smart en city

TOWARDS SMART ZERO CO$_2$ CITIES ACROSS EUROPE
VITORIA-GASTEIZ ✛ TARTU ✛ SØNDERBORG

Deliverable D7.1: KPIs definition for pre-intervention data collection
WP7, Task 7.1

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Abbreviations and Acronyms

Abbreviation/Acronym	Description
SmartEnCity	Towards Smart Zero CO2 Cities across Europe
KPIs	Key performance indicators
WP	Work Package
RFSC	Reference Framework for Sustainable Cities
ISO	International Organization for Standardization
EIP-SCC	European Innovation Partnership on Smart Cities and Communities
LH	Lighthouse
EERA	European Energy Research Alliance
ITU	International Telecommunication Union
inh	inhabitant

Table 1: Abbreviations and Acronyms

0 Publishable Summary

The report "KPIs definition for pre-intervention data collection" is a public document of the SmartEnCity project, delivered in the context of WP7, Task T7.1: *Evaluation plan*. The objective of WP7 is to create a common and methodological framework for the evaluation of the interventions as a whole based in a set of appropriate key performance indicators and evaluation procedures and protocols.

This document introduces the relevance of Key Performance Indicators (KPIs) as tool for planning strategic interventions to transform cities into Smart Zero CO2 cities and monitoring the improvements achieved over the time. The report continues with the enumeration of the tasks of the project where will be used indicators and the description of the typologies of indicators defined in the framework of SmartEnCity. In addition, a first set of indicators for city diagnosis is defined and the criteria which lead to a selection of most appropriate for each final use. Finally, the report establishes the approach for assessing the performance of the interventions and the integrated impact in the LH cities.

This deliverable consists of a working document for the consortium since it sets the basis for the evaluation approach of the Project SmartEnCtiy. Partners in charge of defining the scope of the methodology for evaluating the city diagnosis and assessing the intervention performance (CAR, TEC) have been the main authors of the current deliverable, being reviewed by partners in charge of the city diagnosis, the regeneration strategy and the replicability plan.

1 Introduction

Key performance indicators can be a valuable tool for establishing future urban strategies as well as for evaluating project impacts. However, nowadays, any standard has been developed for evaluating cities under sustainable or smartness and it does not exist any broadly-accepted indicator system which integrate all the pillars on which SmartEnCity is based (Energy, Mobility, ICT, citizen engagement, social acceptance and economic performance). This report intends to define indicators to be used in the project for making city diagnosis which conduct to build regeneration strategies and integrated urban plans.

1.1 Purpose and target group

This objective of this report is to give a description of Key Performance Indicators (KPIs) as tool for planning strategic interventions to transform cities into Smart Zero CO_2 cities and monitoring the improvements achieved over the time. Furthermore, the deliverable introduces the procedure for the selection of these indicators along the project and the approach for assessing the performance of the interventions and the integrated impact in the LH cities.

1.2 Contributions of partners

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

Participant short name	Contributions
CAR	Main responsible of report: scope and deliverable writing. Selection of KPIs for city diagnosis in terms of environment, economic performance, social acceptance, urban mobility, governance, citizen engagement and infrastructure actions
TEC	Selection of KPIs for demo area and energy supply. Collaboration for connecting with the methodologies for evaluating city needs in T2.4
IBS	Provide impressions according to the replicability plan
PLAN, SONF, TREA	First impressions about the suitability of KPIs identified and the procedure proposed for the selection of such indicators
AAU	Viewpoint according to the experience in the energy planning

Table 2: Contribution of partners

1.3 Relation to other activities in the project

The following Table 3 describes 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
D2.4	This report will define the methods for selecting a specific set of indicators, depending on the local conditions and objectives defined in each of the LH project. In addition, it will define the process for evaluating the city diagnosis of the demonstrator cities taking into account the guidelines provided in the current report
D2.7/D2.8	The exhaustive list of KPIs provided in this report will be evaluated in these deliverables in order to include the most suitable for the SmartEnCity Urban Regeneration Strategy
D7.2	The evaluation approach will be completed in this deliverable with the definitive list of indicators to be used in the definition of baseline and in the final assessment of the project and city.
D8.6/D8.7/ D8.10	The exhaustive list of KPIs will be the basis for planning the replication of project solutions within the lighthouse cities and follower cities as well as project lessons learnt to be transferred to other European cities

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 CO_2 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 them an evaluation methodology for assessing the final performance and quantifying the impact generated.

T7.1 is focused in the creation of an evaluation plan constructed on indicators collection process and this deliverable D7.1 "KPIs definition for pre-intervention data collection" will set the basis for the evaluation plan, defining the types of KPIs to be used in the project and identifying a first list of indicators for city diagnosis to be considered in all those tasks of the project linked with the evaluation of city diagnosis and city needs.

2.2 Expected Impact

The set of KPIs identified can be employed for any city which intends to transform into a Smart Zero City. Using these indicators, the cities planners can know the potential features and adverse conditions and defining urban plans or strategies based on the evaluated baseline as well as taking decisions about the most suitable interventions for the cities. Consequently, the set of indicators will be very useful for the five cities currently involved in the project, but also for those which will join to the Smart Cities Network.

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 contributions from different partners.

- Section 4: This section describes the tasks of the project where KPIs will be used for concluding with the description of the types of KPIs defined in SmartEnCity.

- Section 5: This section reveals the need of consulting diverse sources to identify the most suitable KPIs for the project given the large diversity of available sources and the lack of an only integrated index system which cover all the topics to be analysed.

- Section 6: It describes the collaborative procedure for the identification of suitable indicators for the project.

- Section 7: This chapter depicts the fields/areas which take part of the city diagnosis and which will be analysed through KPIs. In addition, first impressions from partners concerning the list of indicators and the procedure for their final selection are briefly added.

- Section 8: It is about the evaluation scheme to be applied in SmartEnCity for making city diagnosis, assessing interventions performance and the impacts obtained in the cities.

- Annex 1: This section includes an exhaustive list of KPIs for city diagnosis to be included in the methods, methodologies and roadmaps to be deployed for LH, follower cities and other European cities.

4 Key Performance Indicators

A Key Performance Indicator is a parameter, or a value derived from parameters, which describes the state of an issue. The purpose of defining KPIs is to establish the criteria to evaluate how an action or intervention is influencing in the achievement of goals.

4.1 Key Performance Indicators in the framework of SmartEnCity

SmartEnCity project aims to develop a highly adaptable and replicable systemic approach towards urban transformation into sustainable, smart and resource-efficient urban environments in Europe through the integrated planning and implementation of measured aimed at improving energy efficiency in main consuming sectors in cities, while increasing their supply of renewable energy and demonstrating its benefits.

In order to reach this purpose, the project is structured in working packages and tasks which conclude with deliverables where the activity carried out is reported. Below it is provided brief descriptions about the actions of SmartEnCity on which key performance indicators acquire a significant value.

- Development of methods for identification of strategic city needs which help to define district interventions (D2.4): LH project team will define the demo actions in WP3, WP4 and WP5 according to the city features and strategic cities needs identified through key performance indicators.

- Create the evaluation and monitoring approach for assessing the baseline and final performance of the interventions and the impact reached in the cities (D2.4, D7.1, D7.2, D7.3, D7.4, D7.6, D7.7, D7.8, D7.9 and D7.13): SmartEnCity project team will define the evaluation procedures and plans as well as monitoring programs in basis of indicators selected. Furthermore, it will design and deploy the ICT platforms for gathering, monitoring and evaluating data from LH cities in T3.7, T4.7, T5.7 and WP6.

- Definition of SmartEnCity Regeneration Strategy which allows European cities to identify the optimal solutions for their transformation into Smart Cities (D2.7, D2.8): WP2 project team will identify which indicators can be incorporated in this methodology in order to contribute to understand the city objectives and support the selection of the most suitable initiatives for the cities according to the feasibility and impacts expected.

