Innovation Action

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D5.1 - City Level Indicators

WP5; Task 5.1

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Abbreviations and Acronyms

Acronym	Description
CITYkeys	Smart city performance measurement framework (CITYkeys). EU project that defined common indicator framework to assess the performance of smart city projects and smart cities in Europe.
CIVITAS	CIVITAS is a network of cities for cities dedicated to cleaner, better transport in Europe and beyond. CIVITAS stands for City VITAlity and Sustainability.
CONCERTO	EU initiative to demonstrate the optimisation of the building sector as whole communities is more efficient and cheaper than optimisation of each building individually.
DAQ	Data acquisition
DoA	Description of Action
EeB	Energy-efficient Buildings
EIP-OIP	European Innovation Partnership on Smart Cities and Communities: Operational Implementation Plan.
ESPRESSO	systEmic Standardisation apPRoach to Empower Smart citieS and cOmmunities (ESPRESSO). EU project to harmonise standardization approaches for smart city lighthouse projects.
GDPR	General Data Protection Regulation
GHG	Greenhouse gas
KPI	Key Performance Indicator
LH	Lighthouse cities (Groningen and Oulu)
PED	Positive Energy District
RTO	Research and Technology Organisation
SCC	Smart Cities and Communities
SCIS	Smart Cities Information System
WP	Work Package

Executive Summary

WP5 “Evaluation framework and social innovation” aims to monitor and evaluate the effectiveness of the project actions and interventions, compared to the initial situation, initial objectives and expected results. Robust monitoring and evaluation protocols will be developed and implemented, including a full methodology for the monitoring and evaluation of the project actions and interventions that will allow the introduction of future data after the end of the project. Within the WP5 and in close collaboration with WP1 “New long-term urban planning towards 2050”, WP2 “Demonstration of PED concept in Oulu”, WP3 “Demonstration of PED concept in Groningen” and WP8 “Collaboration with other SCC-1 projects and networks”, links with (SCIS) Smart Cities Information System database will be established.

Task 5.1 aims at the definition of the evaluation framework that has a twofold scope in order to measure and assess the project activities at PED level (demonstration areas) and city level considering the five major themes defined by CITYkeys: People, Planet, Prosperity, Governance and Propagation, and considering SCIS indicators. This framework includes boundaries of the integrated evaluation and specific approaches to assess the impact of the project actions and interventions in each one of the aforementioned themes. Previous work by CITYkeys (D1.4 “Smart city KPIs and related methodology – final”) has been used as reference as well as the Key Performance Indicator Guide from SCIS. Starting from the definition of a smart city and smart city projects, indicators have been selected for tracking the progress, evaluating the projects in the demonstration areas and focusing on monitoring the evolution of a city towards a smarter city.

City level indicators will be used to show to what extent overall policy goals have been reached, whereas project indicators will be considered in the evaluation of the technical and non-technical actions in technical, economic and social aspects. The evaluation procedures will be used for the definition of the baseline scenario in WP2 (Oulu) and WP3 (Groningen).

In this deliverable, a process of developing the evaluation framework including the city level indicators has been established and aligned with the WP1 developments. The main set of indicators, as targets included in the city plans, have been extracted and integrated into D1.2 in order to define the characterization of the project cities at medium term. Further analysis on the development of city characteristics utilizing the indicators have been carried out and described in D1.2.

1 Introduction

1.1 Purpose and target group

This report constitutes the Deliverable "*D5.1 City Level Indicators*", which has a previous version "*D5.13 City Level Indicators – Initial Version"* submitted in M6, forming one of the main outcomes of the *"Task 5.1 Evaluation Framework*"

The main objective of the deliverable is to define the evaluation framework of the MAKING-CITY project at city level, identifying the specific indicators that will allow measuring the impact of the project in each of the cities that participate in it. Part of these indicators have be obtained through the analysing the existing city plans, so the collaboration with the corresponding task within WP1, T1.2, will be very close.

The targets defined and goals achieved by the eight cities of the project have been collected in the deliverable 1.2. Meanwhile it is necessary to remark that the evaluation of these plans will be considered as input to the diagnosis characterisation towards the definition of the Long Term vision of all the cities. In D1.2, a process to analyse the information included in the city plans have been established being aligned with the WP5 developments and the main set of indicators defined in D5.1.

1.2 Contribution partners

The following Table 1 summarises the main contributions from participant partners in the development of this deliverable.

Table 1: Contribution of partners

Partner nº and short name	Contribution
01-CAR	ToC, indicator requirements, quality control of the deliverable
03-GRO	Indicator definitions
04-TNO	Indicator suggestions, Logic-model for the evaluation framework
13-OUK	Major contributor, Indicator definitions and calculation methods
20-VTT	Leading contributor
32-R2M	General review of the deliverable
34-CAP	Societal indicators

1.3 Relation to other activities in the project

The following Table 2 depicts the main relationship of this deliverable to other activities (or deliverables) developed within the MAKING-CITY project and that should be considered along with this document for further understanding of its contents.

Table 2: Relation to other activities in the project

Deliverable nº	Relation
D1.2	*City Diagnosis: analysis of existing plans*. As the main outcome of the Task "T1.2 Analysis of existing city plans", this deliverable will collect the diagnosis and analysis of the lighthouse and follower cities involved in the project. Indicators defined in D5.1 will be calculated by all the project cities into the task T1.2.
D1.5 – D1.12 (D1.25 – D1.32, Initial Versions)	*Long-term city plans (city vision 2050)*. In Task "T1.3 Advanced Long Term Energy Planning strategies and tools" the main outcome will be the long-term city plans of each of our project cities. The evaluation of the existing city plans, and in fact the City level indicators identified in this deliverable D5.13, are considered as input to the diagnosis towards the definition of the Long Term vision.
D1.13 – D1.20	*New/Updated SECAPs*. As main outcome of the Task "T1.6 Medium-term planning SEAP/SECAP updating", the process of monitoring the implementation of the SEAP/SECAP will be defined in these deliverables, using part of the City Level Indicators here defined.

2 Evaluation framework

The MAKING-CITY project is targeting to develop a large-scale demonstration of three Positive Energy Districts in two European cities, Groningen (Netherlands) and Oulu (Finland) where a rigorous monitoring and evaluation program will be deployed during the course of the project, with special attention (in addition to energy) to data collection, regulation (GDPR), evaluation framework and integration in a monitoring platform.

WP5 “Evaluation framework and social innovation” aims to monitor and evaluate the effectiveness of the project actions and interventions, compared to the initial situation, initial objectives and expected results. Robust monitoring and evaluation protocols will be developed and implemented, including a full methodology for the monitoring and evaluation of the project actions and interventions that will allow the introduction of future data after the end of the project. Within the present WP and in close collaboration with WP1 “New long-term urban planning towards 2050”, WP2 “Demonstration of PED concept in Oulu”, WP3 “Demonstration of PED concept in Groningen” and WP8 “Collaboration with other SCC-1 projects and networks”, links with (SCIS) Smart Cities Information System database will be established.

The scope of the monitoring protocol will be twofold, firstly in order to measure the performance of the actions deployed to reach a validation of PED concept and secondly to evaluate the impact at city level.

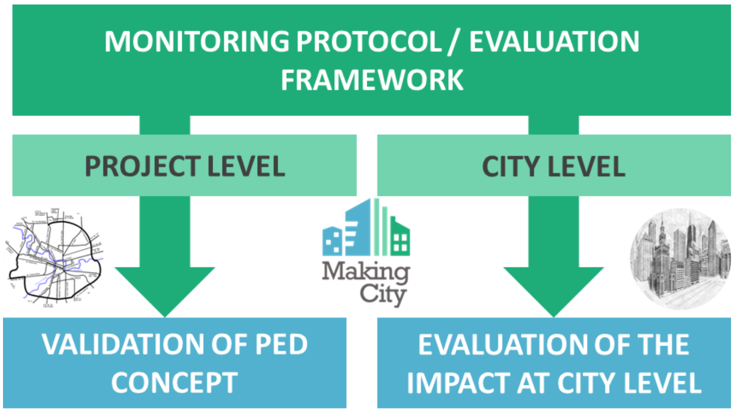

Figure 1: MAKING-CITY Evaluation Framework (source: D9.8)

The city level indicators will be used to show to what extent overall policy goals have been reached, whereas project level indicators (PED KPIs) will be considered in the evaluation of the technical and non-technical actions in technical (energy/environment/ICT), economic and social aspects. The evaluation procedures will be used for the definition of the baseline scenarios in WP2 (Oulu) and WP3 (Groningen), and later on in monitoring of the actions/interventions and overall impact assessment.

2.1 Evaluation objectives in WP5

Task 5.1 aims at the definition of the evaluation framework in order to measure and assess the project activities at PED level (demonstration areas) and city level considering the indicator categories defined by CITYkeys (Smart City Indicators and related methodology), SCIS (Key Performance Indicators Guide, and SRT: Self Reporting Tool) and other relevant reference frameworks (e.g. ESPRESSO, MAtchUP, mySMARTLife). The objective of the task is to select a set of Key Performance Indicators (KPIs) and data collection procedures for the common and transparent monitoring as well as the comparability of smart city actions across the cities.

Within Task 5.2, data sets and requirements for evaluating demonstrations will be defined based on the indicators selected within Task 5.1. The identification of the data sets will also be based on the previous work by CITYkeys and SCIS, and all the information related to these data sets will be included in the deliverable D5.5 that will be submitted by month 36. The data collection and KPI calculation will be carried out in WP2-Oulu (subtask 2.7.2) and WP3-Groningen (subtask 3.7.2). All relevant performance data (i.e. project level KPIs) will be incorporated into SCIS database. A strong coordination with the lighthouse cities will be required in order to integrate useful and useable information as open data within the ICT-city Platforms.

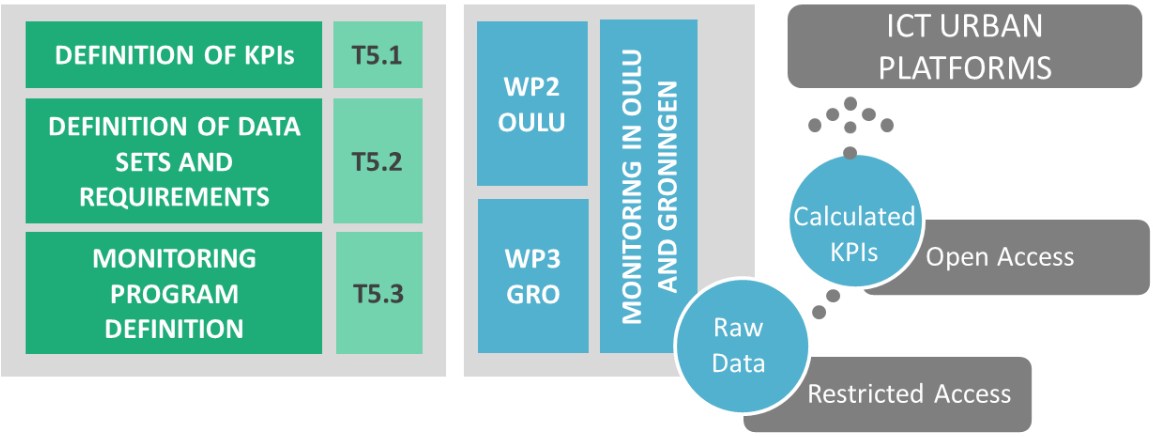

Figure 2: Definition of KPIs, data requirements and monitoring in tasks 5.1 – 5.3 (source: D9.8)

The city level evaluation framework consists of indicators selected for evaluation of the smart city actions on medium- and long-term sustainable energy planning by the lighthouse and follower cities. The evaluation procedure describes the methodology to assess city actions with the defined indicators. It consists of four steps:

1. Selecting and defining the city level indicators
2. Defining the baseline situation in the city and calculating the indicator values at the beginning of the project (before the planned city level actions)
3. Monitoring the indicators during the course of the project (following the indicators for the evaluation of progress), and
4. Performing the final calculation of the indicators at the end of the project for the final evaluation and impact assessment of the progress achieved in the cities.

This deliverable provides the methodological guidance for the procedure, concentrating on the indicator selection and definitions. The following stages in the evaluation framework and procedure will be further described in latter deliverables of WP5. The city level indicators are selected and defined for evaluating the policy actions in the LH and follower cities. The actual indicator values for the current situation in cities have been calculated for this project report on initial (baseline) values.

The actual evaluation of the achieved impacts - impact assessment - and other benefits of the city level actions and interventions will be performed at later stages of the project. Monitoring and evaluation protocols will be developed and implemented in the framework of WP5 with collaboration of the RTO partners of the project, taking into account existing KPIs and requirements for DAQ and GDPR. VTT and CGI are the partners in charge of leading the links with the Oulu and Groningen urban platforms respectively.

Figure 3: Coordination among lighthouse cities and other initiatives to define useful and usable information as open data within ICT city platforms (source: D9.8)

2.2 Relation between project and city level evaluation

Before stating the specific objectives for the evaluation procedure, it is important to notice that indicator-based evaluation is carried out in the MAKING-CITY project both at project and city level for different purposes: firstly, in order to measure the performance of the actions deployed to reach a validation of PED concept; secondly to evaluate the impact at city level. Such protocol will be based on the previous works by CITYkeys and SCIS in order to select a set of Key Performance Indicators (KPIs) and data collection procedures for the common and transparent monitoring as well as the comparability of smart city actions across the cities. All performance data (i.e. KPIs) will be incorporated into SCIS database using the Self Reporting Tool (SCIS SRT):

- D5.1: City level indicators
  - Joint effort with D1.2, with the aim of providing a method to make an advanced city diagnosis for measurement of progress in cities on the road to sustainability and energy smartness with the intention to guide the cities in the design of strategic plans to deploy innovative technologies in energy, mobility and ICT sectors. This framework will be applied in all of the eight cities of the project (lighthouse and follower cities).
- D5.2: Project (PED) level indicators
  - The objective is to evaluate the technical, environmental, economic and social impacts of the demonstration activities implemented in the two lighthouse (LH) cities of Groningen and Oulu.

The indicators for assessing the **project level** serve to assess or evaluate the **PED level** interventions. They indicate the difference the project has made, by comparing the situation without the project with the situation after the implementation of the project. As such, they can also serve to benchmark projects against each other.

The indicators for the **city level** focus on monitoring the evolution of a city towards an even smarter city, in this case specific focus on energy and sustainability planning. The time component - "development over the years"- is an important feature. The city indicators will be used to show to what extent the overall policy goals have been reached, or are within reach. Figure 4 depicts the approach for city diagnosis characterization used in MAKING-CITY. Further details and analysis on the city characterization will be provided in D1.2. In addition, the normalisation of the city level indicators (scoring) as well as the prioritisation of city needs and targets (weighting), have been described in that particular deliverable.

