and with the target groups where more efforts will be invested for the implementation of the SmarEnCity interventions. Hence, each local team has selected the objectives to be evaluated in each city as it is described in the table below:

City	Objectives
Vitoria-Gasteiz	• Evaluate the citizen engagement strategy • Evaluate the level of attendance of residents to information campaigns and events held in the city as part of citizen engagement actions • Evaluate the use of urban platform/web application (apps, added value services, social media and website) as part of citizen engagement actions by residents from district, mobility actors and citizens • Evaluate the successful of the project objectives in the district
Tartu	• Evaluate the citizen engagement strategy • Evaluate the level of attendance of residents (owners and tenants), EV rental users and citizens to information campaigns and events held in the city as part of citizen engagement actions • Evaluate the use of urban platform/web application (apps, added value services, social media and website) as part of citizen engagement actions by residents, EV rental users and citizens • Evaluate the successful of the project objectives in the district and in the mobility action
Sonderborg	• Evaluate the citizen engagement strategy • Evaluate the use of urban platform/web application (apps, added value services, social media and website) as part of citizen engagement actions by tenants • Evaluate the successful of the project in district

Table 73: Citizen engagement objectives to be evaluated in each LH city

11.2 SmartEnCity evaluation approach

11.2.1 Baseline and post-intervention design

This protocol will be implemented for the assessment of the results obtained after the implementation of citizen engagement activities, not requiring any evaluation of the starting point (baseline). The total evaluation will be shown in D7.13 from T7.5, and any section will be included in D3.2, D4.2 and D5.2.

11.2.2 KPIs

A set of KPIs have been proposed to each city. Such indicators come from the list provided in D7.2 which has been updated with new ones. This process guarantees to have a common framework of evaluation but also tailored plans for each city since they have selected those KPIs that better fits with their city objectives. The set of KPIs can be found in the next section.

11.2.3 Methods of evaluation

Table below compiles the tools proposed for quantify each of the objectives proposed.

Objective	Tools
Evaluate the citizen engagement strategy (perception of residents and responsible for their design)	Questionnaire/interviews/working groups discussion. To be aligned with the citizen engagement strategy and taking into account the need of measure social acceptance (probably with the same persons)
Evaluate the level of attendance of residents to information campaigns and events held in the city	Templates which compiles the main data from attendees to be distributed in each relevant event
Evaluate the use of urban platform	Through own mechanism of the urban platform
Evaluate the successful of the project objectives in the district	Log books, templates to be distributed through the partners involved in the evaluation

Table 74: Methods of evaluation to quantify the citizen engagement objectives

All the tools will be designed in posterior deliverables since it is not required to start the evaluation of this protocol. However some guidelines of the information to be collected in each event are provided below for their use immediate since they are being held at this moment of the project.

- Name of the event
- Date
- Objective of the event
- Number of attendees
- Main conclusions

Other decisions to be taken correspond to how and when to evaluate the citizen engagement.

Objectives & tools	How
Evaluate the citizen engagement strategy (perception of residents and responsible for their design) through questionnaires/interviews/working groups	Different alternatives: It will have to be defined if this objective is evaluated once the citizen engagement have concluded, when all the actions of citizen engagement have been ended, once a year, etc.
Evaluate the level of attendance of residents to information campaigns and events held in the city through templates	It has to be decided on which events must be collected the information required for the evaluation of the objectives persuaded
Evaluate the use of urban platform/web application through own mechanisms available in them	The frequency on which users use the urban platform/web application must be defined. In addition, it could be required to measure the quality of services/added value services by surveys. It is needed to think about how to do it
Evaluate the success of the project objectives in the district by templates or log books	The evaluation of the success of the project objectives can be made at the end of the project or in different stages Doubts to be solved can be collected annually.

Table 75: Means and frequency to evaluate the citizen engagement

11.3 Plan for the citizen engagement assessment

This section describes the KPIs proposed to evaluate the objectives identified for the cities as well the KPIs selected by local partners according to the possibilities of evaluation. In addition, the tables which compile the KPIs include some details to be considered when the urban platform/web applications were designed.

A wide collaboration with the partners involved in citizen engagement activities have been kept in order to align the objectives of evaluation with the actions to be executed in the LH cities.

11.3.1 Plan for Vitoria

The list of KPIs selected for Vitoria-Gasteiz is provided below.

Actions	Objectives of evaluation	KPIs	Feedback from local partners (YES/NOT)	Some details to be considered

Citizen engagement strategy	Evaluate the citizen engagement strategy_ through the perception of residents	Number of residents who considered to be **well-informed** during the information campaigns that were carried out as part of citizen engagement actions / Number of residents who answered this question	YES	
		Number of residents who considered to be **well-consulted** during the information campaigns that were carried out as part of citizen engagement actions / Number of residents who answered this question	YES	
		Number of residents who **felt involved** in the decisions taken in the district / Number of residents who answered this question	YES	
		Number of surveys fulfilled by residents/ Number of residents involved in the citizen engagement actions	YES	
	Evaluate the citizen engagement strategy_ through the perception of responsible of their design	Perception of success or failure by actors involved about citizen engagement activities performed	YES	
Citizen engagement plan	Evaluate the level of attendance of residents to information campaigns and events held in the city as part of the citizen engagement strategy	Number of activities carried out for informing residents about the project to implement the district renovation	YES	
		Number of residents involved in the citizen engagement actions carried out to implement the district renovation	YES	
		Number of active residents involved in the citizen engagement actions carried out to implement the district renovation	YES	
	Evaluate the use of urban platform (apps, added value services, social media and website) as part of the citizen engagement strategy by residents from district, mobility actors and citizens	Number of citizens using web application	YES	
		Number of citizens (registered users) using web application	YES	In the case that a registration is contemplated to access certain information of the web. Furthermore, it will be necessary to classify users first
		Number of visits (daily/monthly) to the web application	YES	The user recurrence could be evaluated (how many times the user accesses or participates)
		Increase of new visitors in the web application	YES	Frequency will be detailed in a posterior stage
		Maximum concurrent users/requests in the web application	NO	Although it could be tried to know if the

				connections have any pattern
		Time spent of the web	YES	
		Number of Apps developed in the framework of SmartEnCity	YES	
		Number of Apps developed in the framework of SmartEnCity focused in residents from district	NOT DECIDED YET	
		Number of Apps developed in the framework of SmartEnCity focused in mobility actors	NOT DECIDED YET	
		Number of Apps developed in the framework of SmartEnCity focused in citizens	NOT DECIDED YET	
		Number of mobile app downloads in the framework of SmartEnCity	YES	
		Number of mobile app downloaded by residents from district	NOT DECIDED YET	
		Number of mobile app downloaded by mobility actors	if this separation will be considered in the evaluation	
Citizen engagement plan		Number of mobile app downloaded by residents from district		
		Number of active users of Apps	?	
		Number of active users of Apps in the category of residents	NOT DECIDED YET	
		Number of active users of Apps in the category of mobility actors		
		Number of active users of Apps in the category of citizens		
		Quality of services/added value services	YES	Through surveys to be launched in the app
Citizen engagement strategy + plan	To evaluate the success of project objectives_ building refurbishment action and district heating with RES	Number of dwellings retrofitted	YES	
		Number of buildings connected to the District Heating	YES	
		Number of residents benefited by the intervention	YES	
		Number of residents who were against project	YES	In terms of number of registered complains or negative feedback against the project
		Number of doubts solved face to face	YES	
		Number of doubts solved through citizen inbox	YES	

Table 76: KPIs for citizen engagement evaluation on Vitoria-Gasteiz

At this moment the city of Vitoria is willing to design questionnaires/interviews and the urban platform in order to evaluate the objectives and KPIs selected, but any/some idea about how to do it is known yet.

11.3.2 Plan for Tartu

The list of KPIs selected for Tartu is provided below.