- Deployment of Integrated Urban Plans for Lighthouse and follower cities for planning the replication of project solutions within the lighthouse and follower cities (D8.6): WP8 project team will suggest which type of interventions must be promoted and strengthen in the city plans of these cities, supporting in indicators.

- Replication roadmap for each LH and follower city for enhancing the success of replicability strategy (D8.10): WP8 project team will set up an evaluation and monitoring system for replicated solutions based on systems developed in WP7, including KPIs.

- Widening the scope of replication knowledge through Smart Cities Network and several European platforms (D8.7): Smart Cities Network and other platforms and networks at European or Global Level could benefits from evaluation approach.

4.2 Definition of typologies of KPIs

As it was introduced in the section above, the definition of the district integrated interventions, the plans for evaluating the effects at each demonstration city and the design of the urban regeneration strategy, integrated urban plans and replication roadmaps will require indicators. Consequently, the types of KPIs to be defined must be aligned with their potential uses and the evaluation framework established in the project. Concerning SmartEnCity evaluation framework plan, this must fulfil the following objectives:

- Characterize the cities in order to know the current city profile which allows to defining the interventions to be implemented in LH cities and a posterior evaluation of the effects of the project in the city. Areas of interest are: energy demand and consumption, energy efficiency, energy supply, CO_2 emission, city structure, regulation and normative, standards, stakeholders, citizens and financial schemes.

- Define the baseline scenario of the district in order to evaluate the performance gained after the interventions (energy and CO_2 emissions saving, economic performance, social acceptance, citizen engagement, among others).

- Assess the impact of the project in the city, showing the progress achieved after the implementation of the interventions. The analysis must be done in the same areas considered in the city diagnosis.

Thus, in order to cover all the expectative, three indicators levels have been defined in SmartEnCity:

- "City Level Indicators" will be used to assess how sustainable and smart are the cities in order to identify city's strengths and weaknesses which help to define the most suitable interventions and setting objectives to create a Smart Zero Carbon City. They will take part of the method for evaluating city needs (D.2.4), strategy for urban regeneration (D2.7/D2.8) as well as in the replication activities (D8.6/D8.7/ D8.10).

- "Project Level Indicators" will be the reference for a detailed evaluation of the demo area performance before the execution of interventions and then after the implementation all demo actions. They will be included in the methods for defining the baseline (D2.4) and final performance achieved (D7.3) as well as in the monitoring programs which must be designed according the KPIs definition (D7.6, D7.7 and D7.8). In addition, there will be a close relation with the City Information Open Platform (WP6) and ICT platforms in LH cities which will manage the data monitoring and evaluation (T3.7, T4.7, T5.7). On the other hand, methodologies and procedures focused in transforming cities into smart cities such the SmartEnCity urban regeneration strategy (D2.7/D2.8) and replication roadmaps (D8.10) will consider this type of indicators. Finally, they will be part of the knowledge to be transferred to follower cities, Smart Cities Networks and other European platforms (D8.7).

- "Impact Assessment Indicators" will be additional indicators which allow to quantifying the impact of whole initiatives on the city. Procedures for evaluating effects of interventions in the city (D7.4) will be based on this type of KPIs and could be part of methodologies and procedures focused in transforming cities into smart cities such the SmartEnCity urban

regeneration strategy (D2.7/D2.8) and replication roadmaps (D8.10) as well as part of the knowledge to be transferred to follower cities, Smart Cities Networks and other European platforms (D8.6 and D8.7).

5 Current status in the indicator indexes for smart cities and smart projects

Currently there is a multitude of indicators focus on the measurement of city. In [1] more than 150 city indicator systems developed by public and private institutions were identified. From all these initiatives, there are well-accepted indicator systems deployed in the framework of European Commission (such as the Reference Framework for Sustainable Cities (RFSC) and the European Energy Award), defined by the International Organization for Standardization (ISO 37120: 2014) and by the Global Cities Institute (the Global City Indicators Facility). A more exhaustive list of suitable indicator systems is found in [2].

The result is that cities tend to use the city indicator system that best suits their purposes and therefore it is difficult a fair comparison between cities – and at times between different projects within the same city. On the other hand, not all these systems included indicators around sustainability. This is the reason why European Commission is promoting actions for harmonizing the indicators for city characterization in terms of sustainability. Most relevant initiatives which are working in these issues are: CONCERTO, SCIS, CITYkeys, European Innovation Partnership on Smart Cities and Communities (EIP-SCC), Joint Programme on smart cities from the EERA, Covenant of Mayors and CIVITAS. As a result, several guides of indicators addressed for cities which aspire to be Smart Cities are nowadays available. Finally, it's worth remarking the list of indicators used for making city diagnosis in diverse projects funded by EC working in urban planning (e.g. Project PLEEC and STEEP). On the other hand, ISO is working in the standardization of the sustainable communities through ISO/TC 268 and, as a result, a standard has been published recently with indicators for city services and quality of life (for ISO 37120: 2014). More work is doing in this context and it is expected publications for indicators for smart cities and resilient cities as well as an inventory and review of existing indicators on sustainable development and resilience in cities which correspond with ISO/NP37122, ISO/NP37123 and ISO/DTR37121. Nowadays they are under development.

Concerning smart projects, there are diverse standards or guidelines focus on how to measure the improvement achieved in terms of energy efficiency, economic performance and social acceptance. National standardization bodies and other initiatives such as ASCE, BREEAM or LEED are focus in energy performance of buildings; VTPI and CIVITAS address its activity towards the performance of mobility, whereas initiatives such as CONCERTO, SCIS and CITYkeys are deployed guidelines for evaluating the influence of building retrofitting, mobility and the implementation of ICT in diverse field such as people, environment, prosperity of the city and governance.

Finally, it has to mention to the large demonstration projects funded by EU in the field of smart cities like SmartEnCity (e.g. REPLICATE, SMARTER TOGETHER, SHAR-LLM, REMOURBAN, GrowSmarter Triangulum, CITyFiED, SINFONIA, CITYZEN, R2CITIES,

EUGUGLE, Zenn) which are defined list of KPIs for evaluating the performance of the interventions.

As conclusion, it can remark that there is any one source that can cover all the aspects required in the framework of the project and therefore it is required to consult a wide number of sources, being essential the use of standards and initiatives promoted by European Commission, in special CONCERTO, SCIS and CITYkeys.

6 Procedure for selecting KPIs to be used in SmartEnCity

This section intends to depict the procedure to define the set of indicators which will be applied for each target use.

- Definition of an action plan to be implemented for the selection of indicators.
- Identification of sources where to select indicators.
- Identification of criteria to be used in the selection.

6.1 Definition of action plan

The selection of indicators will be done in a collaborative way and in accordance with the partner cities and experts. Firstly, a screening of indicators will be done by partners responsible for defining the evaluation approach: CARTIF and TECNALIA. Then, a group of partners will be asked about the suitability of these indicators for the corresponding end-use. Partners of LH, city followers and responsible of ITC platforms will be consulted.

The table below shows the target partners which must collaborate in the selection of KPIs and the task associated to the final selection of KPIs.

KPIs	Final use	Target partner	Task to take decisions
City Level Indicators	LH diagnosis	Partners in charge of city diagnosis (mainly task leaders T3.1, T4.1 & 5.1) but also contributions from representative of cities are welcome	ST2.6.3: Identification of City needs and baseline definition process
	SmartEnCity Regeneration	Participants in ST2.6.4	
	Integrated Urban Plans	Participants in ST8.4.1 and ST8.4.2	
	Replication of LH lessons to European cities	Participants in ST8.4.3	
	Replication roadmap for each LH and	Participants in T8.5	

	follower city		
Project Level Indicators	Baseline/Final performance	Partners in charge of evaluation plans, definition of baseline and final performance and representative of ICT Platforms and data collection approach	ST1.1: KPIs definition
Impact Assessment Indicators	Impacts in LH	Partners in charge of city impact evaluation procedure	ST1.1: KPIs definition
	SmartEnCity Regeneration	Participants in ST2.6.4	
	Integrated Urban Plans	Participants in ST8.4.1 and ST8.4.2	
	Replication of LH lessons to European cities	Participants in ST8.4.3	
	Replication roadmap for each LH and follower city	Participants in T8.5	

Table 4: Target partners

It has to be mentioned that as this action plan has been defined at M3, some changes can be produced along the project. It can occur that some tasks not included in this scheme require of KPIs as well as some others do not need any type of KPIs. These changes are more probable for replicability issues given the diversity of approaches that can be proposed under these actions.