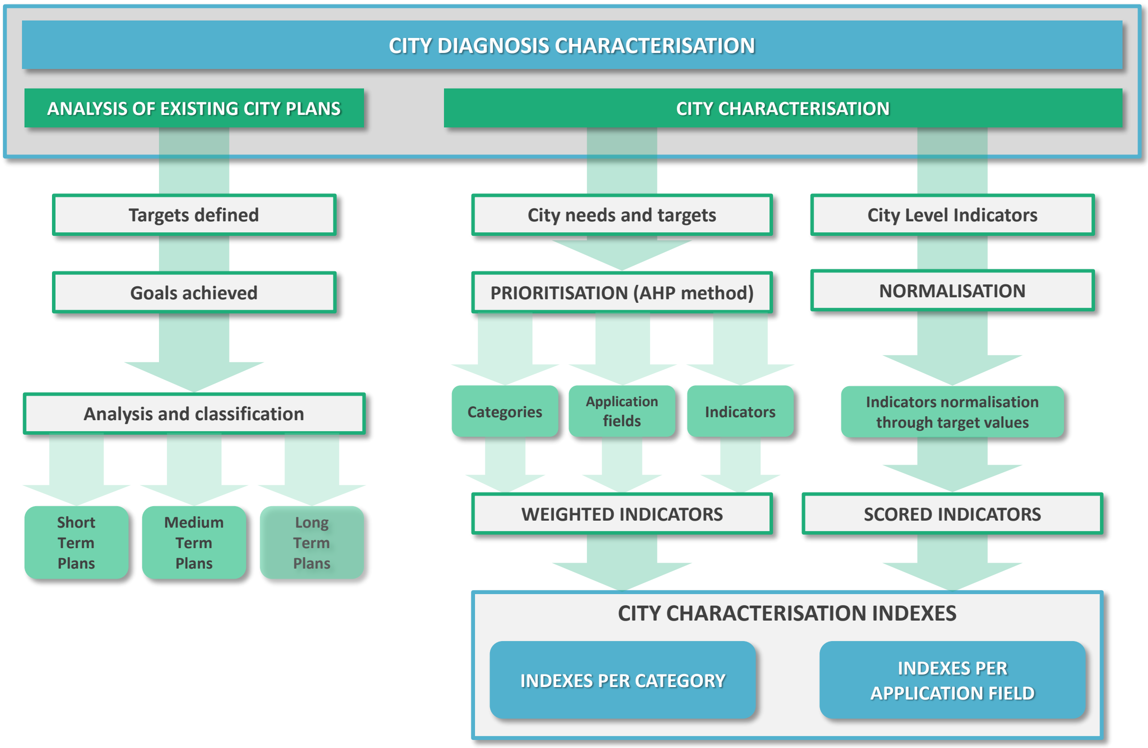

Figure 4: City diagnosis approach for the MAKING-CITY project determined in D1.2 (source: D1.2)

According to the DoA, specific objectives must be met in both Lighthouse cities in terms of energy production/consumption (new technologies highlighted) and (GHG) emission reduction due to the implementation of energy/environment, ICT, mobility and societal actions, in order to achieve Positive Energy District (PED) demo areas. These are the main targets that cities have in the project level and they need to be evaluated after two-three years of monitoring. The outcomes and impacts from the demo areas will be measured at the city level.

The objectives of these evaluation frameworks are somewhat different since the city level evaluation framework developed in WP1 and WP5 aims at medium- or long-term energy & sustainability planning based on efficient policy measures. Both lighthouse and follower cities have to adopt the evaluation process and calculate the indicators, while the project level evaluation framework in WP5 intends to assess the efficiency and benefits of the measures implemented in the demo areas of the two lighthouse cities.

2.3 The Logic-model for impact-based evaluation

Demonstration projects enable the validation of the benefits and potential of the implementation of integrated solutions to improve key parameters that affect overall quality of life in the city. Ranging from the pure environmental ones, passing through those related with citizens' comfort and leading to those that allow a progress in the socioeconomic conditions as the promotion and attraction of talents, or new businesses yielding to and intensive job creation. These projects, in general financed with extra funds (with respect to conventional) should offer society an open pathway to the city transformation, where citizens and stakeholders' engagement is ensured and well structured.

However, inside this context, the weakness related with upscaling and replicability of the solutions successfully deployed is commonly perceived. A real continuity of the urban transformation depends on the city commitment. This commitment can be constrained by several factors that can delay this city transformation and even in some cases, it can be jeopardised.

In order to define and establish the Smart City plans for the lighthouse and follower cities based on the replication potential of the interventions implemented in MAKING-CITY, it is necessary to start analysing the selected actions in an urban context in the earliest stage, i.e. identifying the opportunities and the barriers to the implementation of these actions. This will make it possible to study the feasibility of their implementation, but also to give priority to actions with a favourable context and to raise the barriers for other actions. The actions with a difficult context can then be compared with similar actions set up in partner cities and solutions can be sought to overcome the identified barriers. At this point, a strong coordination with the lighthouse cities will be required to integrate useful information as open data e.g. within the ICT-city Platforms.

The demand side vs. supply side scenarios assessment should be based on a multi-criteria methodology evaluating the sustainability of the scenarios proposed under the three sustainable development dimensions: the economic, social, and environmental impacts of the different scenarios generated.

The reasoning for the impact-based evaluation in MAKING-CITY project is depicted by the Logic-model (Figure 5), that describes the intended logic between the direct outputs and outcomes of the activities and interventions of the project (PED) level (short term effects) and the incurred impact on the city level (medium- or long-term effects).

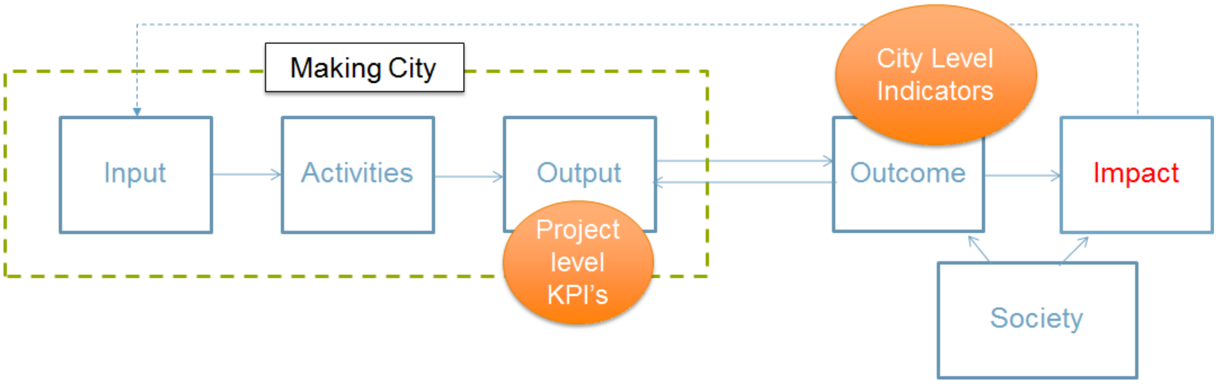

Figure 5: The Logic-model describes the steps from input to impact

Despite this intended logical methodology, the reality in some of the smart city projects - including MAKING-CITY - is that the project level (PED area) represents just a demo-scale selection of mainly energy related actions and technologies, and upscaling the outputs/outcomes from this level into city level impacts, is not necessarily going to represent the real progress or even desired goals. It is of course possible to generate simulations of what would it be like, but in real world, cities are much more complex entities, and just aggregating the demonstration results up to the city level, would be somewhat useless.

This is why in MAKING-CITY, the city level and project level evaluation (starting with indicators vs. KPIs) have intentionally been separated from each other. Only the main energy and environment related indicators are similar (comparable) in both levels. The city level is more concentrated on overall city level development targets (e.g. SECAP, long-term city strategies), whereas the project level aims to introduce new technologies for producing renewable energies and saving energy as much as possible and economically feasible. Both levels are important, but it is not that relevant to try to scale the PED level outcomes up to city level in this case. However, what could be up-scaled, are the new technologies, business models and social innovations that can rise successfully up from the demonstrations. This is what cities could actually spread around in the planning of their smarter futures.

3 Development of indicators for city level evaluation

Task 5.1 aims at the definition of the evaluation framework procedures that will include boundaries of the integrated evaluation and specific approaches to assess the outcomes and impacts of the project actions and interventions (from project level to city level) in each one of the indicator categories selected for the project: Energy & environment, Mobility, Governance and Society & citizens.

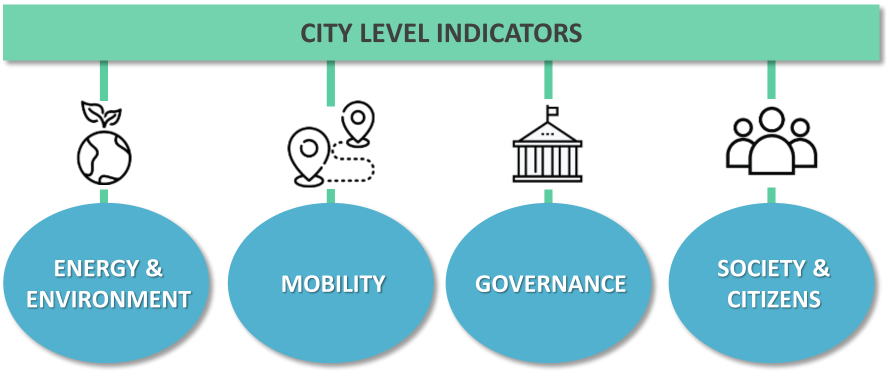

Figure 6: MAKING-CITY classification of City Level Indicators (source: D1.2)

Indicators have been selected for tracking the overall progress of sustainability targets (related to energy & environment, mobility) and other smart functions (related to governance, society & citizens, ICT) in the project cities. Indicators are an essential part of the evaluation framework, which provides guidelines for monitoring the evolution of a city towards a smarter city. In MAKING-CITY, the city level indicators will be used to show to what extent overall policy goals have been reached in mid- or long-term energy planning considering all project cities in the pursuit of emission neutral cities with intelligent energy systems.

3.1 Key performance indicators

According to the CITYkeys report on indicators and city level evaluation (Bosch et al., 2017), indicators serve decision-making in city administrations. Indicator outcomes, be it individual indicators or assessments based on multiple indicators should reach the relevant decision makers. The various parts of the indicators are aimed at decision makers on various levels.

The indicators on project level have two primary target groups:

- Decision makers and experts managing smart city projects, who can use the indicators to learn about the relative success of smart city projects (how have they been performing, what have been factors determining performance) in order to improve in the next projects, which requires integral in-depth knowledge of results and process of the project, and
- Decision makers in the city councils, who need an insight in how the various projects they have decided upon, have been performing (also to be able to take better decisions next time), for which a more aggregated overview may be preferred.

The project indicators can also be used in the design phase of a project: to give an impression on the expected performance based on design specifications, vis-à-vis already realized projects.

The smart city indicators equally have two primary target groups:

- Decision makers in city councils who need to follow the impacts of their smart city strategy over time, essentially answering the questions: “Has the city become smarter?” and “What has been the final result?”, and

- National governments and European bodies, to follow if their smart city policies have resulted in more attention for the overall aims (of reducing energy use and GHG emissions, increasing citizen participation, etc.). In addition, national governments and European institutions tend to use indicators to compare cities.

It is clear that for users of the city level indicators, progress over time is important. Thus, the city indicators should be formulated in such a way that they can easily be included in the city's programme for gathering regular statistics. The outcome of the indicator process, in turn, should get a regular place in the planning processes of the city.

Other groups that are using both project and city indicators include educational and knowledge institutes, and businesses. For citizens, the indicators may help to get a better understanding of complex projects and their impacts (Bosch et al., 2017).

3.1.1 For which purposes cities use indicators?

Indicators are by definition quantitative, qualitative or descriptive measures (ISO, 2018a) that enable information on a complex phenomenon, such as the dynamic urban environment, to be simplified into a form that is relatively easy to use and understand. The three main functions of indicators are quantification, simplification and communication. (ISO, 2010). When periodically evaluated and monitored, they show trends and changes in the measured phenomenon (Haapio, 2012). City indicators thus assist cities in setting targets and monitoring their performance over time (ISO, 2018a). (Huovila, Bosch & Airaksinen, 2019)

Consequently, cities regularly use defined sets of indicators to quantify their targets and systematically monitor the progress towards their goals (Munier, 2011). Cities typically report annually on strategically important indicators to internally keep track and externally communicate on progress (Dameri, 2017). With the exploding amount of urban data, a carefully selected and relatively small number of easily understandable Key Performance Indicators is useful for city managers to get a snapshot (dashboard view) of the city's performance in different areas. Recently, the use of indicators in decision-making has become increasingly popular, as an exponent of the trend to informed decision-making (Kourtit & Nijkamp, 2018). Cities use indicators as support when considering different decision alternatives. Another important trend in the use of indicators in city management is to increase transparency towards citizens through city dashboards (Dameri, 2017). Opposed to indicators used in annual reporting that are mostly based on statistics, city dashboards use real-time data and focus on visualizing indicators on aspects useful for citizens (Kitchin, Lauriault, & McArdle, 2015). (Huovila, Bosch & Airaksinen, 2019)

In the smart city context, cities can use indicators for the following purposes (Huovila et al., 2017a):

- Project management
  - Users: e.g. project managers, urban planners, civil engineers
  - Evaluating a project before, during and after the project
  - Assessing individual projects or a project portfolio
- City management
  - Users: e.g. Mayor's office, Smart city department, Metropolitan observatory, Environmental planners, Local politicians
  - Assessment for city's strategic level, operative level or policy decision making
  - Setting targets for the city and monitoring progress

   - Deciding on new projects, steering existing ones and assessing the performance of past ones
   - Setting quantitative targets for the smart city strategy and monitoring them

3.1.2 International indicator standards on smart city performance assessment

International indicator standards are important as they provide harmonization in indicators, reliability and transparency in calculation methods and comparability of results (Clarke, 2017). International standardization on indicators for smart and sustainable cities is carried out by three bodies, i.e. by International Organization for Standardization (ISO) and International Telecommunication Union (ITU) worldwide and by the coalition of the European standardization organizations European Committee for Standardization (CEN), European Committee for Electrotechnical Standardization (CENELEC) and European Telecommunications Standards Institute (ETSI) in Europe. In addition, globally agreed indicators are defined by different United Nations (UN) bodies. Of particular importance is the UN "Urban" Sustainable Development Goal 11 (SDG 11) 'Make cities and human settlements inclusive, safe, resilient and sustainable' for which indicators have been specified for global reporting of progress (UN-Habitat et al. 2016).

At least the following internationally agreed indicator sets are relevant for the MAKING-CITY project.

- ISO:
   - ISO 37120:2018 Sustainable cities and communities — Indicators for city services and quality of life. Second edition 2018-07. (ISO, 2018a)
   - ISO/FDIS 37122 Sustainable cities and communities - Indicators for Smart Cities. Published 2018-06-06. (ISO, 2018b)
- ITU:
   - Recommendation ITU-T Y.4901/L.1601 Key performance indicators related to the use of information and communication technology in smart sustainable cities. (ITU, 2016a)
   - Recommendation ITU-T Y.4902/L.1602 Key performance indicators related to the sustainability impacts of information and communication technology in smart sustainable cities. (2016b)
   - Recommendation ITU-T Y.4903/L.1603 Key performance indicators for smart sustainable cities to assess the achievement of sustainable development goals. (ITU, 2016c)
- CEN-CENELEC-ETSI:
   - ETSI TS 103 463 Key Performance Indicators for Sustainable Digital Multiservice Cities. (2018/6/15) (ETSI, 2017a)
   - European Telecommunications Standards Institute (2017b). ETSI GS OEU 019 KPIs for Smart Cities. (ETSI, 2017b)
- UN bodies:
   - SDG Goal 11 Monitoring Framework. (UN-Habitat et al., 2016)
   - Collection Methodology for Key Performance Indicators for Smart Sustainable Cities. (ITU, UNECE et al., 2017; ITU, 2018)

The most significant differences between the analysed standards relate to the focus towards sustainability or smartness and the role of ICT. Some standards provide a narrow focus of indicators evaluating the progress in implementing smart urban ICT solutions in detail (e.g. number of smart meters installed, different types of sensors etc.). These standards are suited for short-term evaluation of efficiency in smart city deployment, typically with a strong focus on new Technologies and ICT. Other standards are wider in scope, and allow evaluation of progress in steps and achieved (sustainability) impacts.