Actions	Objectives of evaluation	KPIs	Feedback from local partners (YES/NO)	Some details in case refusing
Citizen engagement strategy	Evaluate the citizen engagement strategy_ through the perception of residents, EV rental users and citizens	Number of **residents** who considered to be **well-informed** during the information campaigns that were carried out as part of citizen engagement actions / Number of residents who answered this question	YES	
		Number of **EV rental users** who considered to be **well-informed** during the information campaigns that were carried out as part of citizen engagement actions / Number of EV rental users who answered this question	YES	But depending on the mobility actions (not all them are defined yet)
		Number of **citizens** who considered to be **well-informed** during the information campaigns that were carried out as part of citizen engagement actions / Number of **citizens** who answered this question	YES	
		Number of **residents** who felt **well-consulted** during the information campaigns that were carried out as part of citizen engagement actions / Number of residents who answered this question	YES	
		Number of **EV rental users** who considered to be **well-consulted** during the information campaigns that were carried out as part of citizen engagement actions / Number of residents who answered this question	YES	But depending on the mobility actions (not all them are defined yet)
		Number of **resident**s who **felt involved** in the decisions taken in the district / Number of residents who answered this question	YES	
		Number of EV rental users who **felt involved** in the decisions taken in the design of mobility strategy / Number of EV rental users who answered this question	NO	EV rental users are not involved into designing the mobility strategy. Therefore basic elements of the mobility actions are not open for co-decision although details in services, apps related to mobility actions etc. may be open for it.
		Number of surveys fulfilled by **residents**/ Number of residents involved in the citizen engagement actions	YES	
		Number of surveys fulfilled by **EV**	YES	

		rental users/ Number of EV rental users involved in the citizen engagement actions		
		Number of surveys fulfilled by **citizens**/ Number of citizens involved in the citizen engagement actions	YES	
	Evaluate the citizen engagement strategy_ through the perception of responsible of their design	Perception of success or failure by actors involved about citizen engagement activities performed	YES	
Citizen engagement plan	Evaluate the level of attendance of residents, EV rental users and citizens to information campaigns and events held in the city as part of the citizen engagement strategy	Number of activities carried out for informing **residents** about the project	YES	
		Number of activities carried out for informing **EV rental users** about the project	YES	
		Number of activities carried out for informing **citizens** about the project	YES	
		Number of **residents** involved in the citizen engagement actions carried out	YES	
		Number of **EV rental users** involved in the citizen engagement actions carried out	YES	
		Number of **citizens** involved in the citizen engagement actions carried out	YES	
		Number of active **residents** involved in the citizen engagement actions carried out	NO	Only in case we will include “more active” residents through social innovation experiments, this may become one indicator as well.
		Number of active **EV rental users** involved in the citizen engagement actions carried out	NO	There is one category – users of EV vehicles
		Number of active **citizens** involved in the citizen engagement actions carried out	NO	
	Evaluate the use of urban platform (apps, added value services, social media and website) as part of the citizen engagement strategy by residents, EV rental users and citizens	Number of citizens using web application	YES	
		Number of citizens (registered users) using web application	NO	
		Number of visits (daily/monthly) in the web application	YES	
		Increase of new visitors in the web application	YES	
		Maximum concurrent users/requests in the web application	NO	
		Time spent of the web	YES	
		Number of Apps developed in the framework of SmartEnCity	YES	Urban platform will be free for public use
		Number of Apps developed in the framework of SmartEnCity focused in residents from the district	NO	
		Number of Apps developed in the framework of SmartEnCity	NO	

		focused in EV rental users		
		Number of Apps developed in the framework of SmartEnCity focused in citizens	NO	
		Number of mobile app downloads	YES	
		Number of mobile app downloads by residents from the district	NO	
		Number of mobile app downloads by EV rental users	NO	These data is operated by the third partner, we will not specifically measure this
		Number of mobile app downloads by citizens	NO	
		Number of active users of Apps	NOT DECIDED YET	
		Number of active users of Apps in the category of residents	NO	
		Number of active users of Apps in the category of EV rental users	NO	
		Number of active users of Apps in the category of citizens	YES	
		Quality of services/added value services	YES	It will be needed to define the term quality
Citizen engagement strategy + plan	To evaluate the success of project objectives_ building refurbishment action and district heating with RES	Number of dwellings retrofitted	YES	
		Number of buildings connected to the District Heating	NO	All are connected already
		Number of residents benefited by the intervention	YES	
		Number of residents who were against project	NO	We are not including these KPIs as these are actually not relevant, considering our context and voting procedures in the housing associations.
		Number of doubts solved face to face	NO	Log books are not being used in Tartu
		Number of doubts solved through citizen inbox	YES	

Table 77: KPIs for citizen engagement evaluation on Tartu

At this moment the city of Tartu is willing to design questionnaires/interviews, templates, the urban platform and other mechanism in order to evaluate the objectives and KPIs selected, with some idea about how to do it.

The perception of the citizen engagement strategy by the own designers will be evaluated through a working group discussion/interview with the members of citizen engagement working group and with additional relevant stakeholders. Regarding when to evaluate this objective, taking into account that Citizen Engagement working Group is meeting bimonthly and regularly reviewing the activities according to the strategy as well as updating the action plan, this could be measured at the end of the citizen engagement activity but also it could be evaluated each year from 2017.

The perception of the citizen engagement strategy by residents and other agents involved: once at the end of the citizen engagement activity.

11.3.3 Plan for Sonderborg

The list of KPIs selected for Sonderborg is provided below.

Actions	Objectives of evaluation	KPIs	Feedback from local partners (YES/NO)	Some details in case refusing
Citizen engagement strategy	Evaluate the citizen engagement strategy_ through the perception of residents	Number of residents who are considered to be **well-informed** during the information campaigns that were carried out as part of citizen engagement actions / Number of residents who answered this question	YES	
		Number of residents who considered to be **well-consulted** during the information campaigns that were carried out as part of citizen engagement actions / Number of residents who answered this question	NO	There is no possibility to consult the tenants one by one in this project.
		Number of residents who **felt involved** in the decisions taken in the district / Number of residents who answered this question	YES	
		Number of surveys fulfilled by residents/ Number of residents involved in the citizen engagement actions		
	Evaluate the citizen engagement strategy_ through the perception of responsible of their design	Perception of success or failure by actors involved about citizen engagement activities performed	YES	
Citizen engagement plan	Evaluate the use of urban platform (apps, added value services, social media and website) as part of the citizen engagement strategy by residents from district, mobility actors and citizens	Number of citizens using web application	YES	
		Number of citizens (registered users) using web application	NO	
		Number of visits (daily/monthly) in the web application	YES	
		Increase of new visitors in the web application	YES	
		Maximum concurrent users/requests in the web application	NO	
		Time spent of the web	YES	
		Number of Apps developed in the framework of SmartEnCity	NO	It is free for public use
		Number of Apps developed in the framework of SmartEnCity focused in residents from district	NO	
		Number of mobile app downloads in the framework of SmartEnCity	YES	
		Number of mobile app downloads by residents from district	MAYBE	

		Number of active users of Apps	YES	
		Number of active users of Apps in the category of residents	NO	
		Quality of services/added value services	YES	
Citizen engagement strategy + plan	To evaluate the success of project objectives_ building refurbishment action and district heating with RES	Number of dwellings retrofitted	YES	
		Number of buildings connected to the District Heating	YES	
		Number of residents benefited by the intervention	YES	
		Number of residents who were against project	YES	
		Number of doubts solved face to face	NO	
		Number of doubts solved through citizen inbox	NO	

Table 78: KPIs for citizen engagement evaluation on Sonderborg

At this moment the city of Sonderborg is willing to design questionnaires/interviews, templates, the urban platform and other mechanism in order to evaluate the objectives and KPIs selected, with any/some idea about how to do it.