6.2 Identification of sources of indicators

As it was reported in Chapter 5, nowadays there is still no integrated indicator system focused on indicators for cities which can be used for SmartEnCity. Hence, it is needed to consult the different documents deployed under diverse initiatives. But considering the big number of initiatives which have worked in deploying lists of indicators, it is needed to make a screening of sources to be consulted by each typology of key performance indicator.

For city level indicators

The selected sources are: ISO 37120, CONCERTO & SCIS, CIVITAS, ITU, STEEP and PLEEC.

A brief description of each initiative is provided below:

- ISO 37120: 2014: It provides a list of KPIs focused on city services and quality of life distributed in 17 areas. For SmartEnCity, indicators included in areas of energy,

environment, finance, telecommunications and innovations, and transportation urban planning could be of interest.

■ CONCERTO Premium: It is a European Commission initiative within the European Research Framework Programme whose main objective is to work out a robust data and information base that serves as the foundation for setting regulatory frameworks and as a support for investor decision-making. The most valuable document for this deliverable consists of a guide for indicators which compiles a list of KPIs for technical, environmental, economic and social issues. http://smartcities-infosystem.eu/

■ SCIS: It started in 2014 as an extension of CONCERTO being also its main goal the collection of data from projects with the aim of creating the basis for comparative visualization as well as providing guidelines and lessons learnt. It will be operative until 2017, being one of its objectives to develop indicators for those sectors not included in CONCERTO: Mobility and ICT (focus on energy dimension) and define indicators for city impacts. http://smartcities-infosystem.eu/

■ CITYKeys: The mission of this Project (2015-2017) is to develop and validate a harmonized and comparable holistic performance measurement framework for being considered in future European cities activities during the implementation of Smart City solutions. The methodology will be based on an extensive collaboration and communication with European cities and as a result, it will develop a set of KPIs specific for Smart Cities initiatives focused on measuring the performance of interventions as well as the effects in the city. A list of KPIs has been published recently (February 2016) for performance of projects and cities' impacts in the areas of People, Planet, Profit, Process and Propagation. http://www.citykeys-project.eu

■ CIVITAS: It is an initiative co-financed by the European Commission whose main aim is to support cities in the introduction of ambitious transport measures and policies towards sustainable urban mobility. It started in 2002 and continues in the actuality through different programmes. It has developed guidelines and handbooks for city evaluation in terms of mobility. http://www.civitas.eu/

■ ITU: It is the United Nations specialized agency for information and communication technologies which focus their activity in radiocommunication, standardization and development through conferences and meetings: http://www.itu.int/en/about/Pages/default.aspx

■ PLEEC and STEEP: They are projects funded under FP7 focus on planning for energy efficient cities. As part of the project activities, they have developed a procedure for cities characterization. http://pleecproject.eu, http://www.smartsteep.eu/

The reason for being selected as main sources to be consulted is depicted below:

■ ISO 37120: We will take into account this source since it is the only standard developed for city indicators. However, it will not be the main source since it is not focused in indicators for smart cities but in city services and quality of life.

■ SCIS (CONCERTO): It will be one of the main sources to be used in the identification of indicators since it integrates the existing results from previous initiatives but in addition because it is mandatory to report results of the evaluation at the final of the project in the database of these projects. Therefore it is understood that they will be the main source consulted for defining the KPIs of the project.

- CITYKeys: It will be one of the main sources to be used in the identification of indicators since it integrates the existing results from previous initiatives. In addition, it is the first source which establishes links among Project and City Level and therefore it will be very useful for evaluating the impact of a Smart City project in cities.

- ITU: Since it is the main source in issues on in ICT and a specific list of indicators in this field was deployed in December 2015.

- PLEEC and STEEP: For taking into account indicators used in projects focus in city planning which were selected in collaboration with cities.

Sources such as Global City Indicators Facility, American Society of Civil Engineers (ASCE), Vitoria Transport Policy Institute (VTPI) and standards on Energy performance of buildings, BREEAM o LEED were not selected given they were analysed previously by the sources chosen.

For project indicators and impact assessment indicator

In this section, we only include some foreseen sources since we need to define the approach of each of the protocols and procedures to be applied in the evaluation of energy, mobility, ICT, etc. For now, we will report some ideas and the definitive sources will be identified in D7.2.

For project level indicators, the main sources could be CONCERTO, SCIS, CITYkeys and CIVITAS.

- For energy assessment, social and economic issues: CONCERTO and CITYkeys.

- For mobility: CIVITAS and SCIS will be the main source.

- For ICT: It will depend on the scope of the evaluation. Some possible sources for this issue are: SCIS, CELSIUS, ECO Grid.eu, ISO/TS 3715.

- For LCA: Indicators will be selected based on the scope of the evaluation. Impact categories identified in the diverse methods for impact evaluation are found in CML, ReciPe, Cumulative energy demand and Ecological footprint.

- For citizen engagement: The indicators will be chosen according to the evaluation plan to be defined for this action.

For city impact assessment: CITYkkeys and SCIS will be the most interesting sources to be consulted.

6.3 Identification of criteria used for the selection

In order to obtain a short list of indicators, a set of criteria which guarantee a suitable screening should be taken into account.

- RELEVANCE: Each indicator should have a significant importance for the evaluation process and for the goals of the project. Further, the indicators should be selected and defined in such a way that the implementation of the smart city project will provide a clear signal in the change of the indicator value. Ambiguous indicators or which are influenced by other factors than the implementation of the evaluated project must not be selected.

- COMPLETENESS: The set of indicators should consider all aspects of the planning and implementation of smart city projects. KPI's must cover all the pillars of the project: interventions (building, mobility, ITC), actions (engagement), impacts (energy, economy, social, environment) and non-technical barriers (governance, people, finance).

- MEASURABILITY: The identified indicators should be capable of being measured, preferably as objectively as possible. For qualitative data, social sciences provide approaches to deal with qualitative information in a semi-quantitative way (Abeyasekera, 2005).

- AVAILABILITY: Data for the indicators should be easily available. As the inventory for gathering the data for the indicators should be kept limited in time and effort, the indicators should be based on data that either:

  - are available from partners

  - can easily be compiled from public sources

  - or can easily be gathered from interviews, maps, or field observations

- RELIABILITY: The definitions of the indicators should be clear and not open for different interpretations. This holds for the definition itself and for the calculation methods behind the indicator.

- FAMILIARITY: The indicators should be easy to understand by the users.

- NON-REDUNDANCY: Indicators within a system/framework should not measure the same aspect of a subtheme.

- INDEPENDENCE: Small changes in the measurements of an indicator should not impact preferences assigned to other indicators in the evaluation.

Such specifications should be considered in all the decisions to be taken for the selection of indicators: the first screening of indicators from the source and the second screening from the complete list provided. For the first screening, the use of credible sources should be also remarked.

7 First set of City Diagnosis Indicators

A set of potential KPI for demo area and city diagnosis is provided in Annex 1. These indicators have been selected by TEC and CAR taking into account the criteria described in previous section. A collaborative work according to the action plan will allow to defining set of KPIs for specific final uses in D.2.4, D7.2, D8.6, D8.7 and D8.10.