3.1.3 Indicator typology for effects evaluation of smart city solutions

CITYkeys project investigated the degree to which smart city projects contribute to reaching city targets (societal goals "doing the right things") with regard to smart sustainable development. This means that the primary focus is on impact indicators (see box 1).

The evaluation methods developed in CITYkeys are based either on the projected impacts for planned smart city projects, or on monitoring results for completed projects. Methodologies for calculating the impact compared to a reference situation without the project have been developed and tested in other assessment systems (Eurbanlab, 2014; ITU L1440, ITU L.1430).

Box 1: Typology of indicators, according to stage in the process[1]

Input indicators

These indicators refer to the resources needed for the implementation of an activity or intervention, measuring the quantity, quality, and timeliness of resources. Policies, human resources, materials, financial resources are examples of input indicators.

Process indicators

Process indicators refer to indicators to measure whether planned activities took place. Examples include holding of meetings, conduct of training courses, or distribution of smart meters.

Output indicators

Output indicators add more details in relation to the product ("output") of the activity, e.g. the number of smart meters distributed, the area of roof that has been isolated, or the number of electric busses in the system.

Outcome indicators

Measuring the intermediate results generated by project outputs. Outcome indicators refer more specifically to the objectives of an intervention that is its 'results', its outcome. These indicators refer to the reason why it was decided to conduct certain interventions in the first place. They are the result of both the "quantity" ("how many") and quality ("how well") of the activities implemented. Often they are 'coverage indicators' measuring the extent to which the target population has been reached by the project.

Impact indicators

Measuring the quality and quantity of long-term results generated by programme outputs (e.g. measurable change in quality of life, reduced energy use, reduced air pollutant emissions and (even a more distant impact) improved air quality).

[1] Based on UNICEF Monitoring and Evaluation Training Resources.

Impact indicators are applicable to all kinds of projects in all contexts: For instance, an indicator in the framework could be 'the reduction in greenhouse gas emissions', whether by e.g. introducing electric vehicles or by insulating dwellings. The number of electric vehicles introduced or houses insulated, is then less relevant, making the indicator framework suitable for evaluation of many types of projects in different contexts.

Impact indicators also leave room for the cities to find their own solutions to achieve a certain performance, instead of prescribing the way they should reach that or the measures that have to be implemented. The latter ones have the risk to lower the possibility for innovative solutions to achieve the same goal, and might be outdated within a few years.

The risk with proposing prescriptive input or output indicators is that many innovative technological and/or IT-based urban solutions are currently being promoted as "smart city solutions" while it can be questionable if they help to achieve environmentally, socially and/or economically sustainable impacts. In addition, limiting the measures to be implemented and the risk of being outdated when better technological solutions has been found.

By focusing the indicators on impacts instead of sectors, also cross-sectoral solutions can be easily evaluated. The indicator framework will not implicitly put a focus on isolated, sector specific solutions. The occurrence of double indicators is minimised (for instance the multiple inclusion of an indicator on e.g. final energy use by each sector).

A disadvantage of impact indicators is that impacts are only apparent after the project has been implemented and is in full use, which might take a few years. In addition, numerous contextual factors can influence the final impact reached. Nevertheless, the impact is the only measure that counts for reaching policy goals.

Having outlined the advantages of impact indicators, still input, process, output and outcome indicators have a role in a smart city indicator framework. They give an impression of the scale of the effort needed for a given impact ("doing things right").

Often simple input or output indicators are easier to define and to measure, than the more complex impact indicators. It is simple a question of counting persons, money, activities, connection, downloads, etc. (Bosch et al., 2017).

3.2 Existing knowledge and references on evaluation of smart city solutions (SCIS, CITYkeys, ESPRESSO)

European initiatives for evaluation and monitoring of smart city lighthouse projects (i.e. SCIS, CITYkeys and ESPRESSO) were used as a basis to select city level indicators (also for PED level KPIs in D5.2) for the evaluation framework and to define the evaluation procedure.

Most of the existing smart or sustainable city frameworks aim at evaluating the performance of cities, but there are not many indicator frameworks to evaluate the effects of smart city projects. Furthermore, among the existing project evaluation frameworks, many are domain specific focusing only on e.g. buildings, energy or transport (Neumann et al., 2015).

As one of the main goals of smart city solutions is to improve efficiency of urban infrastructure and services by integration of different sectors, their assessment also requires a holistic evaluation framework. Therefore, the smart city lighthouse project assessment frameworks developed specifically for this purpose by the above-mentioned initiatives of the European Commission, were selected as the starting points to select the indicators, including monitoring and data integration approaches. In addition, other relevant smart city initiatives such as MAtchUP, Stardust and mySMARTLife, were taken into consideration as well.

The existing material was adapted and further developed as needed for MAKING-CITY purposes in order to align them with the evaluation goals, expected impacts and objectives of individual city actions.

3.2.1 SCIS

The **Smart Cities Information System (SCIS)** is a knowledge platform encouraging exchange of data, experience, know-how and collaboration on smart cities to ensure a high quality of life and a clean, energy-efficient and climate-friendly living environment for the citizens (SCIS, 2019). From the point of view of lighthouse projects, the most typical use of SCIS is its database as reporting of monitoring data to that database is mandatory for all.

SCIS also describes indicators in order to measure technical and economic aspects of energy, mobility and ICT related measures in projects. These should be applicable to European-funded demonstration projects for Smart Cities and Communities (SCC), Energy Efficient buildings (EeB) and designated projects funded under the calls for Energy Efficiency (EE) (SCIS, 2018a). Through SCIS, project developers, cities, research institutions, industry, experts and citizens from across Europe come together to share best practices and lessons learnt from projects (SCIS, 2019). The implementation of SCIS indicators has been done through alignment with other initiatives and already existing indicator sets, such as EIP-OIP[2], CIVITAS[3] and CONCERTO[4]. The KPI indicator lists allow for comparability of solutions between various projects. It should also be mentioned that SCIS focuses on demonstration projects and not on entire cities. The defined indicators reflect this (SCIS, 2018a).

The KPIs can be divided in two categories. A complete list of the core KPIs is provided in Table 3 (SCIS, 2018a).

- Core KPIs: those KPIs identified as the most relevant for SCIS and which should be implemented by the projects in scope of SCIS. Some of these KPIs may not apply to all projects.
- Supporting KPIs: relevant for SCIS and their use is recommended.

Table 3: Core KPIs as defined in SCIS

Core KPIs	
General technical performance indicators	• Energy demand and consumption • Energy savings • Degree of energetic self-supply by RES
General environmental performance indicators	• Greenhouse Gas Emissions • Primary Energy Demand and Consumption • Carbon dioxide Emission Reduction
General economic performance indicators	• Total Investments

[2] https://www.smartcities.at/assets/Uploads/operational-implementation-plan-oip-v2-en.pdf

[3] https://civitas.eu

[4] https://www.concertoplus.eu/

Core KPIs	
	• Grants • Total Annual costs • Payback period • Return on Investment (ROI)
General performance indicators for ICT related technologies	• Increased reliability • Increased Power Quality and Quality of Support (DSO + TSO) • Increased system flexibility for energy players • Reduction of energy price by ICT related technologies • Peak load reduction • Increased hosting capacity for RES, electric vehicles and other new loads • Consumers engagement
General performance indicators for mobility related technologies	• Energy consumption data aggregated by sector fuel • Kilometres of high capacity public transport system per 100 000 population • Passenger-kilometres public transport and private vehicle • Number of efficient and clean (biofuel and hydrogen) vehicles deployed in the area • Number of e-charging stations deployed in the area • Impact of ICT apps into mobility • Carpooling locations • Clean mobility utilization • Modal split

In SCIS, the current approach for data collection is through individual project data collection done by monitoring experts, and this information is periodically updated in the self-reporting tool (SCIS, 2018b). The aim of the data collection is to allow the comparison of results of the projects (SCIS, 2018a). In data collection, a distinction between new systems and renovations of existing systems is made. The evaluation process uses a bottom-up approach, collecting data from small Energy Supply Units (ESU), buildings and implemented mobility and ICT solutions at unit level. These are aggregated in cases where the objective is to evaluate the energy performance of a whole neighbourhood or city. Data quality in SCIS is ensured with:

- Compliance with SCIS data requirements
- Documentation on metadata (such as time of measurement, unit, application area...)
- Adjustments to apparently implausible data is discussed and checked with SCIS

3.2.2 CITYkeys

The CITYkeys assessment method and the indicators (both city and project level) are to be used to evaluate the success of demo projects and the possibility to replicate the (successful) projects in other contexts. As follows from the smart city definition, success is determined by the transition across the entire ecological footprint of urban areas, simultaneously promoting economic prosperity, social aims and resilience to climate change and other external disturbances.

The concept of sustainability – split up in the triple bottom line of social sustainability (People), environmental sustainability (Planet) and economic sustainability (Prosperity) – has gradually become generally accepted in the development of indicator systems for national and regional urban development (SCOPE, 2007). The 3 P's (People, Planet, Prosperity) have also gained considerable ground in company reporting (Kolk, 2004).

The extent to which smart city projects are able to have an effect on social, environmental and economic indicators forms the core of the evaluation. However, this is not enough to determine the success of a smart city project. Success is also determined by how projects have been - or will be - realised in various contexts.

The Governance of developing and implementing urban smart city projects is a determining factor for high scores in People, Planet and Prosperity indicators (Fortune and White, 2006). Hiremath et al. (2013) also notes that Governance has been established as one of the four pillars of sustainable development. Therefore, it is needed to include a number of indicators to evaluate the importance of the city context (external factors) and quality of the development and implementation process (internal factors).

The ability of individual smart city projects to be replicated in other cities and contexts determines its ultimate effect in achieving European goals with regard to energy and CO_2 emissions. Under the Propagation category, smart city projects are evaluated to determine their potential for up-scaling and the possibilities for application in other contexts.

A subdivision of the evaluation framework in impact categories allows for more flexibility than a subdivision in driving forces, actors or sectors. In addition, as smart city projects in various sectors all contribute to the same impacts there will be fewer double indicators (such as 'energy savings' or 'emission of carbon dioxide'). Indicators that are relevant for a specific sector can easily be included or excluded depending on the type of project to be evaluated without disturbing the logic of the assessment.

Each of the major themes (people, planet, prosperity, governance and propagation) encompasses several specific policy goals. In many cases, all of them are not mentioned in a smart city strategy, but may be scattered over various policy documents in a city. For the design of the CITYkeys indicator framework, these policy goals have been arranged under the major theme headings. For instance, under the theme People, subthemes conforming to policy ambitions have been created (see Figure 7): increasing diversity and improving social cohesion, increasing safety, guaranteeing good education for every citizen, etc.

The reasons for doing so are:

- To underline the relation between policy ambitions and the key indicators that are to be used to measure progress towards these ambitions
- To provide the basis for comparing the indicators with each other, whereby users or user groups may attach weightings to policy goals (and thereby to the indicators belonging to a subtheme)
- To ease communication on the outcome of the indicators in terms that are familiar with the decision makers.

People	Planet	Prosperity	Governance	Propagation
•Health	•Energy & mitigation	•Employment	•Organisation	•Scalability
•Safety	•Materials, water and land	•Equity	•Community involvement	•Replicability
•Access to (other) services	•Climate resilience	•Green economy	•Multi-level governance	
•Education	•Pollution & waste	•Economic performance		
•Diversity & social cohesion	•Ecosystem	•Innovation		
•Quality of housing and the built environment		•Attractiveness & competitiveness		

Figure 7: The CITYkeys indicator framework.

3.2.3 ESPRESSO

The third relevant horizontal EU indicative that developed solutions for common issues of all smart city lighthouse projects was **ESPRESSO - systEmic Standardisation apPRoach to Empower Smart citieS and cOmmunities**[5] (2016-2017).

ESPRESSO project focused on the development of a conceptual Smart Cities Information Framework, which consists of a Smart City platform and a number of data provision and processing services to integrate data, workflows, and processes in applications relevant for Smart Cities within a common framework. To build this framework, the project identified relevant open standards, technologies, and information models in use or in development in the various sectors. It analysed potential issues caused by gaps and overlaps across standards developed by the various standardization organizations and provided guidelines on how to effectively solve those issues.

The most relevant results of ESPRESSO for MAKING-CITY purposes will be used when defining data requirements and the monitoring programme in T5.2 and T5.3, with links to development of urban ICT platforms in the lighthouse cities (T2.7).

From the various monitoring programmes and indicator frameworks mentioned above, we can select useful indicators and methods for the MAKING-CITY project, knowing that the developed methodology serves policy goals. In addition, it is needed to make further efforts to connect project level (PED zone) indicators to the same framework. The introduced Logic-model can be helpful in determining which indicators are relevant and useful for both city and project level evaluation.

[5] ESPRESSO website: http://www.espresso-project.eu/

4 Selected indicators for evaluating the performance at city level

4.1 Process of indicator selection and definition

The process for the indicator selection and definition for city level has been an iterative working process between the contributors of Task 5.1. The process started by analysing the main reference indicator systems developed by CITYkeys, SCIS and ESPRESSO. In addition, selected on-going smart city projects were investigated for comparison, including MAtchUP, Stardust and mySMARTLife. From the long list of possible indicators at starting point, a robust set of 20 indicators in four different categories were selected to represent the targets of the project. The detailed definitions and calculation methods were finally processed between the key contributors. An important workshop on the city level indicators and the evaluation process was held within the second periodic meeting in Groningen on the 15th of May 2019. The indicator list was further modified according to the contributions received at the workshop.

The indicator definitions and the logic behind the evaluation process have also been discussed iteratively in the consortium meetings, telcos and face-to-face meetings with city representatives, universities and other technical partners. A draft of a framework template following the work conducted in WP5 with the preliminary indicators was first created to set the main objectives of evaluation. In addition, the necessity to establish periodical communication between sectoral experts was identified. Therefore, specialized task groups were established for grouping the experts of different domains from key partner organisations. Regular mailing lists were set-up and telcos organised to discuss topical issues on these domains, mainly related to the indicators and evaluation in general, but also other domain-specific issues. Most of the telcos and e-mail discussions were open for horizontal communication between the experts in the lighthouse and follower cities as well as technical partners, even if they are not partners working in WP5.

The definition of the city level evaluation framework (including the contribution of lighthouse city partners to identifying indicators) can be summarized into the following steps:

1. Structuring the evaluation framework

VTT prepared the draft list of city level (both technical and non-technical) indicators. At this time *Energy & Environment, Mobility, Governance* and *Society & Citizens* categories were established in order to discuss more in detail about the indicator selection, applicability and data availability.

2. Defining the evaluation procedure and indicators

This step included the matching of indicator framework with city level actions in relation with project level interventions, and the definition of practical steps to collect the data, calculate the indicator values and report of the development. Methodological guidelines on evaluation procedures (baseline definition, impact assessment methods etc.) were further discussed in collaboration between technical partners. This discussion will be continued at later stages of WP5 efforts.

3. Validation of indicators with partners involved in demonstrations

The refined indicator proposal included a list of indicators in association with city level actions / interventions as well as methodological definitions. It was placed under general review for all interested partners in terms of feasibility, relevance, evaluation boundaries, data sources and methodological approaches for baseline calculations and definitions. Final validation and fine-tuning of definitions & calculation methods were processed within the first “test calculations” performed by the city of Oulu. This experience helped other cities in the unclear phases of calculations.

4.2 Criteria for selecting indicators

In general, city level indicators (and even more so KPIs) should express as precisely as possible to what extent an aim, a goal or a standard has been reached or even surpassed. Data that is not linked to standards or specific goals of projects can be used as quantitative background information (e.g. the size of the project in million Euro), but are not suited for evaluation purposes. Often, however, various indicators are available to assess the progression towards a certain goal. A set of criteria has been used, based on the CIVITAS framework (van Rooyen and Nesterova, 2013):

1. RELEVANCE; Each indicator should have a significant importance for the evaluation process. That means that the indicators should have a strong link to the subthemes of the framework.