As has been explained in more detail on section 4.3.4, in Sonderborg the strategy to be followed to engage the citizens in the process will be deployed in different steps. All tenants in the tree housing associations will be invited for meetings where they will receive information about the specific plans for retrofitting and where they will be able to discuss about them. Additionally there will be information available online at the websites of the housing associations.

11.3.4 Comparative summary of the Plans for assessing citizen engagement actions

Table 79 below summarizes comparatively the plans that will be deployed for the assessment of the citizen engagement on the three LH cities.

City	Objectives	Target groups
Vitoria - Gasteiz	Evaluate the citizen engagement strategy through the perception of responsible of their design and residents Evaluate the level of attendance of residents to information campaigns and events held in the city as part of citizen engagement actions Evaluate the use of urban platform/web application Evaluate the successful of the project objectives in the district	Residents
Tartu	Evaluate the citizen engagement strategy through the perception of responsible of their design and residents Evaluate the level of attendance of residents to information campaigns and events held in the city as part of citizen engagement actions Evaluate the use of urban platform/web application Evaluate the successful of the project objectives in the district	Residents
Sonderborg	Evaluate the citizen engagement strategy through the perception of responsible of their design and residents Evaluate the use of urban platform/web application Evaluate the successful of the project objectives in the district	Residents

Table 79: Comparative summary of the citizen engagement evaluation plans for the three LH

12 Economic Performance Protocol

12.1 Scope of the protocol

12.1.1 Actions to be evaluated

Three types of actions can be evaluated in this protocol: District renovation, mobility and citizen engagement actions. The description of these actions is included in Chapter 4.

12.1.2 Target groups to be involved in the protocol

Aligned with the nature of the actions to be implemented in the cities, the following target groups have been identified as potential target audience.

- District intervention: owners and tenants
- Mobility action: vehicles owners and vehicle users from EV and biogas buses
- Citizen engagement actions: actors involved in these actions in SmartEnCity project for empowering the execution of the interventions and achieve the project objectives

12.1.3 Objectives to be evaluated

Economic performance protocol aims to evaluate the cost effectiveness of the interventions previously mentioned, having identified the potential objectives to be quantified:

- Energy costs savings achieved with the implementation of energy solutions in district and in mobility.
- Return of the investment made in district and mobility actions.
- Cost of citizen engagement activities carried out in the project to achieve the project objectives.

Apart from those generic objectives, the different demo sites of SmartEnCity project have identified their own objectives of interest:

City	Objectives
Vitoria-Gasteiz	• Energy costs reductions in district for residents with the implementation of energy solutions in district (in comparison with the initial situation) • Energy costs reductions in last mile EV (in comparison with the initial situation) • Economic viability of district retrofitting (for owners) • Economic viability of investment made in last mile EV
Tartu	• Energy costs savings achieved by owners living in district and housing unions with the implementation of energy solutions in district (in comparison with the initial situation) • Energy costs savings achieved with the rental of EV (cars) and e-bike (in comparison with the initial situation) • Cost of citizen engagement activities carried out in the project to achieve the project objectives.
Sonderborg	• Energy costs savings of tenants living in district (in comparison with the initial situation)

Table 80: Economic objectives for evaluation on the LH cities

As summarized in the above chart, all the demo sites are interested in knowing the energy cost savings achieved in the district and the energy savings achieved with the mobility actions implemented (both in comparison with the initial situation).

12.2 SmartEnCity evaluation approach

The main aim of this economic protocol is measuring costs, savings and viability of the demo sites of the SmartEnCity project. In order to achieve this target, several KPIs have been proposed for the 3 categories of actions: district renovation, mobility and citizen engagement. Then, according to the feedback of each lighthouse city about whether their interest, last minute changes in the actions to be carried out or the possibility of getting the needed information for their calculation, a selection of suitable KPIs has been made for each LH project. Finally, on the following pages, a conceptual explanation of them has been done as well as the formulation of the calculation for each one.

12.2.1 Baseline and post-intervention design

It has to state that the evaluation of this protocol should be done in 2 phases: baseline definition and final performance. The baseline definition must be evaluated at the beginning of the project as a characterization of the initial situation (M18). The final performance must be evaluated at the end of the project as characterization of the final results of the implementation of the different activities.

12.2.2 KPIs

For district renovation

In this section of the document, explanation of economic KPIs referent to building retrofitting has been done. Needs and objectives have been taken into account when proposing this set of KPIs to evaluate the viability of the interventions.

- **Resident costs:** This indicator measures the monetary amount that the residents must pay at the beginning of the project. It is needed to have total project investment and total Grant. Subtraction of this data divided among total dwelling area gives as result resident costs per square meter.

$$RC = \frac{(Investment - Grant)}{Total\ Area} \quad (1)$$

- **Grant rate:** It measures percentage of grant of the total investment, making easy their comparability with other demos. This rate is multiplied per 100.

$$GR = \frac{Grant}{Investment} \times 100 \quad (2)$$

- **Total annual costs:** Indicate the annual costs (for residents) of maintenance and energy per year. Maintenance costs are monetary amount per installation maintenance, equipment maintenance, retrofits break, etc. for all residents. Energy costs are the uptakes of all residents, and are calculated as the multiplication of among KWs country price and KW consumption. Data must be obtained of project results, that is, of the data obtained in the baseline and at the end of project. This sum is split by total dwelling area.

$$TAC = \frac{\sum_{i=1}^{n=n.residents} Maintenance\ costs + Energy\ Costs}{Total\ Area} \quad (3)$$

- **Total annual benefits for residents:** It is calculated as the subtraction among Old costs and total annual costs (Above KPIs). Old costs are annual costs previous at the project, including maintenance and uptakes costs and divided per total area. This "Old cost" must be calculated for Baseline. With this equation it is obtained the annual benefit per square meter with the renovation.

$$BF = Old\ costs - Total\ annual\ Costs\ (TAC) \quad (4)$$

- **Cost saving rate:** percentage of annual benefits of the project. Division among total annual benefits for residents and old costs multiplied per 100. It measures as profitability in a year.

$$CRR = \frac{Total\ Anual\ Benefits\ for\ residents}{Old\ Costs} \times 100 \quad (5)$$

- **Net present value for resident:** The net present value of an investment causing energy savings or energy production in comparison to a baseline is defined as the sum of the discounted net annual incoming related to the investment (BF) less initial costs for the residents (RC). The timing can be determined by the time of the investment and a planning horizon.

$$NPV = -Resident\ Costs + \sum_{i=1}^{n=years} \frac{Total\ Anual\ Benefits\ for\ Residents_{\ i}}{(1+r)^i} \quad (6)$$

"i" is the number of years to consider in the survey, and r is the inflation rate. Inflation to consider could be the average i.e. to 5 years in UE zone (1.3%), or last month UE zone inflation, or inflation of each particular country[17].