Categories of KPIs have been grouped as follows:

- City diagnosis:

    - City characterization: city size, land use, socio-economic and environment features of the city

    - Energy supply network: energy profiles, potential local energy resources, environmental impacts on the energy consumption

    - City transportation diagnosis: mobility city profile, city statistics for mobility, environmental impact of the mobility

    - Suitable urban infrastructures: Infrastructures, public services, existing transport utilities, environmental monitoring, existing city monitoring/information sources, communication infrastructure

    - Governance & City plans and regulations: City plans and strategies, public procurements procedures & regulations and normative, governance

    - Citizen engagement: Existing actions, channels and current scenarios

- Demo area diagnosis: Energy flows, Comfort conditions

7.1 First impressions from cities on the list of KPIs

The list of KPIs selected has been distributed through the consortium and target partners (cities participants, responsible of cities diagnosis and from methodologies for city diagnosis and replicability issues) and have been invited to evaluate the suitability of those indicators. In special, it has required the opinion from those partners involved in LH city diagnosis in order to start defining a procedure to select the definitive list of KPIs for being integrated in Deliverable 2.4: City needs and baseline definition process and methods. It was required marking each indicator as follows:

- "Not applicable" if the indicator is not suitable for the city or intervention focus.

- "Not relevant" if they are applicable to the type of project or policy focus, but are not relevant for the assessment due to deviating circumstances or contexts.

- "Not available" if it is not possible to gather the data.

Furthermore, it was asked about how familiars are indicators.

First impressions from partner cities have been the need to adapt the list to the characteristics of the cities and the selection of the most relevant indicators. At a first glance, indicators seem familiar.

8 Evaluation scheme for performance and impacts to be evaluated in SmartEnCity

A common methodology for evaluation of the interventions as a whole is deployed in WP7 which consist of indicators and comprehensive evaluation procedures to assess the performance of the interventions and calculate the integrated impact at city level. This approach will be completed in D2.4 "City needs and baseline definition process and methods" with the selection of KPIs to be considered for city diagnosis and baseline definition as well as with guidelines for baseline definition.

¡Error! No se encuentra el origen de la referencia. shows the workflow for baseline definition and the outputs generated in the different stages.
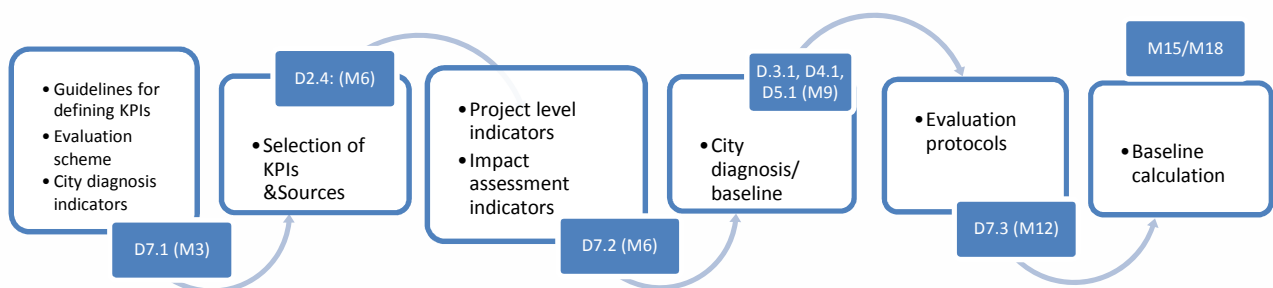
Figure 1: Procedure for baseline definition

Expected decisions must be taking in M4 in order to focus the evaluation workflow.

- Definition of procedure to select definitive KPIs for city diagnosis.

- Definition of the approach of each evaluation plan: It will identify the objectives of the evaluation plans in each one of the application areas: energy, mobility, ITC, LCA, social acceptance and citizen engagement as well as the responsible of corresponding protocols and procedure.

- Definition of the working plan for the baseline calculation.

On the other hand, it is needed to build the scheme for assuring a proper evaluation of final performance and city impact after baseline definition. Figure 2 shows the workflow for defining the monitoring program and monitoring plans.
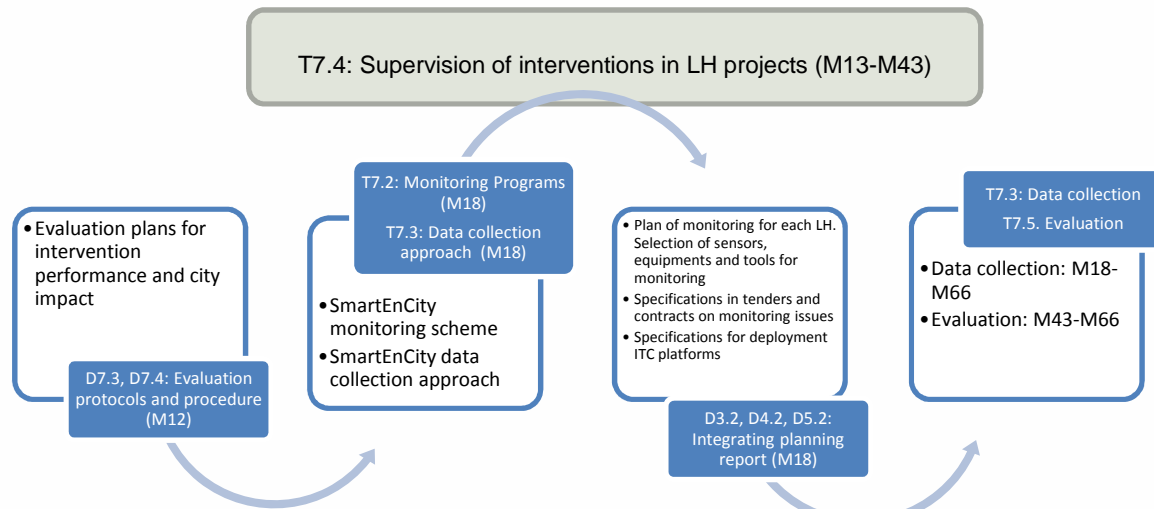
Figure 2: Procedure for demosite performance and city impact

Finally, table below shows the connections among deliverables and tasks in WP7. Specific groups will be arranged around each pillar: energy, mobility, ITC, LCA, social acceptance and citizen engagement in order to assure a well deployment of the protocols and monitoring programs.

Type of KPIs	Utility of KPIs	Procedure for evaluation	Monitoring Programs	Data collection	Performance assessment
City level indicators (M6)	City diagnosis (T3.1, T4.1, T5.1-M9)	D2.4: City needs and baseline definition process and methods: T2.6-M6	--		
Project level indicators (M6)	Baseline before interventions (T3.1, T4.1, T5.1-M9 & WP7-M15)	D2.4: City needs and baseline definition process and methods: T2.6-M6	--	--	--
				Data collection approach: T7.3-M18	
	Final performance after interventions (T7.5-M66)	D7.3: Evaluation protocol for energy assessment of district intervention (energy savings): T7.1-M12	D. 7.6 District retrofitting monitoring program: T7.2-M18	District data collection: T7.3-M66	District performance: T7.5-M66
		D7.3: Evaluation protocols for mobility action (CO_2 avoided, traffic congestion):	D7.7: Vehicle and urban mobility actions monitoring	Urban mobility data collection:	Mobility performance: T7.5-M66

		T7.1-M12	programs: T7.2-M18	T7.3-M66	
		D7.3: Evaluation protocols for integrated infrastructures (tailored): T7.1-M12			
		D7.3: Evaluation protocols for LCA (simplified method): T7.1-M12			
		D7.3: Evaluation protocols for citizens engagement (tailored): T7.1-M12	D7.8: Monitoring program for actions related to the integrated infrastructure pillar: 7.3-M18		Benefit from project in demo area: T7.5-M66
		D7.3: Evaluation protocols for social acceptance (tailored) T7.1-M12		ITC data collection: T7.3-M66	
		D7.3: Evaluation protocols for economic performance (tailored): T7.1-M12			
Impact assessment indicators (M6)	Impacts in the city after interventions and actions (T7.5-M66)	D7.4: City impact evaluation procedure for benefits in the whole city (energy & economic performance; social acceptance, urban mobility and integrated infrastructures actions): T7.1-M12			Benefit from project in city: T7.5-M66

Table 5: Deliverable connections

9 Conclusions

Key performance indicators can be a valuable tool for establishing future urban strategies as well as for evaluating project impacts. However, nowadays, any standard has been developed for evaluating cities under sustainable or smartness and it does not exist any broadly-accepted indicator system which integrate all the pillars on which SmartEnCity is based (building retrofitting, mobility, ICT, economic performance, social acceptance, citizen engagement). In addition, the selection must be done in a collaborative way according to the needs of each city and interventions. As a result, a procedure has been established in order to define the KPIs which will take part of the evaluation plan of the project as well as some guidelines which help in the proper selection of indicators. Furthermore, a potential list of city level indicators is provided in this deliverable to be analysed in posterior months for partners directly involved in methodologies and strategies for making city diagnosis and promote smart city projects around LH cities, follower cities and other European cities.