Furthermore, 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. Indicators that provide an ambiguous signal (when there is doubt on the interpretation of e.g. an increase in the indicator value) are not suited.

2. COMPLETENESS; Selected set of indicators should consider all aspects of the implementation of smart city projects. Indicators can be selected according to the People, Planet, Prosperity and Governance themes (and for project indicators from the Propagation theme as well), which framework is comprehensive in describing public policy goals.
3. 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 the project leader or others involved in the innovation case that is being evaluated,
   - or can easily be compiled from public sources,
   - or can easily be gathered from interviews, maps, or terrain observations.

Indicators that require, for instance, interviews of users or dwellers are not suited as the large amounts of data needed are too expensive to gather. The same holds for indicators that require extensive recalculations and additional data, such as footprint indicators, and some financial indicators.

4. MEASURABILITY; Identified indicators should be capable of being measured, preferably as objectively as possible. However, for some indicator categories, quantitative measurability is limited. Social sciences provide approaches to deal with qualitative information in a semi-quantitative way (Abeyasekera, 2005).

5. RELIABILITY; 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.

6. FAMILIARITY; Indicators should be easy to understand by the users and non-experts as well. For a large number of indicators, we have relied on indicators from existing indicator sets, which generally comply with this requirement. For new indicators, a definition should be developed so that it has a meaning in the context of existing policy goals.

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

8. INDEPENDENCE; Small changes in the measurements of an indicator should not impact preferences assigned to other indicators in the evaluation. As an example, the current energy

system is still largely based on fossil fuels, and there is a direct relation between a reduction in the use of energy and the reduction of the emission of carbon dioxide. This will lead to a certain extent to double counting the impact.

Ideally, the indicators are defined so that they are able to show a direct relationship of the energy-related interventions with other relevant interventions in the MAKING-CITY, energy sustainability being the main target of the project.

4.3 Indicator categories, application fields and the indicators

The four sectors or indicator categories selected for the project are **energy & environment**, **mobility**, **governance** and **society & citizens**. They are further divided into more detailed application fields (see Figure 8). The tables in the following subsections list and briefly describe the individual indicators selected to be the metrics in the city level evaluation. More detailed descriptions and calculation methodology with data needs are presented in tables included in Annex 1. These indicators have been calculated by all project cities (baseline calculation), and further utilized for city characterization and diagnosis in D1.2.

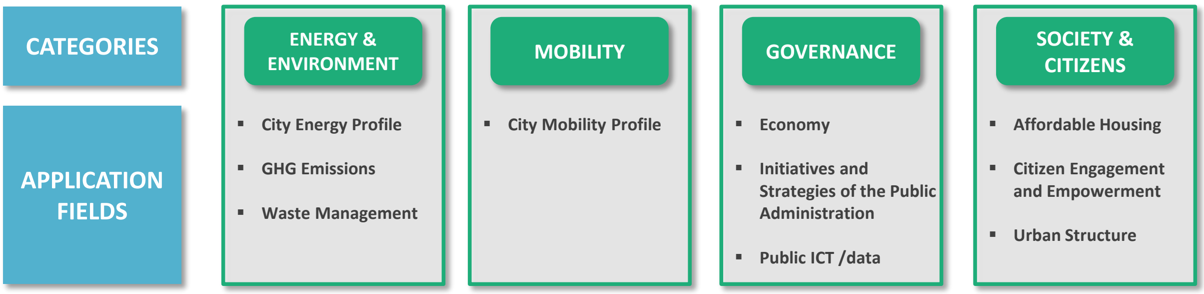

Figure 8: Application fields within the categories of the City Level Indicators (source: D1.2)

4.3.1 Energy & Environment

Table 4: City Energy Profile indicators

City Energy Profile		
Indicator	Unit	Description
Final energy consumption per capita	MWh/cap	Annual final energy consumption for all uses and forms of energy. End users include residential, tertiary sector, public lighting, industry and transport. The final energy consumption is divided by the number of inhabitants in the city (total city population). This applies to the other per-capita indicators.
Primary energy consumption per capita	MWh/cap	This indicator corresponds with the primary energy consumed in the city that is the energy forms found in nature (e.g. coal, oil and gas) which have to be converted (with subsequent losses) to useable forms of energy.

Primary energy sources (shares)	% and MWh/cap	Shares of different fuel types used for energy generation inside city boundaries [Solid fossil fuels, Natural gas, Oil and petroleum, Renewables and biofuels, Electricity from the grid].
Building connected to the DH-network or renewable energy grid	% of buildings/city	Percentage of buildings connected to high-efficiency district heating network or local renewable energy grid in the city.

Table 5: GHG Emissions indicators

GHG Emissions		
Indicator	Unit	Description
GHG emissions per capita	Tonnes of CO_2/cap	The CO_2 emissions generated over a calendar year by all activities including indirect emissions outside city boundaries.

Table 6: Waste Management indicators

Waste Management		
Indicator	Unit	Description
Recycling rate	% of tonnes	Percentage of city's solid waste that is recycled.

4.3.2 Mobility

Table 7: City Mobility Profile indicators

City Mobility Profile		
Indicator	Unit	Description
Modal split	%	Shares of different modes of transportation. The indicator searches the total number but also to distinguish in inner-city traffic and commuter-traffic (from outside) [Walk, bike, public transport, car; private motor vehicle].
Fuel mix in mobility	%	Percentage of the market share of transport fuel for each type of fuel used [Gas oil and diesel oil, Gasoline, Blended biodiesels, Liquefied Petroleum Gases, Electricity, Other fuels].
Energy use for transportation per capita	MWh/cap	Final energy consumption of the transport sector.
Access to public transport	% of people	Share of population with access to a public transport stop within 500 meters.

Public infrastructure promoting low-carbon mobility	km/100,000 people	Length of lanes in the city for low-carbon mobility per 100,000 inhabitants: cycling lanes (including the length of combined cycling and walking lanes, and streets with speed limit <=30 km/h).

4.3.3 Governance

Table 8: Economy indicators

Economy		
Indicator	Unit	Description
Unemployment rate	% of active population	Percentage of the labour force unemployed.
GDP (Gross Domestic Product)	€/cap	City's Gross Domestic Product per capita.

Table 9: Initiatives and Strategies of the Public Administration indicators

Initiatives and Strategies of the Public Administration		
Indicator	Unit	Description
Smart city factor in a city development strategy	Likert scale	Inclusion and level of detail of smart cities strategies in the urban strategic plans of the city. Likert scale: Not at all – 1 – 2 – 3 – 4 – 5 – Very detailed

Table 10: Public ICT / Data indicators

Public ICT / Data		
Indicator	Unit	Description
Quality of open data	Likert scale	The extent to which the quality of the open data produced by the city was increased. Likert scale: Not at all – 1 – 2 – 3 – 4 – 5 – Excellent

4.3.4 Society & Citizens

Table 11: Affordable Housing indicators

Affordable Housing		
Indicator	Unit	Description
Development of housing prices	% of change or % of €/m^2	Development of average price for buying an apartment per m^2 in the city.
Housing cost overburden rate	%	The percentage of the population living in households

		where the total housing costs ('net' of housing allowances) represent more than 40 % of disposable income ('net' of housing allowances).

Table 12: Citizen Engagement and Empowerment indicators

Citizen Engagement and Empowerment		
Indicator	Unit	Description
Citizen engagement/empowerment to climate conscious actions	Likert scale	Appreciation of the benefits of city actions; Energy empowerment at home, satisfaction, happiness of people. Likert scale: No engagement – 1 – 2 – 3 – 4 – 5 – High engagement
Encouraging a healthy lifestyle	Likert scale	The extent to which policy efforts have been undertaken to encourage a healthy lifestyle. Likert scale: Not at all – 1 – 2 – 3 – 4 – 5 – Excellent

Table 13: Urban Structure indicators

Urban Structure		
Indicator	Unit	Description
Inhabitants in dense areas	% of people	Percentage of the population living in dense areas of the city (over 20 inhabitants/ hectare).

5 City level indicators

The following sections from 5.1 to 5.8, present collectively the baseline calculation results of the city level indicators, representing all cities involved in the project. Detailed descriptions of the cities, with their basic characteristics, medium- and long-term strategic plans, data collection measures, calculation deviations and other further city diagnoses have been presented in D1.2. In this deliverable, the baseline situation (status at the beginning of the project) has been determined by calculating the initial values for the selected indicators. Monitoring of the progress (annual calculations) and the final calculation of indicators will follow at later stages of the project.

The overall objective with the selection was that all of the needed data for calculating the city level indicators could be collected as easily as possible from public data sources. However, there can be some limitations to data availability depending on the country, e.g. fuels for individual heating may need to be estimated from respective national consumptions, allocated to the city by using the building volumes ratio of e.g. oil heated buildings. This principle can be applied to other indicators also, if the national figure is known, but city level figure is not. In other words, if volumes and specific consumptions (kWh/unit) are known, multiplying volume with specific consumption can provide required accuracy.

5.1 Calculation of the baseline situation: Oulu

Table 14: Oulu main characteristics

OULU		
Population	Inhabitants	203,750
Area	km²	3,818.00
Density	Inhabitants/km²	53.37

5.1.1 Energy & Environment characterization

Table 15: Oulu Energy & Environment Indicators calculation

ENERGY & ENVIRONMENT				
Application field	Indicator		VALUE	UNIT
City Energy Profile	Final energy consumption per capita		23.00	MWh/cap
	Primary energy consumption per capita		26.00	MWh/cap
	Primary energy sources	Solid fossil fuels	27.00%	%
		Natural gas	0.00%	
		Oil and petroleum	30.00%	
		Renewables and biofuels	35.00%	
		Electricity from the grid	9.00%	
		Solid fossil fuels	6.67	MWh/cap
		Natural gas	0.00	
		Oil and petroleum	7.19	
		Renewables and biofuels	8.56	
		Electricity from the grid	2.11	
	Building connected to the DH-network or renewable energy grid		61%	% of buildings/city
GHG Emissions	GHG emissions per capita		5.50	Tonnes of CO_2 /cap
Waste Management	Recycling rate		99%	% of tonnes

5.1.2 Mobility characterization

Table 16: Oulu Mobility Indicators calculation

MOBILITY				
Application field	Indicator		VALUE	UNIT
City Mobility Profile	Modal split	Walk	22%	%
		Bike	21%	

		Public transport	4%	
		Car (private motor vehicle)	54%	
	Fuel mix in mobility	Gas oil and diesel oil	52.00%	%
		Gasoline	32.00%	
		Liquefied Petroleum Gases	0.00%	
		Electricity	2.00%	
		Other fuels	14.00%	
	Energy use for transportation		7.00	MWh/cap
	Access to public transport		70%	% of people
	Public infrastructure promoting low-carbon mobility		1,000.00	Km/100,000 people

5.1.3 Governance characterization

Table 17: Oulu Governance Indicators calculation

GOVERNANCE			
Application field	Indicator	VALUE	UNIT
Economy	Unemployment rate	9.60%	% of active population
	GDP (Gross Domestic Product)	31,300	€/cap
Initiatives and Strategies of the Public Administration	Smart city factor in a city development strategy	4	Likert scale
Public ICT/ Data	Quality of open data	4	Likert scale

5.1.4 Society & citizens characterization

Table 18: Oulu Society & Citizens Indicators calculation

SOCIETY & CITIZENS			
Application field	Indicator	VALUE	UNIT
Affordable Housing	Development of housing prices	1.90%	% of change or % of €/m^2
	Housing cost overburden rate	6.60%	%
Citizen Engagement and Empowerment	Citizen engagement to climate conscious actions	4	Likert scale
	Encouraging a healthy lifestyle	4	Likert scale
Urban Structure	Inhabitants in dense areas	56.80%	% of people

5.2 Calculation of the baseline situation: Groningen

Table 19: Groningen main characteristics

GRONINGEN		
Population	Inhabitants	231,354
Area	km²	180.00
Density	Inhabitants/km²	1,285.30

5.2.1 Energy & Environment characterization

Table 20: Groningen Energy & Environment Indicators calculation

ENERGY & ENVIRONMENT				
Application field	Indicator		VALUE	UNIT
City Energy Profile	Final energy consumption per capita		24.60	MWh/cap
	Primary energy consumption per capita		30.60	MWh/cap
	Primary energy sources	Solid fossil fuels	0.00%	%
		Natural gas	51.80%	
		Oil and petroleum	24.00%	
		Renewables and biofuels	4.30%	
		Electricity from the grid	19.90%	
		Solid fossil fuels	0.00	MWh/cap
		Natural gas	15.85	
		Oil and petroleum	7.34	
		Renewables and biofuels	1.32	
		Electricity from the grid	6.09	
	Building connected to the DH-network or renewable energy grid		1%	% of buildings/city
GHG Emissions	GHG emissions per capita		5.40	Tonnes of CO_2 /cap
Waste Management	Recycling rate		78%	% of tonnes

5.2.2 Mobility characterization

Table 21: Groningen Mobility Indicators calculation

MOBILITY				
Application field	Indicator		VALUE	UNIT
City Mobility Profile	Modal split	Walk	15%	%
		Bike	55%	

		Public transport	3%	
		Car (private motor vehicle)	27%	
	Fuel mix in mobility	Gas oil and diesel oil	43.20%	%
		Gasoline	54.50%	
		Liquefied Petroleum Gases	2.10%	
		Electricity	0.20%	
		Other fuels	0.00%	
	Energy use for transportation		6.20	MWh/cap
	Access to public transport		98%	% of people
	Public infrastructure promoting low-carbon mobility		275.00	Km/100,000 people

5.2.3 Governance characterization

Table 22: Groningen Governance Indicators calculation

GOVERNANCE			
Application field	Indicator	VALUE	UNIT
Economy	Unemployment rate	7.20%	% of active population
	GDP (Gross Domestic Product)	44,800	€/cap
Initiatives and Strategies of the Public Administration	Smart city factor in a city development strategy	4	Likert scale
Public ICT/ Data	Quality of open data	3	Likert scale

5.2.4 Society & Citizens characterization

Table 23: Groningen Society & Citizens Indicators calculation

SOCIETY & CITIZENS			
Application field	Indicator	VALUE	UNIT
Affordable Housing	Development of housing prices	-4.00%	% of change or % of €/m^2
	Housing cost overburden rate	9.40%	%
Citizen Engagement and Empowerment	Citizen engagement to climate conscious actions	4	Likert scale
	Encouraging a healthy lifestyle	4	Likert scale
Urban Structure	Inhabitants in dense areas	95.30%	% of people

5.3 Calculation of the baseline situation: Bassano del Grappa

Table 24: Bassano del Grappa main characteristics

BASSANO DEL GRAPPA		
Population	Inhabitants	43,412
Area	km^2	47.06
Density	Inhabitants/km^2	922.48

5.3.1 Energy & Environment characterization

Table 25: Bassano del Grappa Energy & Environment Indicators calculation

ENERGY & ENVIRONMENT				
Application field	Indicator		VALUE	UNIT
City Energy Profile	Final energy consumption per capita		18.54	MWh/cap
	Primary energy consumption per capita		29.62	MWh/cap
	Primary energy sources	Solid fossil fuels	8.00%	%
		Natural gas	38.50%	
		Oil and petroleum	22.10%	
		Renewables and biofuels	12.00%	
		Electricity from the grid	19.40%	
		Solid fossil fuels	1.52	MWh/cap
		Natural gas	7.35	
		Oil and petroleum	4.22	
		Renewables and biofuels	2.29	
		Electricity from the grid	3.70	
	Building connected to the DH-network or renewable energy grid		17%	% of buildings/city
GHG Emissions	GHG emissions per capita		4.90	Tonnes of CO_2 /cap
Waste Management	Recycling rate		76%	% of tonnes