- **Return of Investment (ROI) for resident:** Internal rate of return of an investment causing energy savings or energy production in comparison to a baseline is defined as the interest rate that results with a net present value of zero (by clearing "r" in the equation). When "r" is higher than the value obtained, the NPV is negative. This indicator uses the same values than NPV.

$$NPV = -Resident\ Costs + \sum_{i=1}^{n=years} \frac{Total\ Anual\ Benefits\ \ for\ Residents_{\ i}}{(1+r)^i} = 0 \quad (7)$$

- **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. Simple payback takes real (non-discounted) values for future monies. Payback in general ignores all costs and savings that occur after payback has been reached.

$$PB = -Resident\ Costs + \sum_{i=1}^{=years} Total\ Anual\ Benefits\ for\ Residents_{\ i} \quad (8)$$

The following table shows the above indicators summarized:

[17] Information extracted from European Central Bank: https://www.ecb.europa.eu/stats/prices/hicp/html/inflation.en.html

Actions	Project Phase: Baseline	Project Phase: Final performance	List of indicators	Definition	Unit	Data Source	Equation	Equation Number
DISTRICT INTERVENTIONS		X	Resident costs (RC)	Its the subtraction between investments and grants. The investment in the refurbishment of a new set of building is defined as acumulated payments until the initial operation of the building after the refurbishment. Grant is the amount provided by public entities, and is a part of the investment. This result is splited by overall dweling area.	l/m2	Questionnarie	$RC = \frac{(Investment - Grant)}{Total\ Area}$	1
		X	Grant rate (GR)	It is the rate that linking grant with investment. The higher the rate is, the more is the grant. Make easy comparisons between demos.	-	Questionnarie	$GR = \frac{Grant}{Investment} \times 100$	2
	X	X	Total Annual Costs (TAC)	It is the summation of all maintenace costs and energy costs per year, splited by overall dwelling area.	l/m2	Questionnarie	$TAC = \frac{\sum_{i=1}^{n=residents} Maintenance\ costs + Energy\ Costs}{Total\ Area}$	3
		X	Total Annual "Benefits" for resident (BF)	It is the subtraction between old costs and Total Annual Costs. Old costs divided by area that are estimated with before retroffiting uptakes. TAC are calclated with equation number 3.	l/m2	Questionnarie	$BF = Old\ costs - Total\ annual\ Costs\ (TAC)$	4
		X	Cost saving Rate (CSR)	It is the ratio of Total Annual benefits for Resident and estimated Old costs, multiplied per 100. This indicator shows costs saving per year.	%	Questionnarie	$CRR = \frac{BF}{Old\ Costs} \times 100$	5
		X	Net Present Value for resident (NPV)	The net present value of an investment causing energy savings or energy production in comparison to a baseline is defined as the sum of the discounted annual incoming cash-flows related to the investment (BF) less the discounted annual outgoing cash flows related to the investment less the discounted annual incoming cash-flows related to the baseline plus the discounted annual outgoing cashflows related to the baseline over a period of time (RC). The latter can be determined by the time of the investment and a planning horizon.	l/m2	estimated	$NPV = -RC + \sum_{i=1}^{n=years} \frac{BF_i}{(1+r)^i}$	6
		X	ROI for resident	Internal rate of return of an investment causing energy savings or energy production in comparison to a baseline is defined as the interest rate that results into a net present value of zero.	%	Estimated	$NPV = -RC + \sum_{i=1}^{n=years} \frac{BF_i}{(1+r)^i} = 0$	7
		X	Payback for resident	The payback period is the time it 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. Simple payback takes real (non-discounted) values for future monies. Payback in general ignores all costs and savings that occur after payback has been reached.	Years	Estimated	$PB = -RC + \sum_{i=1}^{=years} BF_i$	8

Table 81: Economic KPIs for district renovation

For mobility actions

In this section of the document, explanation of economic KPIs referent to mobility has been done. Needs and objectives have been taken into account when proposing this set of KPIs to evaluate the viability of the interventions. They have been divided into 3 typologies according to the type of vehicle that are referenced to: overall indicators, taxi indicators and private cars indicators.

KPIs from total costs can be calculated by all demos if they fit their characteristics and they are as follows:

- **Total annual costs:** it is the maintenance costs per year of overall mobility initiatives, including bus costs, bike costs, recharge network, etc. Result will be a sum of this above values. Each demo only includes costs related with their demo project.

$$TAC = \sum Bus\ Costs + Bike\ Costs + Recharge\ Costs + Grant\ car\ costs + others \quad (9)$$

- **Benefits by uptake saving:** It is the sum of all saved annual kilometres, measured in the cost of fuel, less cost of electricity usage. For example, kilometres realized with electrical energy multiplied per fuel price minus cost of electricity multiplied per kilometres.

$$BUS = \sum_{i=1}^{n}(electrical\ Km \times Country\ Fuel\ price - electrical\ KW\ uptakes \times country\ KW\ price) \quad (10)$$

- **Benefits:** It is the subtraction between BUS (10)-TAC (9). It measures benefits per year. Indicator shows the net benefit of the project.

$$B = Benefits\ by\ Uptake\ Saving\ (10) - Total\ Anual\ Costs(9) \quad (11)$$

- **Costs of saving a kg of CO2:** It is the rate between total costs and Co2 kilograms saved. It is evaluated overall costs of achieving to save a Kg of CO2.

$$C\ co2 = \frac{TAC\ (9)}{Annual\ Kg\ of\ CO2\ saving} \quad (12)$$

- **Net present value overall:** It the same case that equation number 6. In this case is used indicator “B” (number 11) as benefits and overall costs realized at the first year. “r” and “i” are the same values that in the previous case.

$$NPV = -Initial\ Costs + \sum_{i=1}^{n=years} \frac{B_i}{(1+r)^i} \quad (13)$$

KPIs from private vehicles costs are (only realized by demos that have chosen):

- **Private Costs (PC):** It is the subtraction among investment costs of purchasing a private car and state grant. Indicator shows the real initial investment by the private owner.

$$PC = Investment - Grant \quad (14)$$

- **Total annual private costs (TACp):** total costs per year by summing maintenance and average energy consumption (KW) multiplied per KW country price.

$$TACp = \big((Avge\ KW) \times KW\ price\big) + \sum Maintenance\ Costs \quad (15)$$

- **Net private present value (NPVp):** It the same case that equation number 6, "r" and "i" are same that others cases. Indicator shows if it is profitable to buy an EV in front of one of a gasoline car. In this case, it is measured as possible extra cost of electrical vehicle purchase.

$$NPVp = -DC + \sum_{i=1}^{n=years} \frac{Bp_i}{(1+r)^i} \quad (16)$$

Being that:

  - DC: It is the subtraction among Private cost (14) and Cost of similar gasoline car. The price range of an electrical car.
  - Bp: It is the subtraction among kilometres realized per year multiplied per country price fuel, and KW consumption multiplied per Country KW price. It shows the annual benefit of electrical cars.

The following table shows the above indicators summarized:

Actions	Project Phase		List of indicators	Definition	Unit	Data Source	Equation	Equation Number
	Baseline	Final performance						
MOBILITY: TOTAL COSTS	X	X	Total Anual Costs (TAC)	It is the maintenance costs per year of overall mobility iniciatives, including bus costs, bike costs, recharge network, and so on.	I	Questionnarie	$TAC = \sum Bus\ Costs + Bike\ Costs + Recharge\ Costs + Grant\ car\ costs + + others$	9
		X	Benefits by Uptake Savings (BUS)	It is summation for all saved annual kilometers, measured in the cost of fuel, less cost of electricity usage.	I	Questionnarie	$BUS = \sum_{i=1}^{n}(electrical\ Km \times Country\ Fuel\ price - electrical\ KW\ uptakes \times country\ KW\ price)$	10
		X	Benefits (B)	It is the subtraction between BUS (10)-TAC (9). It measure benefits per year.	I	Questionnarie	$B = BUS\ (10) - TAC(9)$	11
	X	X	Cost of Saving a Kg CO2 (CS)	The rate between total costs and Co2 kilograms saved.	I/Kg CO2	Estimated	$C\ co2 = \frac{TAC\ (9)}{Annual\ Kg\ of\ CO2\ saving}$	12
		X	Net Present value (NPV)	It the same case that equation number 6. In this case is used (B) and everall costs realized at the first year.	I	Estimated	$NPV = -Initial\ Costs + \sum_{i=1}^{n-years} \frac{B_i}{(1+r)^i}$	13
MOBILITY: PRIVATE VEHICLES COSTS		X	private Costs (PC)	Substraction between Investment costs (purchase a private car) and State Grant.	I	Questionnarie	$PC = Investment - Grant$	14
	X	X	Total Anual Costs private (TACp)	Costs per year, sum of maintenance and KW uptake.	I	Questionnarie	$TACp = ((Avge\ KW) \times KW\ price) + + \sum Maintenance\ Costs$	15
		X	Net Present value private (NPVp)	It the same case that equation number 6. In this case it is measured if possible of extra cost of electrical vehicle purchase.	I	Estimated	$NPVp = -DC + \sum_{i=1}^{n=years} \frac{Bp_i}{(1+r)^i}$	16

Table 82: Economic KPIs for mobility actions

For citizen engagement actions

In this section of the document, explanation of economic KPIs referent to citizen engagement has been done. Needs and objectives have been taken into account when proposing this set of KPIs to evaluate the viability of the interventions.