On the other hand, in such complex project as SmartEnCity, there are many connections among tasks, in special in issues which cover the evaluation. Hence, this report is focus on describing the evaluation scheme and the KPIs flow in order to be a working document for SmartEnCity partners involved mainly in WP3, WP4, WP5, WP6 and WP8 and define the bridge among WP7 and D.2.4 "City needs and baseline definition".

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11 Annex: List of City Level of Indicators

A. CITY DIAGNOSIS

a. City characterization

Field	Indicator	Formula	Unit	Description
City features	Size		km^2	Land area of city
	Population		Inh	Total number of persons inhabiting a city
	Population density	Total city population / Land area city	Inh./km^2	Population per unit area in the city
	Annual population change	[Total population / Total population] x 100	%	Change in the number of inhabitants in the last year
	Median population age		Years	Median age is the age that divides a population into two numerically equal groups
	% of population > 75		%	Number of persons older than 75 years
Land use characterization	Land consumption	Nº Buildings/Total city surface	nº build/Km^2	Measure of land use intensity and urban areas density
		Total built surface/Total city surface	Km^2/Km^2	Measure of land use intensity and urban areas density
	Balance between residential and no-residential building use	[Built surface for terciary sector/Total build surface] x100	%	Measure of land use diversity
	Balance between residential and no-residential building use	[Number of buildings for tertiary sector / Total number of buildings] x 100	%	Measure of land use diversity

Socio-economic features of the city (Current economic performance of the city)	GDP per capita	Gross Domestic Product at market prices /Total city population	M€/inh	The monetary value of all the finished goods and services produced within a city's borders in a specific time period considering the number of inhabitants
	Median disposable income		€	Median disposable annual household income
Socio-economic features of the city (City prosperity)	New business registered per 100,000 population	New business /100,000		Number of new business per 100,000 population
	Proportion of working age population with higher education	[Population at working age with higher education/Population at working age] x100	%	Proportion of working age population (18-65 years) qualified at level 5 or 6 ISCED (Short-cycle tertiary education or bachelor's or equivalent level)
	City unemployment rate	[Number of citizens unemployed/Total labour force] x 100	%	Unemployed citizens in relation to employed and unemployed who are legally eligible to work
	Youth unemployment rate	[Number of youth citizens unemployed/Total labour force] x 100	%	Percentage of youth labour force unemployed
Socio-economic features of the city (Innovation)	Creative industries	[Number of citizens working in creative industries/Total labour force] x 100	%	Share of people working in creative industries. Definition can be found in https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/203296/Classifying_and_Measuring_the_Creative_Industries_Consultation_Paper_April_2013-final.pdf
	Research intensity	Expenditure on R&D in a city/GDP of the city	€	R&D expenditure as percentage of city's GDP

Socio-economic features of the city (Equity)	Percentage of the stock reserved for social housing	[Social housing/public protection destiny/ Total building stock] x100	%	Measure of the governmental action to improve housing accessibility
	Affordability of housing	Average price of house or annual rent / Minimum or average annual salary	Ratio	Measure of the affordability of non-social housing
	Fuel poverty	Number of households unable to afford the most basic levels of energy / total number of residential buildings	%	Percentage of households unable to afford the most basic levels of energy
Environmental features of the city	Waste generated per capita	Amount of municipal solid waste generated/city population	Ton/inh	The amount of municipal solid waste generated per capita annually
	Nitrogen dioxide emissions	Annual nitrogen dioxide emissions/city population	g/inh	Annual nitrogen dioxide emissions per capita
	Fine particulate matter emissions	Annual fine particulate matter emissions/city population	g/inh	Annual fine particulate matter emissions (PM 2.5) per capita
	Air quality index: NOx		ppp$_3$ or g/m^3	Annual concentration of NOx
	Air quality index; fine particle		ppp$_3$ or g/m^3	Annual concentration of fine particle (PM 2.5)
	Days PM10 > 50 µg/m3		Days/year	Number of days in a year in which the concentration of particles in the city is higher than 50 µg/m3
	Noise perception	Population affected by noise/city population	%	Share of the population affected by noise >55 dB(a) at night time
	Green space per 100.000 population	Green area/100.000	ha/inh	Measure of quality of the built environment
	Environmental education	Number of schools with environmental education programs / total number of schools	%	The percentage of schools with environmental education programs

B. Energy supply network

Field	Indicator	Formula	Unit	Description
Energy profiles	Total building energy consumption in the city per capita	Total energy use / Total city population	kWh/inhab·year	Residential + non-residential consumption in the city for heating and electricity uses
	Residential buildings energy consumption per capita	Energy consumption in residential buildings over a calendar year / Total city population	GWh/inhab.year	Residencial consumption in the city for heating and electricity uses
	Total residential natural gas energy use per capita	Total residential natural gas use / Total city population	kWh/hab·year	Residential natural gas consumption
	Total residential oil energy use per capita	Total residential oil use / Total city population	kWh/hab·year	Residential oil consumption
	Total residential biomass energy use per capita	Total residential biomass use / Total city population	kWh/hab·year	Residential biomass consumption
	Percentage of the energy consumption by end use in residential buildings: space conditioning	[Energy consumption in the domestic sector related to heating and cooling over a calendar year / Total residential buildings energy consumption] x100	%	Measure of the total energy consumption of heating and cooling in residential buildings.
	Percentage of the energy consumption by end use in residential buildings: domestic hot water	[Energy consumption in the domestic sector related to domestic hot water over a calendar year / Total residential buildings energy consumption] x100	%	Measure of the total energy consumption of DHW in residential buildings
	Percentage of energy consumption by end use in residential buildings: lighting and appliances	[Energy consumption in residential buildings related to lighting and appliances over a calendar year / Total residential buildings energy consumption] x100	%	Measure of the electricity consumption in residential buildings
	Residential electrical energy use per capita	Total residential energy use / Total city population	kWh/hab·year	Residential electricity consumption

	Energy consumption of public buildings per year	Total use of energy by public buildings / Total floor space of these buildings	kWh/m^2	Energy consumption by public buildings
	Energy consumption of public buildings per year	Total use of energy by public buildings / Total number of public building	kWh/number buildings	Energy consumption by public buildings
	Percentage of the energy consumption by end use in public buildings: thermal and cooling uses	[Energy consumption in public buildings related to heating, DHW and cooling over a calendar year / Total public buildings energy consumption] x100	%	Measure of the electricity consumption in public buildings
	Percentage of the energy consumption by end use in public buildings: electrical uses	[Energy consumption in public buildings related to lighting and appliances over a calendar year / Total public buildings energy consumption] x100	%	Measure of the electricity consumption in public buildings
Potential local renewable energy resources	Energy use from District Heating	Total energy supplied by district heating sources/ Total energy consumption	kWh/year	Total energy supplied by district heating in the city
	The percentage of total energy derived from renewable sources	Total consumption of electricity generated from renewable sources / Total energy consumption	%	Energy derived from energy renewable sources related to the total energy
	Energy use from Biomass	Total energy supplied by biomass sources	kWh/year	Total energy supplied by biomass in the city
	Energy use from PV	Total energy supplied by photovoltaic sources	kWh/year	Total energy supplied by photovoltaic plants or distributed photovoltaic elements in the city
	Energy use from Solar Thermal	Total energy supplied by solar thermal sources	kWh/year	Total energy supplied by solar thermal plants or distributed solar thermal elements in the city
	Energy use from Hydraulic	Total energy supplied by water sources	kWh/year	Total energy supplied by hydraulic plants in the city
	Energy use from Mini-Eolic	Total energy supplied by wind sources	kWh/year	Total energy supplied by wind farm plants or distributed eolic elements in the city
	Energy use from Geothermal	Total energy supplied by geothermal sources	kWh/year	Total energy supplied by geothermal plants in the city

