CITYkeys

Co-funded by the European
Commission within the H2020
Programme.
Grant Agreement no: 646440.
2015-02-01…2017-01-31 (24 months).

CITYkeys indicators for smart city projects and smart cities

24-01-2017

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Table of contents

EXECUTIVE SUMMARY

This report describes the selection of indicators for assessing smart city projects and the corresponding indicators on city level. Starting from the definition of a smart city and smart city projects, indicators have been selected that can function as Key Performance Indicators for tracking the progress towards city and project objectives.

The indicators for assessing smart city projects serve to assess or evaluate single projects. 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 smart cities focus on monitoring the evolution of a city towards an even smarter city. The time component -“development over the years”- is an important feature. The city indicators may be used to show to what extent overall policy goals have been reached, or are within reach.

With a starting point in the smart city definition, and taking into account the wishes of cities and citizens with regard to smart city projects and indicators, the indicators are arranged in an extended triple bottom line sustainability framework, including the themes people, planet, prosperity, governance and propagation. Under the main themes subthemes conforming with major policy ambitions have been identified.

Under these subthemes in total 99 project indicators and 76 city indicators have been selected. Not all indicators are equally suited for evaluating all types of smart city projects. Although there is a considerable body of common indicators, for specific sector projects a relevant subset of these may be used (i.e. some indicators are specifically suited for transport projects, other for building related projects, etc.).

The selection was based on an inventory of 43 existing indicator frameworks for (sustainable) cities and projects. The majority of the indicators in the CITYkeys selection have been derived from existing indicator frameworks. New indicators have been suggested to fill gaps in existing frameworks, mostly related to specific characteristics of smart city projects.

The CITYkeys project was funded as a 'horizontal activity' of the Smart Cities and Communities call to develop an indicator framework for smart city project evaluation and thus also support the so called Lighthouse projects also funded under the same call theme. In developing the indicator selection, CITYkeys has collaborated with TRIAGULUM, REMOURBAN and SMARTER TOGETHER lighthouse project consortia through joint workshops, phone calls and email exchange. The lighthouse projects implement tangible technological solutions that are expected to support smart city development and achieve environmentally-friendly, economically viable and socially desirable urban environments.

1. INTRODUCTION

The ultimate goal of CITYkeys is to support the speeding up of wide-scale deployment of smart city solutions and services in order to create impact on major societal challenges around the continuous growth and densification of cities and the Union's 20/20/20 energy and climate targets. Therefore, CITYkeys aims to facilitate and enable stakeholders in projects or cities to learn from each other, create trust in solutions, and monitor progress, by means of a common integrated performance measurement framework.

1.1 Background to the indicators selection

The selection of indicators for the evaluation framework is based on an inventory of the needs of cities and citizens, the CITYkeys working definitions and the structure of the evaluation framework.

1.1.1 Needs of cities and citizens

Cities

Cities confirmed that the topic of "smart city" is high on their agenda as they expect a lot of benefits from becoming smart: efficiency, sustainability, participation of society and better quality of life. In describing what a smart city looks like, they agree that a "smart city" uses innovative technology; combines energy, mobility and infrastructure; increases performance and efficiency; increases the participation of citizens; enables innovation and improves the social and economic fabric of the city.

In both planning and implementing smart city solutions, performance measurement is one key component. Nevertheless, and although they would like to do so, cities haven't yet widely adopted or implemented such performance measurement systems and CITYkeys could become a "facilitator" in this direction.

The areas in which cities mostly need indicators to measure their smart city performance include: energy, greenhouse gas emissions, transportation, digital infrastructure and e-services, resource management, citizens' participation, competitiveness, economy, environment, quality of life and research and knowledge creation. On the smart city project level, the areas in which cities mostly need indicators to measure performance include: greenhouse gas emissions, energy, transportation, digital infrastructure and e-services, environment, quality of life, research and knowledge creation, resource management, innovation, urban planning and social inclusion.

Citizens and stakeholders

Citizens and stakeholders follow adequately what their cities plan and implement and are definitely looking for more results, both in terms of quality and quantity. They define a "smart city" and its objectives in terms similar to the ones used by the cities' experts; nevertheless they put more emphasis in three objectives that are directly important to them:

- Improvement of quality of life;
- Better services from the city to the citizens;
- Creation of an innovative, competent and with high skilled jobs city.

The responses of citizens about their needs on the smart city level were very diverse; see Kontinakis and De Cunto (2015). On the smart city project level, the most important project results included: creation of innovation and knowledge, better public transportation, protection of the environment, better education and skills building, cleaner energy, digital infrastructure and e-services, better city governance, creation of local enterprises, improvement of housing conditions, new jobs, and protection of natural resources.

The outputs of CITYkeys need to take the priorities of all city stakeholders into account. Replying citizens and stakeholders provided two different sets of answers when asked what makes a "smart city project" useful. Useful *for the citizens* means a better environment and quality of life and in practice means better and more efficient services, tackling the social and economic challenges and a focus on innovation and jobs creation. Useful *for the cities* means tackling social issues at the same time as making the city more efficient and sustainable, more competitive and financially robust.