For this initiative has been done 3 KPIs:

- **Investment:** It is the sum of all initiative investments.

$$Investment = \sum Initiative\ investments \quad (17)$$

- **Grant:** It is defined as a part or percentage of investment.

$$Grant\ \% = \frac{Grant}{Investment} \times 100 \quad (18)$$

- **Total annual costs:** The total annual costs are defined the sum of all the costs for the deployment of the strategy for citizen engagement which could include the cost of staff, the purchase of material or the subcontracting cost. The total annual costs are related to the considered interval of time (year).

$$TAC = \sum All\ costs \quad (19)$$

The following table shows the above indicators summarized:

Actions	Project Phase		List of indicators	Definition	Unit	Data Source	Equation	Equation Number
	Baseline	Final performance						
CITIZEN ENGAGEMENT		X	Investement	It is the sum of all initiative investments.	I	Questionnarie	$Investment = \sum Initiative\ investments$	17
		X	Grant	It is defined as a part or percentage of investment.	%	Questionnarie	$Grant\ \% = \frac{Grant}{Investment} \times 100$	18
		X	Total Annual Cost	The total annual costs are defined as sum of all the costs for deployment the strategy for citizen engagement which could include the cost of staff, the purchase of material or the subcontracting cost. The total annual costs are related to the considered interval of time (year).	I	Questionnarie	$TAC = \sum All\ costs$	19

Table 83: Economic KPIs for citizen engagement actions

To facilitate the calculation of the different KPIs, an excel sheet has been prepared whose information with the indicators disaggregated is depicted on Section 15 Annex. The required data is indicated and when completing it, the excel sheet gives the KPI resulting value.

These KPIs are a general and basic way to evaluate a smart city project which includes all intervention mentioned. But taking into account that each demo includes different intervention, in the following sections this protocol is going to be adapted to the necessities of the demos, which have been specified by the partners involved.

12.3 Plan for the economic assessment

12.3.1 Plan for Vitoria-Gasteiz

To evaluate the economic performance in Vitoria, a specific procedure is developed. It is based on the generic procedure and adapted to the objectives selected by the stakeholders involved in the demonstrator project.

1. *"Energy costs reductions in district for residents with the implementation of Energy Solutions in district in comparison with initial situation".*

   Indicators 1, 2, 3, 4, and 5 are going to be used. Below is explained in detail how to calculate it:

- **Resident costs**: This indicator measures the monetary amount that the residents must pay at the beginning of the project.

$$RC = \frac{(Investment - Grant)}{Total\ Area} \quad (1)$$

Total area is the sum of overall square meters of all dwellings.

Investment and Grant are known values at the start of the project.

- **Grant rate:** It measures percentage of grant of the total investment, making easy their comparability with other demos.

$$GR = \frac{Grant}{Investment} \times 100 \quad (2)$$

Values used in this indicator are the same of previous KPI.

- **Total annual costs:** Indicate the annual costs of maintenance and energy per year. Those are the costs for residents. Maintenance costs are monetary amount per installation maintenance, equipment maintenance, retrofits break, and so on of all residents. Energy costs are the uptakes of all residents, and are calculated as multiplication among KWs country price and KW consumption. This sum is split by total dwelling area.

$$TAC = \frac{\sum_{i=1}^{n=n.residents} Maintenance\ costs + Energy\ Costs}{Total\ Area} \quad (3)$$

Kw consumption and maintenance costs must be measured when the intervention are done. They are the project results.

Kw country price: it is the price that residents pay to obtain and uptake a Kw. This value will be an estimation of Spanish average price.

- **Total annual benefits for residents:** It is calculated as the subtraction among Old costs and total annual costs (Above KPI). Old costs are annual costs previous to the project, including maintenance and uptakes costs and divided per total area. This “Old cost” must be calculated for Baseline. With this equation it is obtained the annual benefit per square meter with the renovation.

$$BF = Old\ costs - Total\ annual\ Costs\ (TAC) \quad (4)$$

TAC is calculated in the previous KPI.

Old costs must be calculated to the baseline of the project. Demo´s partners have to know how many the value of these costs before is to begin the renovation.

- **Cost saving rate:** percentage of annual benefits of the project. Its measure of profitability is annual.

$$CRR = \frac{BF}{Old\ Costs} \times 100 \quad (5)$$

It is calculated with the above indicators.

2. "*Economic viability of district retrofitting for owners*"

   To realize this analysis, partners can use the general indicators 6, 7 and 8. With this, they can have indicators that gauge the viability, return of investment and payback of the resident.

- **Net present value for resident:**

$$NPV = -RC + \sum_{i=1}^{n=years} \frac{BF_i}{(1+r)^i} \quad (6)$$

"i" is the number of years to consider in the survey, and r is the inflation rate. Inflation to consider could be the average i.e. to 5 years in UE zone (1.3%), or last month UE zone inflation, or inflation of each particular country[18].

RC is the indicator number 1.

BF is the indicator number 4.

- **Return of Investment (ROI) for resident:** It is defined as the interest rate that results into a net present value of zero, clear r in the equation. This indicator uses the same values than NPV.

$$NPV = -RC + \sum_{i=1}^{n=years} \frac{BF_i}{(1+r)^i} = 0 \quad (7)$$

It uses the same values that the previous indicator.

- **Payback for resident:** The payback period is the time it takes to cover investment costs. It is the same case that the preceding indicators, but in this case it should not discount the flows by the rate of inflation.

$$PB = -RC + \sum_{i=1}^{=years} BF_i \quad (8)$$

[18] Information extracted from European Central Bank: https://www.ecb.europa.eu/stats/prices/hicp/html/inflation.en.html

3. *"Energy costs reductions in last mile EV in comparison with the initial situation"*

For evaluation the indicators 9, 10, 11 and 12 will be used with modifications.

- **Total annual costs:** The maintenance costs per year of overall mobility initiatives (including bus costs, bike costs, recharge network and others). Result will be the sum of those values. Each demo only will include costs related with their initiatives carried out in the project. This KPI includes costs of maintenance of vehicles, insurances and other important values.

$$TAC = \sum Bus\ Costs + Bike\ Costs + Recharge\ Costs + Grant\ car\ costs + others \quad (9)$$

Overall values must be measured at the end of the project.

- **Annual Costs Difference:** It is the subtraction among Average Annual Old Costs (OCa, which includes old maintenance costs, old insurance costs, and so on.) and TAC (above mentioned). It measures costs or annual benefits achieved through the difference among project costs. OCa value must be calculated in the baseline.

$$DCa = OCa - TAC\ (9')$$

- **Benefits by uptake saving:** The sum of all saved annual kilometres, measured in the cost of fuel, less cost of electricity usage. For example, kilometres realized with electrical energy multiplied per fuel price less cost of electricity multiplied per kilometres.

$$BUS = \sum_{i=1}^{n}(electrical\ Km\ \times Country\ Fuel\ price - electrical\ KW\ uptakes\ \times country\ KW\ price) \quad (10)$$

Country fuel price and country Kw price are estimations that depend on each country. In the case of Vitoria the country fuel price is the cost of realizing 1Km with a van or small lorries.

Electrical Kms are the amount of Km realize with EV. It is obtained at the end of the project.

Electrical Kw uptakes are obtained at the end of the project.

- **Benefits:** The sum between BUS (10) and DCa (9´). Measures benefits per year. Indicator shows the net benefit of the project.

$$B = BUS\ (10) + DCa(9´) \quad (11)$$

BUS and DCa are the previous indicators.