Environmental impacts of the energy consumption	Global Warming Potential (GWP) per capita	Emissions of residential and non residential sectors / city population	Tn equiv. CO_2 / year capita	To measure the impact of the activities of the city in the environment with the analysis of the GHG emissions through the impact category of Global Warming Potential (GWP).
	Greenhouse gas emissions in residential buildings	[Energy consumption in residential buildings by energy source (GWh) x CO_2 emissions national factor by energy source (GWh * [TnCO2/GWh])	Tn CO_2	Measure of the impact of the residential buildings consumption and the environmental effect (pollution and climate change contribution).

C. City transportation diagnosis

Field	Indicator	Formula	Unit	Description
Mobility City Profile	Total number of vehicles in the city		Number of vehicles	Number of public and private vehicles in the city
	Total number of private cars		Number of private cars	Number of private cars registered in the city
	Total number of commercial cars		Number of commercial cars	Number of cars used for the delivery of goods and services by commercial enterprises
	Total number of taxis		Number of taxis	Number of taxis registered in the city
	Total number of motorbikes		Number of motorbikes	Number of motorbikes registered in the city
	Total number of trucks		Number of trucks	Number of trucks registered in the city
	Total number of private buses		Number of private buses	Number of buses registered in the city (private buses)
	Total number of public buses		Number of public buses	Number of buses registered in the city (public buses)
	Total number of industrial vehicles		Number of industrial vehicles	Number of industrial vehicles registered in the city
	Total number of public bicycles		Number of public bicycles	Number of available bicycles in public initiatives
	Number of personal automobiles per capita	Total number of private cars / Total city population	Number of cars / Inh	Total number of private cars (excluding automobiles, trucks and vans used for the delivery of goods and services by commercial enterprises), related to the total number of inhabitants
	Number of two-wheel motorized vehicles per capita	Total number of motorcycles / Total city population	Number of motorcycles / inh	Total number of two-wheel motorized vehicles (including scooters and motorcycles, but no bicycles), related to the total number of inhabitants
	Number of bicycles per capita	No. of bicycles in the city / Total city population	No. of bicycles /inh	Measuring the total number of bicycles.

City Statistics for Mobility	Average age of motor vehicles for public transport	Sum of age of motor vehicles for public transport / No. of motor vehicles for public transport	Years	Mesure of the average age of motor vehicles for public transport.
	Kilometers of high capacity public transport system per 100 000 population	Length of high capacity public transport / 100.000	km/100.000 inh.	Length of high capacity public transport network (heavy rail metro, subway and commuter rail systems)
	Kilometers of light passenger public transport system per 100 000 population	Length of light capacity public transport / 100.000	km/100.000 inh.	Length of light capacity public transport network (light rail streetcars, tramways, bus, trolleybus and other)
	Kilometers of bicycle paths and lanes per 100 000 population	Length of bicycle paths and lanes / 100.000	km/100.000 inh.	Length of bicycle paths (independent roads or parts of a road designated for cycles and signed-posted as such) and lanes (part of carriageways designated for cycles and distinguished from the rest by longitudinal road markings)
	Total annual number of trips		Number of trips	Total annual number of trips in the city
	Total annual number of trips by private car		Number of trips	Total annual number of trips by private car
	Total annual number of public transport trips		Number of trips	Total annual number of trips in public transport
	Total annual number of trips by bike		Number of trips	Total annual number of trips by bike
	Total annual number of trips by motorbike		Number of trips	Total annual number of trips by motorbike
	Total annual number of trips by taxi		Number of trips	Total annual number of trips by taxi
	Total annual number of trips on foot		Number of trips	Total annual number of trips on foot

	Annual number of public transport trips per capita	No. of trips made by public transport per year / Total city population	No. of public transport trips /pers.·a	Measure of the use of public transport facilities.
	Daily average time by trip	Annual time of total trips / total number of vehicles / 365	min / vehicle ·day	Measure of the time devoted daily to transport by commuters.
	Daily average length by trip	Annual length of total trips / total number of vehicles / 365	km/ vehicle ·day	Average length of trips in the city
	Daily average length by private car trip	Annual length of total trips by private car/ total number of vehicles / 365	km/ vehicle ·day	Average length of trips in the city by private car
	Daily average length by public transport trip	Annual length of total trips by public transport/ total number of vehicles / 365	km/ vehicle ·day	Average length of trips in the city in public transport
	Daily average length by bike trip	Annual length of total trips by bike/ total number of vehicles / 365	km/ vehicle ·day	Average length of trips in the city by bike
	Daily average length by motorbike trip	Annual length of total trips by motorbike/ total number of vehicles / 365	km/ vehicle ·day	Average length of trips in the city by motorbike
	Daily average length by taxi trip	Annual length of total trips by taxi/ total number of vehicles / 365	km/ vehicle ·day	Average length of trips in the city by taxi
	Daily average length by foot trip	Annual length of total trips on foot/ total city population / 365	km/ inhab ·day	Average length of trips in the city on foot

Percentage of electric private cars	Total number of electric private cars / Total number of private cars	%	Number of electric vehicles related to total number of private cars
Percentage of electric commercial cars	Total number of electric commercial cars / Total number of commercial cars	%	Number of electric vehicles related to total number of commercial cars
Percentage of electric taxis	Total number of electric taxis / Total number of taxis	%	Number of electric vehicles related to total number of taxis
Percentage of electric motorcycles	Total number of electric motorcycles / Total number of motorcycles	%	Number of electric vehicles related to total number of motorcycles
Percentage of electric trucks	Total number of electric trucks / Total number of trucks	%	Number of electric vehicles related to total number of trucks
Percentage of electric public buses	Total number of electric public buses / Total number of public buses	%	Number of electric vehicles related to total number of public buses
Percentage of electric industrial vehicles	Total number of electric industrial vehicles / Total number of industrial vehicles	%	Number of electric vehicles related to total number of industrial vehicles
Number of public EV charging stations		Number of EV charging stations	Total number of public EV charging stations in the city
Total number of recharges per year		Number of recharges	Total number of recharges during a year in the public EV charging stations
Total kWh recharged in the EV charging stations		kWh	Number of estimated kWh recharged during a year in the public EV charging stations
Parking facilities per 100,000 population	[No. of public and private parking facilities / Total city population] x100,000	No. of parking spaces /100,000 pers.	Measure of the facility to park vehicles.

	Number of public parking areas		Number of parkings	Total public parking areas in the city
	Number of available parking slots		Number of parking slots	Total number of public parking slots in the city
	Pedestrian area per 100,000 population	[Pedestrian urban area / Total city population] x 100,000	km² /100,000 pers.	Measure of the facility for pedestrian movement.
	Cost of a monthly ticket for public transport in relation to the national minimum wage or average wage	[Price of a monthly ticket for public transport / National minimum or average wage)] x100	%	Measure the weight of public transport in the household economy.
	Transportation fatalities per 100,000 population	[No. of transportation fatalities over a calendar year / Total city population] x100,000	No. of transportation fatalities /100,000 pers.·a	Measure the overall safety of the transportation system.
Environmental impact with mobility	Transport energy use per capita	Transport energy use over a calendar year / Total city population	kWh /pers.·a	Measure of the total energy use per capita due to public and private transport.
	Transport greenhouse gas emissions per capita	Transport GHG emissions, in equivalent CO2 units, generated over a calendar year / Total city population	t /(pers.·a)	Measure of the total greenhouse gas emissions per capita due to public and private transport.
	Percentage of renewable energy use in public transport	[Renewable energy use in public transport over a calendar year (kWh) / Public transport energy use over a calendar year (kWh)] x100	%	Measure of the use of renewable energy in public transport.