5.3.2 Mobility characterization

Table 26: Bassano del Grappa Mobility Indicators calculation

MOBILITY				
Application field	Indicator		VALUE	UNIT
City Mobility Profile	Modal split	Walk	12%	%

		Bike	10%	
		Public transport	6%	
		Car (private motor vehicle)	72%	
	Fuel mix in mobility	Gas oil and diesel oil	71.00%	%
		Gasoline	20.00%	
		Liquefied Petroleum Gases	8.00%	
		Electricity	0.00%	
		Other fuels	1.00%	
	Energy use for transportation		7.32	MWh/cap
	Access to public transport		97%	% of people
	Public infrastructure promoting low-carbon mobility		112.00	Km/100,000 people

5.3.3 Governance characterization

Table 27: Bassano del Grappa Governance Indicators calculation

GOVERNANCE			
Application field	Indicator	VALUE	UNIT
Economy	Unemployment rate	6.30%	% of active population
	GDP (Gross Domestic Product)	30,800	€/cap
Initiatives and Strategies of the Public Administration	Smart city factor in a city development strategy	2	Likert scale
Public ICT/ Data	Quality of open data	2	Likert scale

5.3.4 Society & Citizens characterization

Table 28: Bassano del Grappa Society & Citizens Indicators calculation

SOCIETY & CITIZENS			
Application field	Indicator	VALUE	UNIT
Affordable Housing	Development of housing prices	-9.00%	% of change or % of €/m^2
	Housing cost overburden rate	8.20%	%
Citizen Engagement and Empowerment	Citizen engagement to climate conscious actions	4	Likert scale
	Encouraging a healthy lifestyle	4	Likert scale
Urban Structure	Inhabitants in dense areas	94.00%	% of people

5.4 Calculation of the baseline situation: León

Table 29: León main characteristics

LEÓN		
Population	Inhabitants	124,722
Area	km²	39.03
Density	Inhabitants/km²	3,195.54

5.4.1 Energy & Environment characterization

Table 30: León Energy & Environment Indicators calculation

ENERGY & ENVIRONMENT				
Application field	Indicator		VALUE	UNIT
City Energy Profile	Final energy consumption per capita		25.66	MWh/cap
	Primary energy consumption per capita		36.62	MWh/cap
	Primary energy sources	Solid fossil fuels	0.00%	%
		Natural gas	28.18%	
		Oil and petroleum	51.29%	
		Renewables and biofuels	0.19%	
		Electricity from the grid	20.34%	
		Solid fossil fuels	0.00	MWh/cap
		Natural gas	7.23	
		Oil and petroleum	13.16	
		Renewables and biofuels	0.05	
		Electricity from the grid	5.22	
	Building connected to the DH-network or renewable energy grid		0%	% of buildings/city
GHG Emissions	GHG emissions per capita		6.62	Tonnes of CO_2 /cap
Waste Management	Recycling rate		21%	% of tonnes

5.4.2 Mobility characterization

Table 31: León Mobility Indicators calculation

MOBILITY				
Application field	Indicator		VALUE	UNIT
City Mobility Profile	Modal split	Walk	64%	%
		Bike	1%	

		Public transport	6%	
		Car (private motor vehicle)	29%	
	Fuel mix in mobility	Gas oil and diesel oil	85.45%	%
		Gasoline	14.43%	
		Liquefied Petroleum Gases	0.10%	
		Electricity	0.02%	
		Other fuels	0.00%	
	Energy use for transportation		7.69%	MWh/cap
	Access to public transport		100%	% of people
	Public infrastructure promoting low-carbon mobility		24.86	Km/100,000 people

5.4.3 Governance characterization

Table 32: León Governance Indicators calculation

GOVERNANCE			
Application field	Indicator	VALUE	UNIT
Economy	Unemployment rate	14.10%	% of active population
	GDP (Gross Domestic Product)	21,700	€/cap
Initiatives and Strategies of the Public Administration	Smart city factor in a city development strategy	4	Likert scale
Public ICT/ Data	Quality of open data	1	Likert scale

5.4.4 Society & Citizens characterization

Table 33: León Society & Citizens Indicators calculation

SOCIETY & CITIZENS			
Application field	Indicator	VALUE	UNIT
Affordable Housing	Development of housing prices	5.32%	% of change or % of €/m^2
	Housing cost overburden rate	8.90%	%
Citizen Engagement and Empowerment	Citizen engagement to climate conscious actions	3	Likert scale
	Encouraging a healthy lifestyle	3	Likert scale
Urban Structure	Inhabitants in dense areas	87.52%	% of people

5.5 Calculation of the baseline situation: Kadıköy

Table 34: Kadıköy main characteristics

KADIKÖY		
Population	Inhabitants	458,638
Area	km²	25.20
Density	Inhabitants/km²	18,199.92

5.5.1 Energy & Environment characterization

Table 35: Kadıköy Energy & Environment Indicators calculation

ENERGY & ENVIRONMENT				
Application field	Indicator		VALUE	UNIT
City Energy Profile	Final energy consumption per capita		14.05	MWh/cap
	Primary energy consumption per capita		19.05	MWh/cap
	Primary energy sources	Solid fossil fuels	0.00%	%
		Natural gas	20.00%	
		Oil and petroleum	0.00%	
		Renewables and biofuels	1.00%	
		Electricity from the grid	79.00%	
		Solid fossil fuels	0.00	MWh/cap
		Natural gas	0.67	
		Oil and petroleum	0.00	
		Renewables and biofuels	0.06	
		Electricity from the grid	2.68	
	Building connected to the DH-network or renewable energy grid		0%	% of buildings/city
GHG Emissions	GHG emissions per capita		3.34	Tonnes of CO_2 /cap
Waste Management	Recycling rate		6%	% of tonnes

5.5.2 Mobility characterization

Table 36: Kadıköy Mobility Indicators calculation

MOBILITY				
Application field	Indicator		VALUE	UNIT
City Mobility Profile	Modal split	Walk	49%	%
		Bike	1%	

		Public transport	24%	
		Car (private motor vehicle)	26%	
	Fuel mix in mobility	Gas oil and diesel oil	64.00%	%
		Gasoline	10.00%	
		Liquefied Petroleum Gases	25.00%	
		Electricity	1.00%	
		Other fuels	0.00%	
	Energy use for transportation		3.57	MWh/cap
	Access to public transport		100%	% of people
	Public infrastructure promoting low-carbon mobility		3.31	Km/100,000 people

5.5.3 Governance characterization

Table 37: Kadıköy Governance Indicators calculation

GOVERNANCE			
Application field	Indicator	VALUE	UNIT
Economy	Unemployment rate	13.80%	% of active population
	GDP (Gross Domestic Product)	11,500	€/cap
Initiatives and Strategies of the Public Administration	Smart city factor in a city development strategy	2	Likert scale
Public ICT/ Data	Quality of open data	2	Likert scale

5.5.4 Society & Citizens characterization

Table 38: Kadıköy Society & Citizens Indicators calculation

SOCIETY & CITIZENS			
Application field	Indicator	VALUE	UNIT
Affordable Housing	Development of housing prices	-3.41%	% of change or % of €/m^2
	Housing cost overburden rate	9.50%	%
Citizen Engagement and Empowerment	Citizen engagement to climate conscious actions	4	Likert scale
	Encouraging a healthy lifestyle	4	Likert scale
Urban Structure	Inhabitants in dense areas	100.00%	% of people

5.6 Calculation of the baseline situation: Trenčín

Table 39: Trenčín main characteristics

TRENČÍN		
Population	Inhabitants	54,916
Area	km^2	81.99
Density	Inhabitants/km^2	669.79

5.6.1 Energy & Environment characterization

Table 40: Trenčín Energy & Environment Indicators calculation

ENERGY & ENVIRONMENT				
Application field	Indicator		VALUE	UNIT
City Energy Profile	Final energy consumption per capita		19.25	MWh/cap
	Primary energy consumption per capita		32.69	MWh/cap
	Primary energy sources	Solid fossil fuels	20.00%	%
		Natural gas	24.00%	
		Oil and petroleum	22.00%	
		Renewables and biofuels	11.00%	
		Electricity from the grid	23.00%	
		Solid fossil fuels	3.85	MWh/cap
		Natural gas	4.62	
		Oil and petroleum	4.24	
		Renewables and biofuels	2.12	
		Electricity from the grid	4.43	
	Building connected to the DH-network or renewable energy grid		No data	% of buildings/city
GHG Emissions	GHG emissions per capita		5.66	Tonnes of CO_2 /cap
Waste Management	Recycling rate		40%	% of tonnes

5.6.2 Mobility characterization

Table 41: Trenčín Mobility Indicators calculation

MOBILITY				
Application field	Indicator		VALUE	UNIT
City Mobility Profile	Modal split	Walk	34%	%
		Bike	7%	

		Public transport	17%	
		Car (private motor vehicle)	42%	
	Fuel mix in mobility	Gas oil and diesel oil	68.80%	%
		Gasoline	28.60%	
		Liquefied Petroleum Gases	0.30%	
		Electricity	2.30%	
		Other fuels	0.00%	
	Energy use for transportation		5.78	MWh/cap
	Access to public transport		95%	% of people
	Public infrastructure promoting low-carbon mobility		55.61	Km/100,000 people

5.6.3 Governance characterization

Table 42: Trenčín Governance Indicators calculation

GOVERNANCE			
Application field	Indicator	VALUE	UNIT
Economy	Unemployment rate	5.50%	% of active population
	GDP (Gross Domestic Product)	13,400	€/cap
Initiatives and Strategies of the Public Administration	Smart city factor in a city development strategy	3	Likert scale
Public ICT/ Data	Quality of open data	3	Likert scale

5.6.4 Society & Citizens characterization

Table 43: Trenčín Society & Citizens Indicators calculation

SOCIETY & CITIZENS			
Application field	Indicator	VALUE	UNIT
Affordable Housing	Development of housing prices	7.86%	% of change or % of €/m^2
	Housing cost overburden rate	8.40%	%
Citizen Engagement and Empowerment	Citizen engagement to climate conscious actions	3	Likert scale
	Encouraging a healthy lifestyle	2	Likert scale
Urban Structure	Inhabitants in dense areas	20.00%	% of people

5.7 Calculation of the baseline situation: Vidin

Table 44: Vidin main characteristics

VIDIN		
Population	Inhabitants	41,583
Area	km²	63.22
Density	Inhabitants/km²	657.77

5.7.1 Energy & Environment characterization

Table 45: Vidin Energy & Environment Indicators calculation

ENERGY & ENVIRONMENT				
Application field	Indicator		VALUE	UNIT
City Energy Profile	Final energy consumption per capita		7.50	MWh/cap
	Primary energy consumption per capita		13.20	MWh/cap
	Primary energy sources	Solid fossil fuels	14.00%	%
		Natural gas	1.00%	
		Oil and petroleum	16.00%	
		Renewables and biofuels	14.00%	
		Electricity from the grid	55.00%	
		Solid fossil fuels	1.51	MWh/cap
		Natural gas	0.10	
		Oil and petroleum	1.76	
		Renewables and biofuels	1.55	
		Electricity from the grid	6.08	
	Building connected to the DH-network or renewable energy grid		0%	% of buildings/city
GHG Emissions	GHG emissions per capita		3.07	Tonnes of CO_2 /cap
Waste Management	Recycling rate		40%	% of tonnes

5.7.2 Mobility characterization

Table 46: Vidin Mobility Indicators calculation

MOBILITY				
Application field	Indicator		VALUE	UNIT
City Mobility Profile	Modal split	Walk	40%	%
		Bike	10%	

		Public transport	20%	
		Car (private motor vehicle)	30%	
	Fuel mix in mobility	Gas oil and diesel oil	66.00%	%
		Gasoline	27.00%	
		Liquefied Petroleum Gases	6.00%	
		Electricity	0.00%	
		Other fuels	1.00%	
	Energy use for transportation		1.37	MWh/cap
	Access to public transport		100%	% of people
	Public infrastructure promoting low-carbon mobility		112.00	Km/100,000 people

5.7.3 Governance characterization

Table 47: Vidin Governance Indicators calculation

GOVERNANCE			
Application field	Indicator	VALUE	UNIT
Economy	Unemployment rate	11.30%	% of active population
	GDP (Gross Domestic Product)	3,900	€/cap
Initiatives and Strategies of the Public Administration	Smart city factor in a city development strategy	2	Likert scale
Public ICT/ Data	Quality of open data	2	Likert scale

5.7.4 Society & Citizens characterization

Table 48: Vidin Society & Citizens Indicators calculation

SOCIETY & CITIZENS			
Application field	Indicator	VALUE	UNIT
Affordable Housing	Development of housing prices	5.50%	% of change or % of €/m^2
	Housing cost overburden rate	19.70%	%
Citizen Engagement and Empowerment	Citizen engagement to climate conscious actions	4	Likert scale
	Encouraging a healthy lifestyle	3	Likert scale
Urban Structure	Inhabitants in dense areas	90.00%	% of people

5.8 Calculation of the baseline situation: Lublin

Table 49: Lublin main characteristics

LUBLIN		
Population	Inhabitants	339,850
Area	km²	147.,47
Density	Inhabitants/km²	2,304.54

5.8.1 Energy & Environment characterization

Table 50: Lublin Energy & Environment Indicators calculation

ENERGY & ENVIRONMENT				
Application field	Indicator		VALUE	UNIT
City Energy Profile	Final energy consumption per capita		9.50	MWh/cap
	Primary energy consumption per capita		11.78	MWh/cap
	Primary energy sources	Solid fossil fuels	4.52%	%
		Natural gas	31.17%	
		Oil and petroleum	0.19%	
		Renewables and biofuels	36.13%	
		Electricity from the grid	27.99%	
		Solid fossil fuels	0.53	MWh/cap
		Natural gas	3.67	
		Oil and petroleum	0.02	
		Renewables and biofuels	4.25	
		Electricity from the grid	3.30	
	Building connected to the DH-network or renewable energy grid		75%	% of buildings/city
GHG Emissions	GHG emissions per capita		8.56	Tonnes of CO_2 /cap
Waste Management	Recycling rate		94%	% of tonnes

5.8.2 Mobility characterization

Table 51: Lublin Mobility Indicators calculation

MOBILITY				
Application field	Indicator		VALUE	UNIT
City Mobility Profile	Modal split	Walk	24%	%
		Bike	11%	

		Public transport	33%	
		Car (private motor vehicle)	32%	
	Fuel mix in mobility	Gas oil and diesel oil	36.30%	%
		Gasoline	47.20%	
		Liquefied Petroleum Gases	14.30%	
		Electricity	0.00%	
		Others	2.20%	
	Energy use for transportation		6.56	MWh/cap
	Access to public transport		80%	% of people
	Public infrastructure promoting low-carbon mobility		51.20	Km/100,000 people

5.8.3 Governance characterization

Table 52: Lublin Governance Indicators calculation

GOVERNANCE			
Application field	Indicator	VALUE	UNIT
Economy	Unemployment rate	3.70%	% of active population
	GDP (Gross Domestic Product)	7,700	€/cap
Initiatives and Strategies of the Public Administration	Smart city factor in a city development strategy	4	Likert scale
Public ICT/ Data	Quality of open data	3	Likert scale

5.8.4 Society & Citizens characterization

Table 53: Lublin Society & Citizens Indicators calculation

SOCIETY & CITIZENS			
Application field	Indicator	VALUE	UNIT
Affordable Housing	Development of housing prices	8.00%	% of change or % of €/m^2
	Housing cost overburden rate	6.70%	%
Citizen Engagement and Empowerment	Citizen engagement to climate conscious actions	4	Likert scale
	Encouraging a healthy lifestyle	4	Likert scale
Urban Structure	Inhabitants in dense areas	81.00%	% of people

6 Conclusions

In the process to become a smart city, establishing a reliable metric is a key point to support cities to identify strengths and weaknesses and consequently set priorities for action. For this reason, WP1 and WP5 have worked aligned in order to establish a set of city level indicators useful for the city diagnosis and for the identification of their needs and priorities.