- **Costs of saving a kg of CO2:** The rate between total costs and Co2 kilograms saved. The overall costs from saving a Kg of CO2 are evaluated.

$$C\ co2 = \frac{TAC\ (9)}{Annual\ Kg\ of\ CO2\ saving} \quad (12)$$

TAC is a previous indicator.

Annual Kg of Co2 saving are obtained at the end of the project.

4. *"Economic viability of investment made in last mile EV":*

- **Net present value overall:** The same case that equation number 6. In this case is used indicator "B" (number 11) as benefits and overall costs realized at the first year. "r" and "i" are the same values that in the previous case.

$$NPV = -Initial\ Costs + \sum_{i=1}^{n=years} \frac{B_i}{(1+r)^i} \quad (13)$$

Initial costs are all of payments realized in the beginning at the project. They are a project values.

12.3.2 Plan for Tartu

To evaluate the economic performance in Tartu, a specific protocol is developed. It is based on the generic procedure and adapted to the objectives selected by the stakeholders involved in the demonstrator project.

1. *"Energy costs savings achieved by owners living in district and housing unions with the implementation of energy solutions in district in comparison with the initial situation".*

   Indicators 1, 2, 3, 4, and 5 are going to be used. Below is explained in detail how to calculate it:

- **Resident costs:** This indicator measures the monetary amount that the residents must pay at the beginning of the project.

$$RC = \frac{(Investment - Grant)}{Total\ Area} \quad (1)$$

Total area is the sum of overall square meters of all dwellings.

Investment and Grant are known values at the start of the project.

- **Grant rate:** It measures percentage of grant of the total investment, making easy their comparability with other demos.

$$GR = \frac{Grant}{Investment} \times 100 \quad (2)$$

Values used in this indicator are the same of previous KPI.

- **Total annual costs:** Indicate the annual costs of maintenance and energy per year. Those are the costs for residents. Maintenance costs are monetary amount per installation maintenance, equipment maintenance, retrofits break, and so on of all residents. Energy costs are the uptakes of all residents, and are calculated as multiplication among KWh country price and KWh consumption. This sum is split by total dwelling area.

$$TAC = \frac{\sum_{i=1}^{n=n.residents} Maintenance\ costs + Energy\ Costs}{Total\ Area} \quad (3)$$

Kw consumption and maintenance costs must be measured when the intervention are done. They are the project results.

Kw country price: it is the price that residents pay to obtain and uptake a Kwh. This value will be an estimation of Estonian average price.

- **Total annual benefits for residents:** It is calculated as the subtraction among Old costs and total annual costs (Above KPI). Old costs are annual costs previous to the project, including maintenance and uptakes costs and divided per total area. This "Old cost" must be calculated for Baseline. With this equation it is obtained the annual benefit per square meter with the renovation.

$$BF = Old\ costs - Total\ annual\ Costs\ (TAC) \quad (4)$$

TAC is calculated in the previous KPI.

Old costs must be calculated to the baseline of the project. Demo´s partners have to know how many the value of these costs before is to begin the renovation.

- **Cost saving rate:** percentage of annual benefits of the project. Its measure of profitability is annual.

$$CRR = \frac{BF}{Old\ Costs} \times 100 \quad (5)$$

It is calculated with the above indicators.

2. *"Energy costs savings achieved with the rental of EV (cars) and e-bike in comparison with the initial situation."*

   For evaluation the indicators 9, 10, 11 and 12 will be used with modifications.

- **Total annual costs:** The maintenance costs per year of overall mobility initiatives (including bus costs, bike costs, recharge network and others). Result will be the sum of those values. Each demo only will include costs related with their initiatives carried out in the project.

$$TAC = \sum Bus\ Costs + Bike\ Costs + Recharge\ Costs + Grant\ car\ costs + others \quad (9)$$

Overall values must be measured at the end of the project.

- **Benefits by uptake saving:** The sum of all saved annual kilometres, measured in the cost of fuel, less cost of electricity usage. For example, kilometres realized with electrical energy multiplied per fuel price less cost of electricity multiplied per kilometres.

$$BUS = \sum_{i=1}^{n}(electrical\ Km\ \times Country\ Fuel\ price - electrical\ KWh\ uptakes\ \times country\ KW\ price) \quad (10)$$

Country fuel price and country Kw price are estimations that depend on each country. In the case of Tartu the country fuel price is the cost of realizing 1Km with a medium car.

Electrical Kms are the amount of Km realize with EV. It is obtained at the end of the project.

Electrical Kwh uptakes are obtained at the end of the project.

- **Benefits:** The subtraction between BUS (10)-TAC (9). Measures benefits per year. Indicator shows the net benefit of the project.

$$B = BUS\ (10) - TAC(9) \quad (11)$$

BUS and TAC are the previous indicators.

- **Costs of saving a kg of CO2:** The rate between total costs and Co2 kilograms saved. The overall costs from saving a Kg of CO2 are evaluated.

$$C\ co2 = \frac{TAC\ (9)}{Annual\ Kg\ of\ CO2\ saving} \quad (12)$$

TAC is a previous indicator.

Annual Kg of Co2 saving are obtained at the end of the project.

3. *"Cost of citizen engagement activities carried out in the project to achieve the project objectives".*

   Calculated with indicators 17, 18, and 19.

- **Investment:** The sum of all initiative investments.

$$Investment = \sum Initiative\ investments \quad (17)$$

It is a project value.

- **Grant:** Defined as a part or percentage of investment.

$$Grant\ \% = \frac{Grant}{Investment} \times 100 \quad (18)$$

It is a project value.

- **Total annual costs:** The total annual costs are defined as the sum of all the costs for deployment the strategy for citizen engagement which could include the cost of staff, the purchase of material or the subcontracting cost. The total annual costs are related to the considered interval of time (year).

$$TAC = \sum All\ costs \quad (19)$$

It is a project value.

12.3.3 Plan for Sonderborg

To evaluate the economic performance in Sonderborg, a specific protocol is developed. It is based on the generic procedure and adapted to the objectives selected by the stakeholders involved in the demonstrator project.

1. *"Energy costs savings of tenants living in district in comparison with the initial situation".*

   Indicators 1, 2, 3, 4, and 5 are going to be used. Below is explained in detail how to calculate it:

- **Resident costs:** This indicator measures the monetary amount that the residents must pay at the beginning of the project.

$$RC = \frac{(Investment - Grant)}{Total\ Area} \quad (1)$$

Total area is the sum of overall square meters of all dwellings.

Investment and Grant are known values at the start of the project.

- **Grant rate:** It measures percentage of grant of the total investment, making easy their comparability with other demos.

$$GR = \frac{Grant}{Investment} \times 100 \quad (2)$$

Values used in this indicator are the same of previous KPI.

- **Total annual costs:** Indicate the annual costs of maintenance and energy per year. Those are the costs for residents. Maintenance costs are monetary amount per installation maintenance, equipment maintenance, retrofits break, and so on of all residents. Energy costs are the uptakes of all residents, and are calculated as multiplication among KWs country price and KW consumption. This sum is split by total dwelling area.

$$TAC = \frac{\sum_{i=1}^{n=n.residents} Maintenance\ costs + Energy\ Costs}{Total\ Area} \quad (3)$$

Kw consumption and maintenance costs must be measured when the intervention are done. They are the project results.

Kw country price: it is the price that residents pay to obtain and uptake a Kw. This value will be an estimation of Danish average price.

- **Total annual benefits for residents:** It is calculated as the subtraction among Old costs and total annual costs (Above KPI). Old costs are annual costs previous to the project, including maintenance and uptakes costs and divided per total area. This “Old cost” must be calculated for Baseline. With this equation it is obtained the annual benefit per square meter with the renovation.

$$BF = Old\ costs - Total\ annual\ Costs\ (TAC) \quad (4)$$

TAC is calculated in the previous KPI.