D. Suitable urban infrastructures

Field	Indicator	Formula	Unit	Description
Infrastructures (transport, energy, sewage, water)	Lighting system connected		YES/NO	Is there an automated lighting management system in the city?
	Waste management system		YES/NO	Is there an automated waste management system in the city?
	Traffic management system		YES/NO	Is there an automated traffic management system in the city?
	Parking management system		YES/NO	Is there an automated parking management system in the city?
	EV charging management system		YES/NO	Is there an automated EV charging management system in the city?
	Air quality management system		YES/NO	Is there an automated Air Quality management system in the city?
	Noise management system		YES/NO	Is there an automated noise management system in the city?
	Weather management system		YES/NO	Is there an automated weather management system in the city?
Public services	Public bicycles management system		YES/NO	Is there an automated public bicycles management system in the city?
	Public transport management system		YES/NO	Is there an automated public transport management system in the city?
Existing transport utilities	Number of fee parking management elements		Number of fee elements	Total number of public elements to management the fee parking in the city
	Number of parking information panels		Number of parking information panels	Total numbers of panels in the city with availability information in public parking

Environmental monitoring	Number of sensors deployed in the city		Number of sensors deployed in the city	Total number of sensors deployed in the city categorized by topic measured (ex: weather, noise, parking lots, …)
	Number of air quality stations		Number of air quality stations	Total number of air quality stations located in the city
	Number of noise stations		Number of noise stations	Total number of noise stations located in the city
	Number of weather stations		Number of weather stations	Total number of weather stations located in the city
	Number of loan point for public bicycles		Number of loan point for bicycles	Total number of loan points for public bicycles located in the city
	Number of smart-meters installed		Number of smart-meters	Total number of smart-meters installed in the city
Existing city monitoring/information sources	ICT citizen oriented platforms		YES/NO	Is there any public ICT global platform available for citizen offering general information about the city?
	Number of ICT citizen oriented platforms		Number of ICT citizen oriented platforms	Total number of ICT citizen oriented platforms
	Data privacy		Likert	The level of data protection by the city
Comunication infrastructure	Percentage of the population covered by a mobile-cellular network		People who own a mobile cellular/city population	
	Percentage of the population covered by at least a 3G mobile network		People who own a mobile cellular at least 3G/city population	
	3G Mobile network cells		Number of 3G mobile network cells	Total number of 3G (UMTS & CDMA2000) mobile network cells to cover the land area of the city from a mobile phone perspective

	4G Mobile network cells		Number of 4G mobile network cells	Total number of 4G (WiMAX) mobile network cells to cover the land area of the city from a mobile phone perspective
	Number of cell phone connections per 100.000 population	Number of cell phone connections / 100.000	Connections/100.000 hab.	Total number of cell phone connections in the city in relation to the population of the city
	Number of internet connections per 100.000 population	Number of internet connections / 100.000	Connections/100.000 hab.	Total number of internet connections in the city in relation to the population of the city
	Number of landline phone connections per 100.000 population	Number of landline phone connections / 100.000	Connections/100.000 hab.	Total number of landline phone connections (excluding cellular connections) in the city in relation to the population of the city
	Smartphone penetration	Number of smartphones / Total mobile phones	%	Number of smartphones in relation to total mobile phones
	Free Wi-Fi zones		Number of free Wi-Fi zones identified in the city	Total number of free Wi-Fi zones offered to citizens
	Cable Network		YES/NO	Is there any network cable system deployed in the city?
	Cable Network Types		Types of cable network available in the city (twisted pair cable, coaxial cable, fibre optic,…)	Different types of networks deployed in the city

E. Governance & City plans and regulations

Field	Indicator	Unit	Description
City plans and strategies	Existence of plans/programs to promote energy efficient buildings	Number of plans	Is there any specific plan for promoting energy efficient buildings in the city?
	Existence of plans/programs to promote sustainable mobility	Number of plans	Is there any specific plan for promoting sustainable mobility in the city?
	Existence of local sustainability action plans	YES/NO	Is there any specific sustainability plan in the city?
	Signature of Covenant of Mayors	YES/NO	Has the municipality signed the Covenant of Mayors?
	Existence of Smart Cities strategies	YES/NO	Is there any specific Smart Cities strategy in the city?
	Existence of public incentives to promote energy efficient districts	Numbers of plans	Is there any specific public incentives for promoting of energy efficient districts in the city?
	Existence of public incentives to promote sustainable mobility	Numbers of plans	Is there any specific public incentives for promoting of sustainable mobility in the city?
Public procurement procedures & Regulations and normative	Existence of regulations for development of energy efficient districts	Number of regulations	Is there any specific regulation for developing energy efficient districts in the city?
	Existence of regulations for development of sustainable mobility	Number of regulations	Is there any specific regulation for developing sustainable mobility in the city?
	Existence of local/national Energy Performance Certificate (EPC)	YES/NO	Is there any specific EPC for buildings in the city?
	Share of Green Public Procurement	%	Percentage annual procurement using environmental criteria as share of total annual procurement of the city administration
	Level of correspondence between local energy codes	YES/NO	Is there any discrepancy between different local energy codes for buildings?

	Level of correspondence with national regulation	YES/NO	Is there any discrepancy between local codes and national regulation?
	Level of correspondence with European legislation	YES/NO	Is there any discrepancy between local codes and European legislation?
	Level of correspondence with international construction standards	YES/NO	Is there any discrepancy between local codes and international construction standards?
Governance	Involvement of the administration on smart city projects	Likert scale	The extent to which the smart city strategy has been assigned to one department/director and staff resources have been allocated
	Involvement of the administration on smart city projects	Likert scale	What extent to which the local authority is involved in the development of smart city projects, other than financial?
	Expenditures by the municipality for a transition towards a smart city	€	Annual expenditures by the municipality for a transition towards a smart city
	Multilevel government	Likert scale	The extent to which the city cooperates with other authorities from different levels

F. Citizen engagement

Field	Indicator	Formula	Unit	Description
Existing actions for citizen engagement	Amount of solid waste recycled/amount of municipal solid waste generated		%	Percentage of the city's solid waste that is recycled
	Voter turnout in last municipal election	[Number of persons that voted in the last municipal election / Total city population eligible to vote] x 100	%	Voter participation level
	Number of local associations per capita	Number of associations / Total city population	Number of consultations / inhab.	Total number of citizen associations in the city
Channels for citizen engagement	Number of information contact points for citizens		Number of information points	Total number of information contact points, related to municipal citizen offices, information about energy efficiency, mobility, environment, etc.
	Number of municipal websites for citizens		Number of municipal websites	Total number of municipal websites for citizens (citizen participation portal, open data, transparency, etc.)
	Number of websites consultation per capita	Number of websites consultations / Total city population	Number of consultations / hab.	Total number of websites consultations related to total city population
	Number of interactive social media initiatives		Number of social media links	Total number of municipality links in social media channel as Facebook, Twitter, YouTube, etc.
	Number of interactive multimedia tools or apps		Number of interactive tools	Total number of interactive multimedia tools or apps dedicated to the citizens
	Number of newsletters		Number of newsletters	Total number of newsletters dedicated to the citizens

	Number of discussion forums		Number of forums	Total number of discussion forums dedicated to the citizens
	Number of video screens		Number of video screens	Total number of video screens dedicated to the citizens
	Number of discussion forums		Number of forums	Total number of discussion forums dedicated to the citizens
	Number of awareness raising campaigns		Number of awareness raising campaigns	Number of awareness raising campaigns (energy, mobility, etc.)
	Number of thematic events		Number of thematic events	Number of thematic events dedicated to citizens
	Number of newspaper columns		Number of newspaper columns	Number of newspaper columns for citizens
	Number of videos on local TV		Number of videos on local TV	Number of videos on local TV for citizens
Current scenarios of citizen engagement	Citizens participation in smart city projects	Number of smart city project with citizens participation/total smart city projects	%	The number of projects in which citizens actively participated as a percentage of the total projects executed
	Professional stakeholder involvement		Likert scale	What extent to which professional stakeholders are involved in planning and execution of urban strategies in your city?