Task 5.1 aims at the definition of the evaluation framework in order to measure and assess the project activities at both **project (PED) level** (demonstration areas) and **city level** considering the indicator categories defined by CITYkeys (Smart City Indicators and related methodology), SCIS (Key Performance Indicators Guide) and other relevant reference frameworks (e.g. ESPRESSO, MAtchUP, mySMARTLife). The objective of the task is to select a set of Key Performance Indicators (KPIs) and data collection procedures for the common and transparent monitoring as well as the comparability of smart city actions across the cities. The city level indicators are selected and defined for evaluating the policy actions in the lighthouse and follower cities.

This deliverable describes the process of developing the evaluation framework including the selection of city level indicators that have been established and aligned with the WP1 developments. The main set of indicators as targets included in the city plans will be extracted and integrated into D1.2 in order to define the demand-side characterization of the project cities at medium- or long-term.

In total, 20 indicators were finally selected from four main categories, which are:

1. Energy & Environment
2. Mobility
3. Governance
4. Society & Citizens

In the MAKING-CITY project, the primary focus of the city level is on impact indicators. The aim is to investigate the degree to which smart city actions contribute to reaching city targets (societal goals "doing the right things") with regard to smart sustainable development and more technical actions related to e.g. energy.

The set of city level indicators were selected in consensus on the basis, that they all should be relevant for the context of the project, easy to measure and monitor by all cities, and they should concentrate on the impact that can be evaluated in medium- or long-term. This means that the indicators are meant to be continues monitoring tools for cities, not only for the period of the project, but also after that.

This deliverable provides the methodological guidance of the procedure for the cities on how to measure and calculate the indicators; what aspects should be taken into consideration and what should be left out. Deliverable 1.2 will then continue analysing the city plans in a more detailed manner. The actual indicator values for the current situation in cities have been calculated for this project report on initial (baseline) values. The actual evaluation of the achieved impacts - impact assessment - and other benefits of the city level actions and interventions will be performed at later stages of the project.

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Annex: Description of the city level indicators

Energy & environment

Table 54: Final energy consumption per capita indicator description

Final energy consumption per capita	City Energy Profile
Description incl. justification	Reduced and effective energy use can create substantial savings and can enhance security of the energy supply. Reducing the energy consumption also reduces greenhouse gas emissions and the ecological footprint, which contribute to combating climate change and achieve a low carbon economy. (ISO 37120, 2013) This indicator shall assess the final energy consumption per capita in cities taking into account all forms of energy (e.g. electricity, gas, heat/cold, fuels) and for all functions (transport, buildings, lighting, ICT, industry, etc.). The final energy consumption is the energy actually consumed by the end-user. This in contrast with primary energy use, the energy forms found in nature (e.g. coal, oil and gas) which have to be converted (with subsequent losses) to useable forms of energy, a more common indicator for evaluating energy consumption. When moving towards a renewable energy system, however, measuring the primary energy consumption loses its value. A reduction in primary energy consumption, for example by increasing the production of renewable energy, does not directly lead to a reduction in final energy consumption.
Definition	Annual final energy consumption for all uses and forms of energy. End users include residential, tertiary sector, public lighting, industry and transport.
Calculation	Final energy consumption / Total city population. Unit: MWh/cap The percentage of the decrease in energy consumption is calculated as the difference between the total consumption of energy per year (MWh/cap) at the end of the project (numerator) divided by the total consumption of energy per year (MWh/cap) at the beginning of the project (denominator). To facilitate the calculation of the total energy consumption, the indicator can be broken down into energy consumption of various sectors: buildings, transport, industry, public services, etc. This can, of course, be further subdivided, for example for 'buildings', in residential buildings, commercial buildings and public buildings, or for 'transport' in public and private transport. All forms of energy need to be taken into account, including electricity consumption, natural gas or thermal energy for heating and cooling and fuels. These will be given in different units of energy (kWh, GJ, m^3), but they all have to be calculated or converted to MWh of energy in order to be able to sum up the separately calculated energy consumptions and achieve the total energy consumption of the project. Relevant unit conversions are 1 J = 1 Ws; 1 kWh= 3,600,000 J; and 1 TOE = 41.868 GJ; 11,630 kWh; or 11.63 MWh (ITU-T L.1430: 2013).
Strengths and weaknesses	Strengths: High relevance with regard to policy aims, high relevance for replication. In most cases, the required input data can be obtained via various resources, e.g.

	monitoring equipment, energy bills. Weaknesses: The reliability of data for the different kinds of energy consumption varies. While in some cases the data is highly reliable (e.g. monitoring equipment of a building), in others this is not the case (e.g. estimations in transport sector). The consideration of the energy consumption of buildings must take into account the fact that values of energy consumption take some years to settle down to normal operational level after the renovation.
Data requirements	
Expected data source	Data from energy statistics and monitoring equipment provided by the energy service company etc. Calculations or simulations provided by the planning consultant, in case energy provider is involved in the project the data can be obtained from this source as well; consumption data of public facilities can be provided by the municipal utility or municipal department responsible for operation, supervision or statistics. For buildings data for (central) heating and cooling maybe more easily accessible than consumption for appliances.
Expected availability	High, as energy data should be generally available. Note for Residential building consumption: As the total energy consumption may vary considerably per household (or per user of the building) in some cases this indicator may be restricted to energy for heating, cooling, and hot water provision. These data sets can be more easily gathered, also in a planning stage (Eurbanlab: 2014).
Collection interval	At the beginning and end of the project, or ex-ante to evaluate the progress
Expected reliability	The reliability varies depending on the kind of energy consumption. Note: All calculations need to be thoroughly recorded for transparency.
Expected accessibility	High.

References

- Eurbanlab (2014). The Eurbanlab Selection of Indicators. Version 4.
- ISO/DIS 37120 (2013). Sustainable development and resilience of communities — Indicators for city services and quality of life. ICS 13.020.20
- ITU-T L.1430 (2013)

Table 55: Primary energy consumption per capita indicator description

Primary energy consumption per capita	City Energy Profile
Description incl. justification	This indicator shall assess the primary energy consumption per capita in cities taking into account all forms of energy (e.g. electricity, gas, heat/cold, fuels) and for all functions (transport, buildings, ICT, industry, etc.). The primary energy consumption refers to primary energy use, the energy forms found in nature (e.g. coal, oil and gas) which have to be converted (with subsequent losses) to useable forms of energy, a more common indicator for evaluating energy consumption. When moving towards a renewable energy system, however, measuring the primary energy consumption loses its value. A reduction in primary energy consumption, for example by increasing the production of renewable energy, does not directly lead to a reduction in final energy consumption.
Definition	Primary energy consumed in the city that is the energy forms found in nature (e.g. coal, oil and gas) which have to be converted (with subsequent losses) to useable forms of energy.
Calculation	Primary energy consumption / Total city population. Unit: MWh/cap The percentage of the decrease in energy consumption is calculated as the difference between the total consumption of energy per year (MWh/cap) at the end of the project (numerator) divided by the total consumption of energy per year (MWh/cap) at the beginning of the project (denominator). To facilitate the calculation of the total primary energy consumption, the indicator can be broken down into energy consumption of various sectors: buildings, transport, industry, public services, etc. This can, of course, be further subdivided, for example for 'buildings', in residential buildings, commercial buildings and public buildings, or for 'transport' in public and private transport. All forms of energy need to be taken into account, including electricity consumption, natural gas or thermal energy for heating and cooling and fuels. These will be given in different units of energy (kWh, GJ, m^3), but they all have to be calculated or converted to kWh of energy in order to be able to sum up the separately calculated energy consumptions and achieve the total energy consumption of the project. Relevant unit conversions are 1 J = 1 Ws; 1 kWh= 3,600,000 J; and 1 TOE = 41.868 GJ; 11,630 kWh; or 11.63 MWh (ITU-T L.1430: 2013).
Strengths and weaknesses	Strengths: High relevance with regard to policy aims, high relevance for replication. In most cases, the required input data can be obtained via various resources, e.g. monitoring equipment, energy bills. Weaknesses: The reliability of data for the different kinds of energy consumption varies. While in some cases the data is highly reliable (e.g. monitoring equipment of a building), in others this is not the case (e.g. estimations in transport sector). The consideration of the energy consumption of buildings must take into account the fact that values of energy consumption take some years to settle down to normal operational level after the renovation.
Data requirements	

Expected data source	Data from energy statistics and monitoring equipment provided by the energy service company etc. Calculations or simulations provided by the planning consultant, in case energy provider is involved in the project the data can be obtained from this source as well; consumption data of public facilities can be provided by the municipal utility or municipal department responsible for operation, supervision or statistics. For buildings data for (central) heating and cooling maybe more easily accessible than consumption for appliances.
Expected availability	High, as energy data should be generally available. Note for Residential building consumption: As total energy consumption may vary considerably per household (or per user of the building) in some cases this indicator may be restricted to energy for heating, cooling, and hot water provision. These data can be more easily gathered, also in a planning stage (Eurbanlab: 2014).
Collection interval	At the beginning and end of the project, or ex-ante to evaluate the progress
Expected reliability	The reliability varies depending on the kind of energy consumption. Note: All calculations need to be thoroughly recorded for transparency.
Expected accessibility	High.
References:	

- Eurbanlab (2014). The Eurbanlab Selection of Indicators. Version 4.
- ISO/DIS 37120 (2013). Sustainable development and resilience of communities — Indicators for city services and quality of life. ICS 13.020.20
- ITU-T L.1430 (2013)

Table 56: Primary energy sources (shares) indicator description

Primary energy sources (shares)		City Energy Profile
Description incl. justification	Shares of different fuel types (both fossil fuels and renewable energy sources) used for energy generation including production outside city boundaries, including own production and imported electricity into the city from national grid (using average production mix for electricity grid). Production of electricity is included in primary energy sources. Local CHP plant fuels are allocated 100% to the city, i.e. fuels here. Large-scale industry is not included.	
Definition	Shares of different fuel types (both Fossil fuels and Renewable Energy Sources) used for energy generation including production outside city boundaries. Including own production and imported electricity into the city from national grid (using e.g. average production mix for electricity grid), excluding embedded energy in materials. Disaggregation including: • Solid fossil fuels • Natural gas • Oil and petroleum • Renewables and biofuels • Electricity from the grid	
Calculation	[Primary energy source (MWh) / Total primary energy sources (MWh)] x100 [Primary energy source (MWh) / Total city population] Unit: % and MWh/cap	
Strengths and weaknesses	Strengths: High relevance with regard to policy aims, high relevance for replication. Weaknesses: The reliability of data for the different kinds of energy consumption varies.	
Data requirements		
Expected data source	Classes, see e.g. https://bit.ly/2X5nzcU. Fewer details may be ok, if there is no data available.	
Expected availability	High, as energy data should be generally available through statistics and data from energy providers.	
Collection interval	At the beginning and end of the project, or ex-ante to evaluate the progress	
Expected reliability	Good	
Expected accessibility	No sensitivities expected	
References:		
• Eurbanlab (2014). The Eurbanlab Selection of Indicators. Version 4. • ISO/DIS 37120 (2013). Sustainable development and resilience of communities — Indicators for city services and quality of life. ICS 13.020.20 • ITU-T L.1430 (2013)		

Table 57: Building connected to DH-network or renewable energy grid indicator description

Buildings connected to DH-network or renewable energy grid	City Energy Profile
Description incl. justification	Percentage of buildings connected to high-efficiency district heating network or local renewable energy grid in the city. Renewable energy grid meaning e.g. local "islanded grid" using RES.
Definition	Percentage of buildings connected to high-efficiency district heating network or local renewable energy grid.
Calculation	(Nº of buildings connected to the DH / Total number of buildings) x100 Unit: % of buildings/city, % DH-m3/all m3
Strengths and weaknesses	Strengths: High relevance for replication.
Data requirements	
Expected data source	General city statistics, local energy companies.
Expected availability	High, as energy data should be generally available.
Collection interval	At the beginning and end of the project, or ex-ante to evaluate the progress.
Expected reliability	Good
Expected accessibility	No sensitivities expected

Table 58: GHG emissions per capita indicator description

GHG emissions per capita	GHG Emissions
Description incl. justification	Greenhouse gases (GHGs) are gases in the atmosphere that absorb infrared radiation that would otherwise escape to space; thereby contributing to rising surface temperatures. There are six major GHGs: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF6) (ISI/DIS 37120, 2013). The warming potential for these gases varies from several years to decades to centuries. CO_2 accounts for a major share of GHG emissions in urban areas. The main sources for CO_2 emissions are combustion processes related to energy generation and transport. CO_2 emissions can therefore be considered a useful indicator to assess the contribution of urban development on climate change. Indirect emissions include those from manufacturing materials and overall economic/industrial activity that serves the city despite being located outside city boundaries. The indicator should express the difference of situation before and after the development of the project or, in case of new developments, to a state-of-the-art or business-as-usual option.
Definition	Percentage reduction in direct (operational) CO_2 emissions achieved by the project.
Calculation	GHG emissions of the city (tons) / Total city population Unit: Tons of CO_2(-eq.)/cap Note: the indicator could also be calculated as the direct (operational) reduction of the CO_2 emissions over a calendar year: at the beginning of the project and at the end of the project. The result will be divided by the CO_2 emissions before the project, and then it is multiplied by 100 to express the result as a percentage. To calculate the direct CO_2 emissions, the total energy reduced, as reflected in the indicator 'reduction in annual final energy', can be translated to CO_2 emission figures by using conversion factors for different energy forms as described in below tables.
Strengths and weaknesses	Strengths: high policy relevance linked to EU, national and local policies Weaknesses: documentation of used CO_2 emission factors is needed, as they in reality, differ case by case.
Data requirements	
Expected data source	Project owner, energy utility or provider in case these are involved in the project
Expected availability	High, as most projects will have an energy or GHG reduction target. If not immediately available to be calculated from the reduction in energy consumption using emission factors.
Collection interval	At the beginning and end of the project, or ex-ante to evaluate the progress.
Expected reliability	Monitoring data of energy combined with emission factors are expected to have high reliability.
Expected accessibility	High, dependent on the accessibility of energy consumption data. For buildings data for (central) heating and cooling maybe more easily accessible then consumption for

	appliances.