Old costs must be calculated to the baseline of the project. Demo´s partners have to know how many the value of these costs before is to begin the renovation.

- **Cost saving rate:** percentage of annual benefits of the project. Its measure of profitability is annual.

$$CRR = \frac{BF}{Old\ Costs} \times 100 \quad (5)$$

It is calculated with the above indicators.

12.3.4 Comparative summary of the Plans for the economic performance assessment

Table below shows the summary of the KPIs selected on the LH cities for the economic performance assessment.

City	Actions	Target groups	Objectives	KPIs
Vitoria - Gasteiz	District renovation	Owners and tenants	Energy costs reductions in district for residents with the implementation of energy solutions in district (in comparison with the initial situation)	Resident Costs
				Grant rate
				Total annual costs
				Total annual benefits for residents
				Cost saving rate
			Economic viability of district retrofitting (for owners)	Net present value for resident
				Return of investment for resident
				Payback for resident
	Mobility	Vehicle owners and vehicle users	Energy costs reductions in last mile EV (in comparison with the initial situation)	Total annual costs
				Annual costs difference
				Benefits by uptake savings
				Benefits
				Costs of saving CO2
			Economic viability of investment made in last mile EV	Net present value overall
Tartu	District renovation	Owners and tenants	Energy costs savings achieved by owners living in district and housing unions with the implementation of energy solutions in district (in comparison with the initial situation)	Resident costs
				Grant rate
				Total annual costs
				Total annual benefits for residents
				Cost saving rate
	Mobility	Vehicle owners and vehicle users	Energy costs savings achieved with the rental of EV (cars) and e-bike (in comparison with the initial situation)	Total annual costs
				Benefits by uptake savings
				Benefits
				Cost of saving a kg of CO2
	Citizen engagement	Actors involved	Cost of citizen engagement activities carried out in the project to achieve the project objectives.	Investment
				Grant
				Total annual costs

Sonderborg	District renovation	Owners and tenants	Energy costs savings of tenants living in district (in comparison with the initial situation)	Resident costs
				Grant rate
				Total annual costs
				Total annual benefits for residents
				Cost saving rate

Table 84: comparative of plans for the economic assessment on the three LH cities

13 Deviation of the plan

The fact that mobility actions are still not defined due to cascade funding problems implies not to conclude with some protocols directly linked to this aspect. The mobility protocol will be updated, whereas cities will think about to include such mobility actions in the protocols related to social acceptance and economic performance. It is expected that the actions can be defined and approved by the Commission in the coming months in order to be able to update such protocols at M18 in the corresponding deliverables to be submitted at this time. Otherwise, such protocols will be updated at a further moment once the mobility actions are definitive.

14 Outputs for other WPs

The present deliverable becomes the stepping stone for remaining WP7 deliverables related to monitoring program, data collection and final performance evaluation. In addition, D7.3 will be taken into account for the evaluation of the baselines in WP3 (currently included in D3.2), WP4 (currently included in D4.2) and WP5 (currently included in D5.2) and will be considered in the definition of the platform data model (D6.3) and the regeneration strategy to be set by the project (D.2.7 and D2.8). On the other hand, the KPIs selected will be considered in D7.4 where a procedure for the evaluation of impacts in cities is developed.

Finally, it has to be remarked that the fact that a wide number of partners (15) from the three cities have worked in the definition in this methodology for evaluation, guarantees the well implementation of the protocols since partners have decided how to evaluate each of the interventions. In addition, these partners cover all the roles in the project (responsible for district renovation, mobility action, citizen engagement and deployment of urban platforms) but also other participants which are not involved directly in local projects have set the basis of this evaluation (CAR, TEC and ACC) and have contributed to reach a common understanding among cities and a common evaluation framework in order to allow the comparison of the results obtained in the three cities.

Following, they are indicated some issues to be considered in the coming deliverables.

Baseline evaluation

- Baseline will be evaluated for the following protocols in the deliverables D3.2, D4.2 and D5.2 to be submitted at M18: Energy assessment, ICT, LCA and economic performance and depending on the moment in which mobility actions can be defined in the cities, it will evaluate the baseline of mobility protocol at M18. In other case, it will be evaluated in other deliverables.
- Protocols of social acceptance and citizen engagement will not be evaluated at M18 since they don't need to compare the final performance obtained with a previous situation (baseline). The total evaluation will be shown in D7.13 from T7.5, and any section will be included in D3.2, D4.2 and D5.2.

Social acceptance evaluation

- The decision to evaluate mobility actions in Sonderborg as part of this protocol will be postponed until the actions affected by cascade funding are defined and approved by the Commission. In this case, the protocol will be updated in the corresponding deliverable to be submitted at M18.
- The design of the surveys (questionnaires and interviews) and log books needs to be done by local partners. Such design must be done in English for being reported in the corresponding deliverable but also in local language for their distribution. In addition, the information obtained from questionnaires and surveys will be post-processed through a statistical analysis and reporting according to the structure agreed. All these issues will be concluded in D7.9 "Data collection approach" at M18 since they correspond with the collection procedure. In addition, the design and distribution of

questionnaires/interviews related to social acceptance and citizen engagement could be aligned in order to reduce efforts in the evaluation.

- For the method data measurements, giving the difficulty to take a conclusion at this moment about which data are measured at the same time by meters (following the energy assessment protocols, ICT protocol, mobility protocol) and by questionnaires, interviews and log books (following social acceptance), this method will be concluded in a posterior deliverable from WP7 to be submitted at M18.

Economic performance evaluation

- The decision to include mobility actions in Sonderborg will be postponed until the actions affected by cascade funding are defined and approved by the Commission. In this case, the protocol will be updated in the corresponding deliverable to be submitted at M18.

Partners role

- The procedure for the identification of the roles of the participants of the coming deliverables have been started in order to work in them properly.

15 Annex

In this annex, the templates from the excel files for the calculation of economic KPIs are added.

Generic protocol calculation

District renovation

Indicator: nº 3	
Total Maintenance Costs (€)	1
KWs uptakes (Kw)	1
KWs country price (€)	2
TAC (3) (€/m2)	**3**

Include all maintenance costs of the year.
Include all KW consumption .
Insert electricity price of each demo site.
KPI nº3

indicator nº 4	
Old costs (€/m2)	5
BF (4) (€/m2)	**2**

Costs previous at the project divided per total area.
KPI nº 4

indicator nº 5	
CRR (5) (%)	**40%**

KPI nº 5

indicator nº 6	
n	10
i	0,013
RC	-7
BF1 (€/m2)	2
BF2 (€/m2)	2
BF3 (€/m2)	2
BF4 (€/m2)	2
BF5 (€/m2)	2
BF6 (€/m2)	2
BF7 (€/m2)	2
BF8 (€/m2)	2

Number of years to study.
Inflation rate
Insert numbers of flows indicated above.

BF9 (€/m2)	2
BF10 (€/m2)	2
BF11 (€/m2)	
BF12 (€/m2)	

NPV (6) (€/m2)	**11,64 €**	KPI nº 6

indicator nº 7

ROI (7) (%)	**26%**	KPI nº 7

indicator nº 8

PB (€/m2)	13	
Year (9)	**6,5**	KPI nº 8

Mobility

Indicator nº9

Initiative Bus costs (€)	2	All costs of initiative mobility labours.
Initiative Bikes costs (€)	1	
Initiative recharge costs (€)	5	
Grants (€)	3	
Others (€)	7	

TAC (9) (€)	**18**

Indicator nº10

Electrical Kilometres (km)	2000	All Electrical Kms realized with electrical vehicles and bikes.
country fuel Price per Km(€)	0,06	Gasoline price in each demo country.
electrical consumption (KW)	500	Electrical consumption of all new vehicles.
Country KW price	0,08	Energy price in each demo country.