B. AREA OF INTERVENTION

Field	Indicator	Formula	Unit	Description/Relevance of the indicator
Energy consumption	Primary energy demand and consumption	$$PEN_{I,t} = \frac{\sum_{i \in I} PEN_{i,t} * Cap_i}{\sum_{i \in I} Cap_i}$$ $PEN_{I,t}$ = Primary energy demand/consumption of set I of buildings based on annual data of year t [kWh/(m²·a)] $PEN_{i,t}$ = Primary energy demand/consumption of building i based on annual data of year t [kWh/(m²·a)] Cap_i = Floor area of building i [m²]	kWh/m²	This indicator encompasses in addition to the final energy demand/consumption, the energy that is used within the supply chain of the used energy carriers
	Final energy consumption	$$EN_{I,t} = \frac{\sum_{i \in I} EN_{i,t} * Cap_i}{\sum_{i \in I} Cap_i}$$ $EN_{I,t}$ = Final energy demand/consumption of set I of buildings based on annual data of year t [kWh/(m²·a)] $EN_{i,t}$ = Final energy demand/consumption of building i based on annual data of year t [kWh/(m²·a)] Cap_i = Floor area of building i [m²]	kWh/m²	This indicator corresponds with the final uses of the energy for different areas of application within the building (space heating, space cooling, domestic water heating, electrical appliances)
	Degree of accordance with national laws and standards	$$DC_{I,t} = \frac{\sum_{i \in I} Cap_i * DC_{i,t}}{\sum_{i \in I} Cap_i}$$ where $DC_{I,t}$ Degree of congruence of a set I of buildings regarding calculated final energy demand and monitored consumption based on annual data of year t $[kWh/(m^2\ a)]$ $DC_{i,t}$ Degree of building i's congruence of calculated final energy demand and monitored consumption based on annual data of year t $[kWh/(m^2\ a)]$ Cap_i Floor area of building i $[m^2]$	kWh/kWh	The degree of energetic self-supply is defined as ratio of locally produced energy and the local consumption over a period of time (usually one year)

	Degree of congruence of calculated annual final energy demand and monitored consumption	$ESS_{AA,I,t,RES} = \dfrac{\sum_{EC} In_{EC,AA,I,t} * RES_{EC,I,t}}{\sum_{EC} In_{EC,AA,I,t}}$ $ESS_{AA,I,t,RES}$ Share of renewable energy in energy consumption/demand of set I of buildings for application area in year t [kWh/kWh] $In_{EC,AA,I,t}$ Input (>0) energy flow into set I of buildings for application area in year t regarding energy carrier (or source) [kWh/a] $RES_{EC,I,t}$ Share of renewable energy in energy carrier EC supplying set I of buildings in year t [kWh/kWh]	kWh/m^2	It is the final energy consumed within the boundary of the district not including the renewable energies in-situ produced or the renewable fraction of the energies acquired from external grids
Energy demands	Density of final energy demand	$DEN_{EC,I,t} = \dfrac{\sum_{AA=AA1}^{AA4} In_{EC,AA,I,t}}{Cap_I}$ where $DEN_{EC,I,t}$ Density of final energy demand/consumption of a set I of buildings in year t regarding energy carrier EC [kWh/a] $In_{EC,AA,I,t}$ Input (>0) energy flow into set I of buildings for application area AA in year t regarding energy carrier EC [kWh/a] $In_{EC,AA,I,t} = \sum_{i \in I} In_{EC,AA,i,t}$ Cap_I Area or number of set I of buildings I [$km^2\ territory\ area, buildings$]	kWh/m^{2}year	Ratio of final energy demand (for heating or cooling) of a cohesive set of buildings. Effort that a district heating or cooling network operator would have in order to supply these buildings
	Peak load and profile of electricity demand	**Load profile** $LP_{I,EC=electricity\ ,t,\Delta t_k} = \dfrac{\sum_{AA1}^{AA4} In_{EC,AA,I,\Delta t_k}}{\Delta t_k * 8760}$ where $LP_{I,EC=electricity\ ,t,\Delta t_k}$ Load of set I of buildings regarding energy carrier EC = electricity in Δt_k $(k = 1, …, k)$ as part of a partition of year t [kW] $In_{EC,AA,I,\Delta t_k}$ Input (>0) energy flow into set I of buildings for application area AA in Δt_k $(k = 1, …, k)$ as part of a partition of year t [kWh/a] **Peak load** $LP_{I,EC=electricity\ ,t,max} = max_{k=1,…,k}(LP_{I,EC=electricity\ ,t,\Delta t_k})$ where $LP_{I,EC=electricity\ ,t,max}$ Peak load of a set I of buildings regarding energy carrier EC based on a partition of year t [kW] $LP_{I,EC=electricity\ ,t,\Delta t_k}$ Load of set I of buildings regarding energy carrier EC = electricity in Δt_k $(k = 1, …, k)$ as part of a partition of year t [kW]	kW	The load profile describes the demand characteristics over time. The electricity supply has to be able to cover the peak load. The load profile gives information about the possibilities or potentials of storage, demand-side management and self-supply via photovoltaic etc.

	Peak load and profile of thermal energy demand	**Load profile** $$LP_{I,AA,t,\Delta t_k} = \frac{\sum_{EC} In_{EC,AA,I,\Delta t_k}}{\Delta t_k * 8760}$$ where $LP_{I,AA,t,\Delta t_k}$ — Load of set I of buildings regarding application area AA in Δt_k ($k = 1, ..., k$) as part of a partition of year t [kW] $In_{EC,AA,I,\Delta t_k}$ — Input (>0) energy flow into set I of buildings for application area AA in Δt_k ($k = 1, ..., k$) as part of a partition of year t regarding energy carrier EC [kWh/a] **Peak load** $$LP_{I,AA,t,max} = max_{k=1,...,k}\left(LP_{I,AA,t,\Delta t_k}\right)$$ where $LP_{I,AA,t,max}$ — Peak load of a set I of buildings regarding application area AA based on a partition of year t [kW] $LP_{I,AA,t,\Delta t_k}$ — Load of set I of buildings regarding application area AA in Δt_k ($k = 1, ..., k$) as part of a partition of year t [kW]	kW	The load profile describes the demand characteristics over time. The thermal energy supply has to be able to cover the peak load. The peak load and the load profile of the thermal (heat and cold) energy demand require a high temporal resolution. The load profile gives information about the possibilities or potentials of storage as well as supply-side and demand-side management
Indoor environmental quality *	Local thermal comfort	Direct test. Compared results with ISO 7730:2005	%	Evaluation of the thermal conditions to know how they affect the health/wellness of inhabitants and the energy consumption of the buildings
	Percentage outside range		%	The percentage outside range is defined as the period of time (T) in which indoor local thermal comfort is outside the desired range according to the target category
	Visual comfort	IDA ICE dynamic simulation tool/Direct test (compare results with IES Standards)	lux	Evaluation of the lighting levels to assess how they affect the health/wellness of inhabitants and the energy consumption of the buildings
	Acoustic comfort	Direct test: background noise (LA [db]), reverberation time (T [s])	dBA	Evaluation of the acoustic levels to assess how they affect the health/wellness of inhabitants and the energy consumption of the buildings
	Indoor air quality	Direct tests to be compared with EN15251	n.a.	Evaluation of the quality of the air inside the buildings to assess how they affect the health/wellness of inhabitants and the energy consumption of the buildings

(*) In case there are equipments to take direct measures within demo team in order to compare with standards