References
• ISO/DIS 37120 (2013). Sustainable development and resilience of communities — Indicators for city services and quality of life. ICS 13.020.20 • Covenant of Mayor: http://www.eumayors.eu/IMG/pdf/technical_annex_en.pdf

Table 59: Recycling rate indicator description

Recycling rate	Waste Management
Description incl. justification	The consumption of materials and resources has an impact on the environment and might contribute to depletion of resources. It is therefore beneficial to decrease the consumption as well as the consequent impacts. In this sense, the trias energetica can also be applied to materials: 1) reduce materials consumption, 2) use recycled materials (and make sure the materials used are recyclable again) and 3) use renewable materials. This indicator targets the second step in this logic. Recycled materials are materials that have been used before and that can be re-used as they are (e.g. bathtubs), or that can be reproduced/adjusted, thereby requiring energy input, to fit their new destination (e.g. recycled concrete or aluminium). By using recycled materials in the process, the environmental impact will be reduced as less virgin resources have to be exploited/mined and less energy has been used to process the raw materials into useful products. The construction industry has, for instance, set a goal of 70 % of construction waste to be recycled [1].
Definition	The percentage rate of recycled and re-used materials in the city area. Excluding mineral waste (sand, gravel etc.). Recycling includes recycling as material and for power and heat production.
Calculation	(Total amount of the city's solid wasted recycled / Total amount of solid waste produced) x100 Unit: % of tons
Strengths and weaknesses	Strengths: Important indicators of the general stage of the city. Weaknesses: For some recycling processes, the extra resource consumption for transportation and preparation for use might outweigh the benefits. In addition, a possible decreased service life compared to materials produced from virgin raw-materials and extra maintenance and repair in the use phase could be factors in deciding against using certain types of recycled materials in specific situations. This has to be decided on a case-by-case basis.
Data requirements	
Expected data source	Total material amounts and as recycled materials should be collected by project and be found in project documentation or provided by the project leader. Material reuse and recycling potentials should be collected from material producers and published within material information databases (E-library).
Expected availability	Good in general. However, in some countries, the share of recycled materials used is not recorded and analysed.
Collection interval	At the beginning and end of the project, or ex-ante to evaluate the progress.
Expected reliability	Good
Expected accessibility	No sensitivities expected
References:	

- Eurbanlab (2014). The Eurbanlab Selection of Indicators. Version 4.

- [1] http://ec.europa.eu/environment/waste/construction_demolition.htm

Mobility

Table 60: Modal split indicator description

Modal split	City Mobility Profile
Description incl. justification	Modal split is the percentage of travellers using a particular type of transportation or number of trips using each type. In freight transportation, this may be measured in mass. Modal split is an important component in developing sustainable transport within a city or region. In recent years, many cities have set modal share targets for balanced and sustainable transport modes.
Definition	Shares of different modes of transportation or the distribution of transport over the modalities public and collective transport, private vehicles, and biking and walking. The indicator searches the total number but also to distinguish in inner-city traffic and commuter-traffic (from outside). Disaggregation includes: • Walk • Bike • Public transport • Car (private motor vehicle)
Calculation	Percentage of shares of different modes of transportation within the city. Unit: % of modes
Strengths and weaknesses	Strengths: A good indication of situation. Weaknesses: Does not give absolute values (fuel consumptions etc.), which would be important from emissions point of view.
Data requirements	
Expected data source	Modal split data is usually obtained by travel surveys, which are often conducted by local governments, using different methodologies. Sampling and interviewing techniques, definitions, the extent of geographical areas and other methodological differences can influence comparability.
Expected availability	General figures will be available with the above sources.
Collection interval	At the beginning and end of the project, or ex-ante to evaluate the progress.
Expected reliability	In some cases, it might be difficult to measure and has to be estimated.
Expected accessibility	No sensitivities expected.
References	
• 2DECIDE • CIVITAS • H2020 work programme, 2016-2017. 10. 'Secure, Clean and Efficient Energy' • SCIS	

Table 61: Fuel mix in mobility indicator description

Fuel mix in mobility	City Mobility Profile
Description incl. justification	Worldwide, the transport sector consumes more than 60 per cent of oil products, which constitute about 98 per cent of transport energy use. The structure of energy consumption by transport is directly related to the composition of pollutant emissions. The use of renewable fuels such as biofuels, hydrogen and electricity can provide climate benefits as well as air quality improvements. Despite efforts at the EU level to promote alternative (electricity, natural gas, fuel cells) and renewable energy sources (biofuels) for transport, these still have a low penetration. In this indicator, we focus on the fuel mix for the transport within the city boundaries. Smart city projects may aim at reducing the environmental burden of inner-city transport (mainly motor traffic, although in some cities ships can provide an alternative).
Definition	The ratio of different fuels in the local transport (fuel mix) in the city. Percentage of the market share of transport fuel for each type of fuel used (petrol, diesel, petrol/LPG, electric, hydrogen, electric and hybrid vehicles). Disaggregation includes: • Gas oil and diesel oil • Gasoline • Liquefied petroleum gases • Electricity • Other fuels
Calculation	Percentage of shares of different transport fuels used in the city. Unit: %
Strengths and weaknesses	Strengths: Good indication of the overall situation. Weaknesses: This indicator requires detailed calculations and data.
Data requirements	
Expected data source	Fuel consumption by each type of vehicle and the corresponding vehicle-km can be collected from service operators, by recording fuel used and vehicle-km completed during the given periods. Vehicles using both traditional fuels and alternative fuels should be included. The results from former cases can be used for baseline or business-as-usual assessments.
Expected availability	If the city has paid attention to this, figures will be available with the above sources.
Collection interval	At the beginning and end of the project, or ex-ante to evaluate the progress.
Expected reliability	Actual increase in renewable fuels might be difficult to measure and have to be estimated.
Expected accessibility	No sensitivities expected
References	
• 2DECIDE • CIVITAS	

Table 62: Energy use for transportation indicator description

Energy use for transportation	City Mobility Profile
Description incl. justification	Worldwide, the transport sector consumes more than 60 per cent of oil products, which constitute about 98 per cent of transport energy use. The structure of energy consumption by transport is directly related to the composition of pollutant emissions. Freight transport can happen by different modes, such as trains, airplanes, ships and trucks. These vehicles can be powered by fossil fuels such as diesel and natural gas, but also by biofuels, hydrogen and electricity. The use of renewable fuels such as biofuels, hydrogen and electricity can provide climate benefits as well as air quality improvements. Despite efforts at the EU level to promote alternative (electricity, natural gas, fuel cells) and renewable energy sources (bio-fuels) for transport, these still have a low penetration In this indicator, we focus on the fuel mix for “last mile of transport”, that is the transport within the city boundaries. Smart city projects may aim at reducing the environmental burden of inner city transport (mainly motor traffic, although in some cities ships can provide an alternative). For the definition of the indicator, we haven’t made a distinction in fuel types or transport modes or transport vehicles, however this can be supporting information.
Definition	Final energy consumption of the transport sector.
Calculation	Final energy consumption of the transport sector (MWh) / Total city population. MWh (/cap)
Strengths and weaknesses	Strengths: Good indication of the situation in transport sector. Weaknesses: This indicator requires detailed sectoral data.
Data requirements	
Expected data source	Fuel consumption by each type of vehicle and the corresponding vehicle-km can be collected from service operators, by recording fuel used and vehicle-km completed during the given periods. Vehicles using both traditional fuels and alternative fuels should be included. The results from former cases can be used for baseline or business-as-usual assessments.
Expected availability	If the city has paid attention to this, some figures will be available with the above sources.
Collection interval	At the beginning and end of the project, or ex-ante to evaluate the progress.
Expected reliability	Actual increase in renewable fuels might be difficult to measure and have to be estimated.
Expected accessibility	No sensitivities expected
References	
• 2DECIDE • CIVITAS	

Table 63: Access to public transport indicator description

Access to public transport	City Mobility Profile
Description incl. justification	It is presumed that availability of alternatives to cars will lead to less car use, thereby contributing to an accessible, green and healthy neighbourhood and moreover contributes to European policy goals for sustainable mobility and transport development (EC, 2011). It is assumed that these factors contribute to the success of smart city projects. The quality, accessibility and reliability of transport services will also gain increasing importance in the coming years, inter alia due to the ageing of the population. While walking and cycling are alternative modes of transport for short distances, public transport connections are needed for longer trips. Providing access to public transport is an important means to promote its use. This indicator analyses the number of public transport stops or connections, including all modes of public transport; train, tram, subway, bus, etc. Service interval of the public transport stop not taken into account.
Definition	The extent to which public transport stops are available within 500 meters or share of population with access to a public transport stop within 500 meters.
Calculation	(Number of inhabitants with a public transport stop <500 meters / Total city population) x100 Unit: % of people NB. It can be calculated as the sum of buildings with a point of access within 500 meters, multiplied by its inhabitants. A point of access is defined as the location where a mode of transportation can be accessed. NB. As local circumstances vary, no absolute benchmark is attached to this indicator. The evaluator is asked to provide an indication of the extent to which public transportation stops are present. A building is considered to have access to a transport network if a point of access is located within 500 meters of said building. A point of access is defined as the location where a mode of transportation can be accessed.
Strengths and weaknesses	Strengths: The indicator provides an absolute measure for the ease of access of public transportation. Weaknesses: Access to sustainable modes of transport does not necessarily guarantee use. Transport mode choices have been linked to other factors besides accessibility, including perceptions of convenience, practicality, safety, comfort, individuality and cost.
Data requirements	
Expected data source	Routing and schedule plans of public transport and/or project documentation or interviews with city experts.
Expected availability	The required information should be readily available from above sources.
Collection interval	At the beginning and end of the project, or ex-ante to evaluate the progress.
Expected reliability	Because of the subjectivity that cannot be excluded, this indicator is not 100 % reliable.

Expected accessibility	No sensitivities expected

References

- http://www.highdensityliveability.org.au/community_sustainable_transport.php
- City Protocol (2015). CPWD - [-] 002 Anatomy Indicators- City Indicators. City Protocol Agreement (CPWD-[-]002)
- European Commission (2011). WHITE PAPER - Roadmap to a Single European Transport Area – Towards a competitive and resource efficient transport system. Brussels, 28.3.2011, COM(2011) 144 final.

Table 64: Public infrastructure promoting low-carbon mobility indicator description

Public infrastructure promoting low-carbon mobility	City Mobility Profile
Description incl. justification	A transportation system that is conducive to bicycling can reap many benefits in terms of reduced traffic congestion and improved quality of life (ISO/DIS 37120, 2013). Economic rewards both to the individual and to society are also realized through reduced health care costs and reduced dependency on auto ownership (and the resulting in insurance, maintenance and fuel costs). Bicycle lanes also require smaller infrastructure investments than other types of transportation infrastructure. Cycling has less of an environmental impact. This indicator provides cities with a useful measure of a diversified transportation system. Bicycle lanes shall refer to part of a carriageway designated for cycles and distinguished from the rest of the road/carriageway by longitudinal road markings (ISO/DIS 37120, 2013). Bicycle paths shall refer to independent road or part of a road designated for cycles and sign-posted as such. A cycle track is separated from other roads or other parts of the same road by structural means.
Definition	Length of lanes in the city for low-carbon mobility per 100,000 inhabitants. E.g. the length of the combined cycling and walking lanes, or them separately if not combined. Also streets with speed limit <=30 km/h. % of bicycle paths and lanes in relation to the length of streets (excluding motorways)
Calculation	[Length of bicycle lanes (km) / Total city population] x100,000 Unit: km/100,000 people The indicator shall be calculated as the total kilometres of bicycle paths and lanes (numerator) divided by one 100,000th of the city's total population (denominator). The result shall be expressed as the kilometres of bicycle paths and lanes per 100,000 population.
Strengths and weaknesses	Strengths: A solid indicator of the physical availability of e.g. cycling infrastructure in comparison to the infrastructure for cars, the mode of transport it wants to replace. Weaknesses: It may be deceptive with regards to the usability, quality (e.g. connectivity), safety (e.g. separate bike paths) and consistency of the bike routes as well as the geographic terrain (steep or even terrain).
Data requirements	
Expected data source	The department of traffic/mobility will have information on the length of streets and bicycle lanes/paths. Information might also be available on the local city website. The urban audit database also has information on the length of bicycle network (dedicated cycle paths and lanes).
Expected availability	The information will be readily available with the above sources
Collection interval	At the beginning and end of the project, or ex-ante to evaluate the progress.
Expected reliability	This indicator should be highly reliable.
Expected accessibility	If the information is available, there is no reason to believe that it will not be accessible (not sensitive information)
References	

- ISO/DIS 37120 (2013). Sustainable development and resilience of communities —Indicators for city services and quality of life. ICS 13.020.20
- United Nations Economic Commission for Europe (UNECE) (2015). United Smart Cities: Towards UNECE-approved smart cities indicators. A UNECE project. Draft smart city KPI list (ongoing work) distributed for UNECE smart city KPI workshop participants after workshop in Rakvere June 3-5 2015.

Governance

Table 65: Unemployment rate indicator description

Unemployment rate	Economy
Description incl. justification	The unemployment rate is considered one of the single, most informative labour market indicators reflecting the general performance of the labour market and the health of the economy as a whole. It is used to measure a city's unutilized labour supply and track business cycles. When economic growth is strong, unemployment rates tend to be low and when the economy is stagnating or in recession, unemployment rates tend to be higher (ISO/DIS 37120, 2013). Unemployment shall refer to individuals without work, actively seeking work in a recent past period (past four weeks), and currently available for work. Persons who did not look for work but have a future labour market stake (arrangements for a future job start) are counted as unemployed (International Labour Organization). Discouraged workers or hidden unemployed shall refer to persons who are not actively seeking work because they believe the prospects of finding it are extremely poor or they have restricted labour mobility, face discrimination, and/or structural, social, and cultural barriers – are not counted as unemployed or as part of the labour force. Not actively seeking work shall refer to people who have not taken active steps to seek work (i.e. job searches, interviews, informational meetings etc.) during a specified recent period (usually the past four weeks). (ISO/DIS 37120, 2013) Labour Force shall refer to the sum of the total persons employed and unemployed who are legally eligible to work.
Definition	Percentage of the labor force unemployed
Calculation	A city's unemployment rate shall be calculated as the number of working-age city residents who during the survey reference period were not in paid employment or self-employment, but available for work, and seeking work (numerator) divided by the total labor force (denominator). The result shall be multiplied by 100 and expressed as a percentage (ISO/DIS 37120, 2013). Unit: % of active population
Strengths and weaknesses	Strengths: City's unemployment rate can be considered as a sound measure for indicating a city's social and economic performance. Weaknesses: Although there exists e.g. a definition for the calculation of the unemployment rate by ISO/DIS 37120 (2013), each country/city is to be expected to calculate the unemployment rate based on own policies and rules (e.g. indicating people as unemployed if they are in trainings or not), therefore for the purpose of comparison these exceptional rules have to be taken into account.
Data requirements	
Expected data source	Statistics from local labor bureau, city statistical office.
Expected availability	Statistics are usually frequently (at least yearly) updated by the labor bureaus.
Collection interval	Yearly. At the beginning and end of the project, or ex-ante to evaluate the progress.
Expected reliability	Various calculation rules regarding the rate within each country/city are to be

	expected and taken into account regarding comparison between cities.
Expected accessibility	High.

References

- Unemployment rate definition, Eurostat, http://ec.europa.eu/eurostat/statisticsexplained/index.php/Glossary:Unemployment_rate
- ISO/DIS 37120 (2013). Sustainable development and resilience of communities - Indicators for city services and quality of life. ICS 13.020.20
- CITYkeys

Table 66: Gross domestic product, GDP indicator description

Gross domestic product, GDP	Economy
Description incl. justification	Gross domestic product, abbreviated as GDP, is a basic measure of a city's overall economic production. As an aggregate measure of production, GDP is equal to the sum of the gross value added of all resident institutional units (i.e. industries) engaged in production, plus any taxes, and minus any subsidies, on products not included in the value of their outputs. Gross value added is the difference between output and intermediate consumption. GDP is also equal to: • the sum of the final uses of goods and services (all uses except intermediate consumption) measured in purchasers' prices, minus the value of imports of goods and services; • the sum of primary incomes distributed by resident producer units.
Definition	City's gross domestic product per capita.
Calculation	Unit: €/cap
Strengths and weaknesses	Strengths: Well-known and accepted method for measuring of economic performance. Weaknesses: the indicator does only take into account all 'transactions done over the market' and not e.g. free of charge transactions and services. Furthermore, the indicator should be cleaned from actions being good for economic development but bad in the development for human wellbeing.
Data requirements	
Expected data source	Datasets needed: GDP and population. Cities statistics bureau, national statistics bureau if it provides geographical disaggregation or Eurostat NUTS3 level as proxy if no other data is available.
Expected availability	Often GDP figures are only available at a regional level, which may not be appropriate for a small city.
Collection interval	Annually. At the beginning and end of the project, or ex-ante to evaluate the progress.
Expected reliability	The indicator is well-known, therefore reliability should be expected.
Expected accessibility	No sensitivities expected.