BUS (10) (€)	**80**

Indicator nº11

B (11) (€)	**62**

Indicator nº12

Co2 saved (Kg)	200	Saving of Co_2 per year estimated.

C Co2 (12) (€/Kg)	**0,09**

Indicator nº13

n (y)	5	years of the survey.
i	0,013	Inflation rate.
Initial costs	200	Project initial costs.
B1 (€)	62	
B2 (€)	62	
B3 (€)	62	
B4 (€)	62	
B5 (€)	62	
B6 (€)		
B7 (€)		
B8 (€)		
B9 (€)		
B10 (€)		

NPV (13) (€)	**98,27 €**

PRIVATE VEHICLES

Indicator nº14

Investment (€)	1000	Average vehicle cost.
Grant (€)	20	State aid.

PC (14) (€)	**980**

Indicator nº15

Maintenance costs (€)	21
Average consumption (KW)	1000
Country price KW (€)	0,08

TACp (15) (€)	101

Indicator nº16

n (years)	10	Years number of the survey.
i	0,013	Inflation rate.
Old maintenance (€)	1	Maintenance costs of an old gasoline vehicle (estimated).
Average Km realized (km)	5000	Average of Km realized per vehicle.
Country fuel price per Km (€)	0,06	Fuel price in each demo.
DC	1000	It is how much more it cost an electrical car.
Bp1 (€)	200	
Bp2 (€)	200	
Bp3 (€)	200	
Bp4 (€)	200	
Bp5 (€)	200	
Bp6 (€)	200	
Bp7 (€)	200	
Bp8 (€)	200	
Bp9 (€)	200	
Bp10 (€)	200	
Bp11 (€)		
Bp12 (€)		

NPV (16) (€)	864,13 €

Citizen engagement

Indicator nº17

Investments (17) (€)	100

Indicator nº18

Grant (€)	30

Grant % (18)	30%

Indicator nº19

TAC (19) (€)	**200**	All initiative costs,

Vitoria

District renovation

Indicator: 1

Investment (€)	10	Insert a total district renovation investment.
Grant (€)	3	Insert a total district renovation grant.
Total area (m2)	1	Insert a total dwelling area.
RC (1) (€/m2)	**7**	KPI nº1

Indicator: 2

GR(2) (%)	**30%**	KPI nº2

Indicator: 3

Total Maintenance Costs (€)	1	Include all maintenance costs/year, renovation already done.
KWs uptakes (Kw)	1	Include all KW consumption .
KWs country price (€)	2	Insert electricity price of each demo site.
TAC (3) (€/m2)	**3**	KPI nº3

indicator nº 4

Old costs (€/m2)	5	Costs previous at the project divide per total area. Including maintenance and uptakes energy before renovation.
BF (4) (€/m2)	**2**	KPI nº 4

indicator nº 5

CRR (5) (%)	**40%**

KPI nº 5

indicator nº 6

n	10
i	0,013
RC	-7
BF1 (€/m2)	2
BF2 (€/m2)	2
BF3 (€/m2)	2
BF4 (€/m2)	2
BF5 (€/m2)	2
BF6 (€/m2)	2
BF7 (€/m2)	2
BF8 (€/m2)	2
BF9 (€/m2)	2
BF10 (€/m2)	2
BF11 (€/m2)	
BF12 (€/m2)	

Number of year to study.
Inflation rate

Insert numbers of flows indicated above.
If number of years is not 10 only extend the table.

NPV (6) (€/m2)	**11,64 €**

KPI nº 6

indicator nº 7

ROI (7) (%)	**26%**

KPI nº 7

indicator nº 8

PB (€/m2)	13
Year (9)	**6,5**

KPI nº 8

Mobility

Indicator nº9

Initiative Annual Bus costs (€)	2
Initiative Annual Bikes costs (€)	1
Initiative Annual recharge costs (€)	5
Grants (€)	3

All costs of initiative mobility labours.

Others (€)	7
TAC (9) (€)	**18**

Indicator nº9´

Average Annual Old Costs (€)	20
DCa(9´) (€)	**2**

Indicator nº10

Electrical Kilometres (km)	2000	All Electrical Kms realized with electrical vehicles.
country fuel Price per Km(€)	0,06	Gasoline price in each demo country.
electrical consumption (KW)	500	Electrical consumption of all new vehicles.
Country KW price	0,08	Energy price in each demo country.
BUS (10) (€)	**80**	

Indicator nº11

B (11) (€)	**82**

Indicator nº12

Co2 saved (Kg)	200	Saving of Co_2 per year estimated.
C Co2 (12) (€/Kg)	**0,09**	

Indicator nº13

n (y)	5	years of the survey.
i	0,013	Inflation rate.
Initial costs	200	Project initial costs.
B1 (€)	82	
B2 (€)	82	
B3 (€)	82	
B4 (€)	82	

B5 (€)	82
B6 (€)	
B7 (€)	
B8 (€)	
B9 (€)	
B10 (€)	

NPV (13) (€)	**194,482708**

Tartu

District renovation

Indicator: 1

Investment (€)	10	Insert a total district renovation investment.
Grant (€)	3	Insert a total district renovation grant.
Total area (m2)	1	Insert a total dwelling area.

RC (1) (€/m2)	**7**	KPI nº1

Indicator: 2

GR(2) (%)	**30%**	KPI nº2

Indicator: 3

Total Maintenance Costs (€)	1	Include all maintenance costs/year, renovation already done.
KWhs uptakes (Kwh)	1	Include all KWh consumption .
KWhs country price (€)	2	Insert electricity price of each demo site.

TAC (3) (€/m2)	**3**	KPI nº3

indicator nº 4

Old costs (€/m2)	5	Costs previous at the project divide per total area. Including maintenance and uptakes energy before renovation.

BF (4) (€/m2)	**2**	KPI nº 4

indicator nº 5

CRR (5) (%)	**40%**	KPI nº 5

Mobility

Indicator nº9

Initiative Annual Bus costs (€)	2	All costs of initiative mobility labours.
Initiative Annual Bikes costs (€)	1	
Initiative Annual recharge costs (€)	5	
Grants (€)	3	
Others (€)	7	
TAC (9) (€)	**18**	

Indicator nº10

Electrical Kilometres (km)	2000	All Electrical Kms realized with electrical vehicles.
country fuel Price per Km(€)	0,06	Gasoline price in each demo country.
electrical consumption (KWh)	500	Electrical consumption of all new vehicles.
Country KWh price	0,08	Energy price in each demo country.
BUS (10) (€)	**80**	

Indicator nº11

B (11) (€)	**62**	

Indicator nº12

Co2 saved (Kg)	200	Saving of Co_2 per year, estimated.
C Co2 (12) (€/Kg)	**0,09**	

Citizen engagement

Indicator nº17	
Investments (17) (€)	**100**

Indicator nº18	
Grant (€)	30
Grant % (18)	**0,3**

Indicator nº19		
TAC (19) (€)	**200**	All initiative costs,

Sonderborg

District renovation

Indicator: 1		
Investment (€)	10	Insert a total district renovation investment.
Grant (€)	3	Insert a total district renovation grant.
Total area (m2)	1	Insert a total dwelling area.
RC (1) (€/m2)	**7**	KPI nº1

Indicator: 2		
GR(2) (%)	**30%**	KPI nº2

Indicator: 3		
Total Maintenance Costs (€)	1	Include all maintenance costs/year, renovation already done.
KWs uptakes (Kw)	1	Include all KW consumption .
KWs country price (€)	2	Insert electricity price of each demo site.

TAC (3) (€/m2)	**3**	KPI nº3

indicator nº 4

Old costs (€/m2)	5	Costs previous at the project divide per total area. Including maintenance and uptakes energy before renovation.
BF (4) (€/m2)	**2**	KPI nº 4

indicator nº 5

CRR (5) (%)	**40%**	KPI nº 5