References

- http://ec.europa.eu/eurostat/statisticsexplained/index.php/Glossary:Gross_domestic_product_%28GDP%29
- http://ec.europa.eu/eurostat/statistics-explained/index.php/GDP_at_regional_level
- CITYkeys

Table 67: Smart city factor in a city development strategy indicator description

Smart city factor in a city development strategy	Initiatives and Strategies of the Public Administration
Description incl. justification	In the past decades, governments have increasingly been "attempting to provide active support for the generation and adoption of environmental innovations" (Beise and Rennings 2005, 6). The creation of a supporting framework has been identified as a success factor for shaping responses at the urban level (Suzuki, et al. 2010, Romero-Lankao 2012). A framework typically includes a shared vision statement that contains a set of long-term goals. This long-term vision sets out a visualization of where future city development should go, and provides ways to relate responses to urban development aspirations (UN-Habitat 2011). Integrating goals into a long-term strategic vision for urban development thus is a critical step in support of the transition to smart cities. The existence of such comprehensive smart city visions, alongside with a strong smart city strategy, provides ways in which smart city projects can connect to larger development aims within the city, as well as benefit from supporting measures.
Definition	The extent to which the city has a supportive smart city policy. Inclusion and the level of details of smart cities strategies in the urban strategic plans of the city.
Calculation	Is there a specific smart city factor included in the development strategy of the city? What is the level of detail? Likert scale: Not at all – 1 — 2 — 3 — 4 — 5 — Very detailed. 1. Not at all: there is a complete absence of a smart city factor from the side of the government in the urban strategic plans of the city. 2. Poor: the smart city factor is not detailed or well integrated in the urban strategic plans of the city. 3. Neutral: the smart city factor included in the development strategy of the city has had a significant, positive or negative, impact for smart city initiatives. 4. Somewhat detailed: the smart city factor has to some extent detailed in the urban strategic planning and has some benefits for the development of smart city initiatives. 5. Very detailed: there is a very detailed smart city factor integrated in the development strategy of the city that stimulates the environment for smart city initiatives to a great extent.
Strengths and weaknesses	Strengths: This indicator allows for benchmarking with smart city projects in other cities. Weaknesses: Although it is tried to make scoring the indicator as objectively as possible, a certain amount of subjectivity is present. The interpretation and definition of a smart city policy may differ between cities.
Data requirements	
Expected data source	To be derived from city administration documentation, policy documents and/or interviews with project leader. Likert scale to be assessed by an expert panel.
Expected availability	Information on a supportive framework for the project will be easily available using

	the above sources.
Collection interval	At the beginning and end of the project, or ex-ante to evaluate the progress.
Expected reliability	Because of the subjectivity that cannot be excluded, this indicator is not 100% reliable.
Expected accessibility	Information on policies is public and problems with regards to accessibility are not expected.

References

- Eurbanlab (2014). The Eurbanlab Selection of Indicators. Version 4.
- Beise, M., and K. Rennings. “Lead markets and regulation: a framework for analyzing the international diffusion of environmental innovations.” Ecological Economics 52, no. 1 (2005): 5-17.
- Suzuki, H., A. Dastur, S. Moffatt, N. Yabuki, and H. Maruyama. Eco2 Cities: Ecological Cities as Economic Cities. Washington, DC, Washington: The World Bank, 2010.
- Romero-Lankao, P. “Governing Carbon and Climate in the Cities: An Overview of Policy and Planning Challenges and Options.” European Planning Studies 20, no. 1 (2012): 7-26.
- UN-Habitat. Cities and Climate Change: Global report on human settlements 2011.
- Human Settlements Programme, United Nations, London: EarthScan, 2011.

Table 68: Quality of open data indicator description

Quality of open data	Public ICT / Data
Description incl. justification	Open data, especially open government data, is a tremendous resource that is as yet largely untapped (opendatahandbook.org). In a large number of areas, open government data is already creating value. Examples include participation, self-empowerment, innovation, improved efficiency and effectiveness of government services, etc. While there are numerous instances of the ways in which open data is already creating both social and economic value, we don't yet know what new things will become possible. New combinations of data can create new knowledge and insights, which can lead to whole new fields of application. The quality and ease of use of open data is an important quality because the main aim of opening data is to make it widely available to the public (City Protocol). Therefore, evaluating the quality of the open data from this perspective is important to promote the ease of use and the openness of municipal data. Another important feature is that the data are regularly updated and maintained, even after project completion. This indicator therefore assesses the ease of use of datasets produced by the city and whether they are kept up-to date.
Definition	The extent to which the quality of the open data produced by the city was increased.
Calculation	Likert scale, partly based on the average stars across all datasets. Generated by the city according to the 5-star deployment scheme for Open Data defined by Tim Berners Lee (5stardata.info): Likert scale: Not at all – 1 – 2 – 3 – 4 – 5 – Excellent 1. Not at all: most of the data are not available to the public or only upon appointment with an expert. 2. Poorly: most of the data are available to the public as structured data (e.g. excel instead of image scan of a table). 3. Somewhat: most of the data are available to the public, in a non-proprietary open format (e.g. CSV). 4. Good: most of the data are available using URIs to denote things, so that people can point at your data. 5. Excellent: all government data are available and linked to other data to provide context (well structured).
Strengths and weaknesses	Strengths: The 5-star system makes the qualification of the datasets much more objective and comparable across projects. Weaknesses: Quality of the data is only expressed as the openness and ease of use of data. Other aspects like accurate, available, complete, conformant, consistent, credible, processable, relevant, timely have not been taken into account.
Data requirements	
Expected data source	To be derived from project documentation and/or interviews with project leader. Likert scale to be assessed by expert panel.
Expected availability	Data is open for assessment.
Collection interval	At the beginning and end of the project, or ex-ante to evaluate the progress.

Expected reliability	Because of the subjectivity that cannot be excluded, this indicator is not 100 % reliable.
Expected accessibility	Since it concerns government services, the information is public.

References

- http://5stardata.info/en/
- http://opendatahandbook.org/guide/en/why-open-data/

Society & citizens

Table 69: Development of housing prices indicator description

Development of housing prices	Affordable Housing
Description incl. justification	For inhabitant, housing price is one of the most important measures in housing and has certain upper limit. As in many cases this upper limit is reached to have a satisfactory living conditions, housing price must be considered. Concerning especially projects with technical interventions, those must not increase the housing cost, but rather decrease it at least in long term.
Definition	Development of average price for buying an apartment per m2 in the city. Would be better to look at the development of housing prices (not costs of housing since this includes mortgages, costs of insurance etc.) in relation with interventions.
Calculation	% of change Unit: % of €/m2 / % of change, annual average rate / annual average index (unit can differ by country).
Strengths and weaknesses	Strengths: interesting factor for both citizens and decision makers. Easily obtained from statistics. Clear numerical data. Weaknesses: The price reflects strongly the ratio of demand and offerings, i.e. the location, quality of surroundings, reputation, services, trends etc. define the popularity of certain area and when this is compared to the amount of the available apartments, one may get the market price. The technical adjustments may have little effect compared to the effect of the other issues.
Data requirements	
Expected data source	City statistics or commercial sources.
Expected availability	Readily available.
Collection interval	At the beginning and end of the project, or ex-ante to evaluate the progress.
Expected reliability	Good
Expected accessibility	No sensitivities expected

Table 70: Housing cost overburden rate indicator description

Housing cost overburden rate	Affordable Housing
Description incl. justification	Good and affordable housing conditions are an important aspect of making and keeping cities attractive and liveable. However, many European cities struggle with increasing spatial segregation processes – caused by social polarisation – making it increasingly difficult for low-income or marginalised groups to find decent housing at affordable prices. Gentrification combined with an increase in housing costs; make it more difficult for (low-income) residents to find affordable housing. The average cost of housing compared to income gives an indication of the affordability of the housing in the city area. The average cost of housing usually differs between owner-occupiers (lower) and tenants (higher). As a generally (worldwide) accepted rule of thumb, no more than 25-40% of income should be spent on housing in order to be considered affordable. For developed countries, the upper limit of what is considered acceptable is about 33%. The indicator can mostly be applied in cases in which new dwellings are built, as renovation projects generally do not change the population and/or the housing costs in a way that would change the indicator score. However, in the evaluation the physical planning context on a larger scale should be taken into account, as a small area may consciously be developed with more expensive housing to increase the diversity in that particular part of the city.
Definition	The percentage of the population living in households where the total housing costs ('net' of housing allowances) represent more than 40 % of disposable income ('net' of housing allowances).
Calculation	(Population living with housing cost overburden / Total city population) x100 Unit: % of population
Strengths and weaknesses	Strengths: The indicator is relevant for policies aimed at poverty reduction and increasing the diversity within the city. Weakness: Definitions and circumstances differ greatly throughout Europe. In some cities housing costs are higher than in others, which is socially accepted. The indicator is usually based on averages (for income data often derived from statistics on larger areas) that may compromise accuracy.
Data requirements	
Expected data source	City or commercial statistics for prices, e.g. tax administration data for income. Project documentation, marketing material of real estate brokers. The gross household income can be derived from city or regional statistics if not available for the immediate context of the project.
Expected availability	Household income data might be difficult to get. Often data are not regularly available in the required geographical detail. Estimates or proxies may be used instead.
Collection interval	At the beginning and end of the project, or ex-ante to evaluate the progress.
Expected reliability	Depending on the quality of the income data.

Expected accessibility	No data for individual dwellings will be available for reasons of privacy / data protection.
References:	

- Eurbanlab (2014). The Eurbanlab Selection of Indicators. Version 4.

Table 71: Citizen engagement/empowerment to climate conscious actions indicator description

Citizen engagement/empowerment to climate conscious actions	Citizen Engagement and Empowerment
Description incl. justification	Consciousness of citizenship is the awareness (consciousness) of one's community, civic rights and responsibilities and as such contributes to the sense of community. At the very least, it means that the individual is aware of what is going on around him. Ideally, it would mean that the individual is involved in the life of the community --understanding his role in the community -- seeking to contribute when he is able to do so. Civic consciousness includes (Ng, 2015): 1. Personal identity and citizenship: awareness, pride, obedience to the law, equality 2. National identity: respect for the national authorities, belief in the current political system, development of the country 3. Moral consciousness: being a good citizen in public and private, trusting that others are too 4. Ecological consciousness: awareness of the finite nature of resources, thinking about environmental consequences of actions 5. Social citizenship: family values and virtues, actively concerned with others at home and abroad
Definition	Appreciation of the benefits of city actions; Energy empowerment at home, satisfaction, happiness of people. Also the extent to which the project has contributed in increasing consciousness of citizenship.
Calculation	The indicator provides a qualitative measure and is rated on a five-point Likert scale: No engagement – 1 — 2 — 3 — 4 — 5 — High engagement 1. None: The city has made no effort to increase civic consciousness. 2. Little: The city has made a small effort to increase civic consciousness. 3. Somewhat: The city has developed some initiatives to increase civic consciousness. 4. Significant: The city has executed several activities to increase civic consciousness 5. High: increasing civic consciousness was (one of) the main goals of the city and it has done substantial effort to enhance it.
Strengths and weaknesses	Strengths: the indicator allows the evaluation and comparability of a wide range of project types and (still to-be-developed) solutions for increasing awareness. Weaknesses: although it is tried to make scoring the indicator as objectively as possible, a certain amount of subjectivity is present.
Data requirements	
Expected data source	City experts panel.
Expected availability	The possible intention will be readily available. The actual efforts made by the city can easily be provided by the project leader with a consistency check with project partners.
Collection interval	At the beginning and end of the project, or ex-ante to evaluate the progress.
Expected reliability	Because the effort is evaluated and not the actual result, this indicator is not 100%

	reliable.
Expected accessibility	The intention of and effort made by the project is not considered sensitive information, so no problems are expected with regards to accessibility.
References	

- International Telecommunication Union (2014). Key performance indicators (KPIs) definitions for Smart Sustainable Cities. SSC-0162-rev3
- Ng, J.A.I. (2015). Scale on Civic Consciousness (SCC) for the National Service Training Program. International Journal of Humanities and Management Sciences (IJHMS) Volume 3, Issue 3 (2015) ISSN 2320–4044

Table 72: Encouraging a healthy lifestyle indicator description

Encouraging a healthy lifestyle	Citizen Engagement and Empowerment
Description incl. justification	Simply telling people to change unhealthy behaviours does not work. We often rely on automatic behaviours to get us through the day. People change if unhealthy behaviours become too inconvenient: making bad choices harder is actually the best way to help people get healthier. For example programming elevator doors to close very slowly actually motivates more people to climb stairs. Little changes like these reach everyone - not just the people targeted with a health message. In addition, they get us healthier just by letting us stay on autopilot. Encouraging a healthy lifestyle includes: - biking facilities in the neighbourhood - walking opportunities (network of pedestrian walkways covering the entire area, crossing arrangements) - public sports facilities - non-smoking zones - making healthier food choices the norm - support in work/life balance
Definition	The extent to which policy efforts are undertaken to encourage a healthy lifestyle.
Calculation	Likert scale: No at all – 1 — 2 — 3 — 4 — 5 — Excellent 1. Not at all: no measures were taken to encourage a healthy lifestyle. 2. Poor: there was little encouragement of a healthy lifestyle. 3. Somewhat: there was some encouragement of a healthy lifestyle with the implementation of some measures 4. Good: a sufficient encouragement of a healthy lifestyle was translated into several offline (biking facilities, public sports facilities) and online (i.e. app reminders) initiatives. 5. Excellent: a healthy lifestyle was extensively encouraged offline (biking facilities, public sports facilities, pedestrian networks) and online (i.e. exercise apps).
Strengths and weaknesses	Strengths: Encouraging a healthy lifestyle is considered a success factor regarding health care and wellbeing, and therefore relevant to the subtheme health. Weaknesses: Although the aim is to make this indicator as objective as possible, a certain amount of subjectivity is present. Acceptance by people may be uncertain.
Data requirements	
Expected data source	City experts panel.
Expected availability	If the smart city strategy has a healthy lifestyle component, it is expected that this information will be available. If there is no documentation available, city experts should be able to provide insight upon which the assessor can base the score.
Collection interval	At the beginning and end of the project, or ex-ante to evaluate the progress.
Expected reliability	Because of the subjectivity that cannot be excluded, this indicator is not 100% reliable.

Expected accessibility	It is expected that this information will be accessible (no sensitivities).
References	

- http://www.scientificamerican.com/podcast/episode/make-healthy-choices-easier-options-12-09-20/

Table 73: Inhabitants in dense areas indicator description

Inhabitants in dense areas	Urban Structure
Description incl. justification	Population living in dense areas (e.g. over 20 inhabitants / hectare) of the city. "Dense" has a specific definition – but it can differ by country. This is an important indicator for technical replication. Interesting combined with climate information.
Definition	Percentage of the population living in dense areas (over 20 inhabitants / hectare) of the city. The definition for dense can differ by country, please specify if so.
Calculation	Population living in dense areas / total population of the city Unit: % of people
Strengths and weaknesses	Strengths: Important for replication of PED areas. Weaknesses: The definition varies by country. Not easy to compare.
Data requirements	
Expected data source	Statistics.
Expected availability	Data are easily available in most countries.
Collection interval	At the beginning and end of the project, or ex-ante to evaluate the progress.
Expected reliability	Good.
Expected accessibility	No sensitivities expected.