As resources and availability of data differ according to the size of cities, questionnaires and drafts of the indicators lists were distributed to a variety of cities in Europe. In this way we have gathered opinions of smaller cities as well. With the exception of Tampere, the cities that are partner in CITYkeys have more than 600.000 inhabitants.

1.1.2 CITYkeys working definitions

In Neumann et al. (2015) the definition of a smart city and a smart city project as used in CITYkeys are introduced. The definition was further developed highlighting the aspect of smartness (that is innovative methods and technologies to enable sustainability) in the definition:

A **smart city** is a city that efficiently mobilizes and uses available resources (including but not limited to social and cultural capital, financial capital, natural resources, information and technology) for efficiently

- improving the quality of life of its inhabitants, commuting workers and students, and other visitors [people]
- significantly improving its resource efficiency, decreasing its pressure on the environment and increasing resiliency [planet]
- building an innovation-driven and green economy [prosperity]
- fostering a well-developed local democracy [governance].

A **smart city project** is a project that

- has a significant impact in supporting a city to become a smart city along the four axis of sustainability mentioned above
- actively engages citizens and other stakeholders
- uses innovative approaches
- is integrated, combining multiple sectors.

A smart city project can be executed on the scale of:

- a single building, for instance improving the energy performance of a theatre, or
- a neighbourhood, for instance improving the waste collection, to the scale of
- a city or even a region, think of an improvement in the public transport system.

Thus there is a wide range of possible projects that need to be covered by the evaluation framework.

1.1.3 Target groups for the indicator system

Indicators serve decision making. Indicator outcomes, be it individual indicators or assessments based on multiple indicators should reach the relevant decision makers. The various parts of the CITYkeys indicators are aimed at decision makers on various levels.

The indicators on project level have two primary target groups:

- those decision makers 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 council, who need an insight in how the various projects they have decided upon, have been performing (also to be able to take better decision next time), for which a more aggregated overview may be more appropriate.

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.

Because the European Commission is financing the, so called, lighthouse projects they are (temporarily) in a similar position as a city council, needing insight in the performance of their investments.

The smart city indicators equally have two primary target groups:

- decision makers in the city council 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 greenhouse gas emissions, increasing citizens participation, etc). In addition national government and European institutions tend to use indicators to compare cities.

It is clear that for users of the city 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.

1.1.4 Indicators at city and project level

The CITYkeys evaluation framework will support Smart Cities in strengthening their strategic planning and measure their progress. The indicators are thus primarily performance oriented (Hiremath et al., 2013). An important feature of this framework is that it focuses on the city as well as the project level, and most importantly, it will establish a link between the two. The CITYkeys evaluation framework will:

1. Evaluate the impact of a smart city project comparing before and after situations or comparing expected impact with a reference situation. As such they can also serve to benchmark projects against each other. It should be noted that a complete project assessment includes an extensive description of the context of the project, the

activities and technologies in the project, financing and the business model, and the implementation process.

2. Monitor the progress of the city as a whole towards smart city goals. The time component -“development over the years”- is an important feature. The city indicators may be used to show to what extent overall policy goals have been reached, or are within reach. In addition city-level indicators may be used to compare cities with each other, although such a comparison should be done with care.
3. Assess how the project has contributed to the objectives at city level. This requires connecting outcomes of a project evaluation with corresponding indicators on the city level. How this can be done in practice, and for which and how many indicators, is still a challenge to be tested in 2016.

For the design of the indicator lists, we have started with creating a list of indicators that are useful and feasible to evaluate smart city projects (using the principles described in the next Section). With this list as a starting point we have scanned existing urban indicator sets for corresponding indicators for evaluating city policies. In a few cases it appeared possible to find a corresponding indicator, in which the impact of smart city projects can be immediately expressed (in other words: if one would add the results of all smart city projects in a city, this could immediately be translated in (or related to) the score of the city indicator). For as much as possible, we have used existing indicators; new indicators were only created if no existing indicator was fit for measuring the desired aspect.

For instance, the reduction of CO_2 emissions by a smart city project can be related to the city indicator ‘yearly CO_2 emission’. Of course, it must be kept in mind that there are also external influences at work in the city (i.e. CO_2 emissions may also be affected by macroeconomic developments, next to the project results). Therefore it may be necessary to provide more context. In the majority of the cases it is not possible to add project indicator scores quantitatively, but an indicator on the city level can be found that expresses the same intentions, but using a value that cannot be measured on the project level. Appendix 3 contains the overview of the link between the CITYkeys project and city indicators.

1.2 CITYkeys Evaluation Framework

The CITYkeys assessment method and the indicators are to be used to evaluate the success of smart city 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. Over the past decennia, the concept of sustainability - split up in the triple bottom line of social sustainability (**People**), environmental sustainability (**Planet**) and economic sustainability (**Prosperity**) - has become generally accepted in the development of indicator systems for national and regional urban development (SCOPE, 2007). The 3 Ps (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 developement.

Therefore we need 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).

Finally, 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.

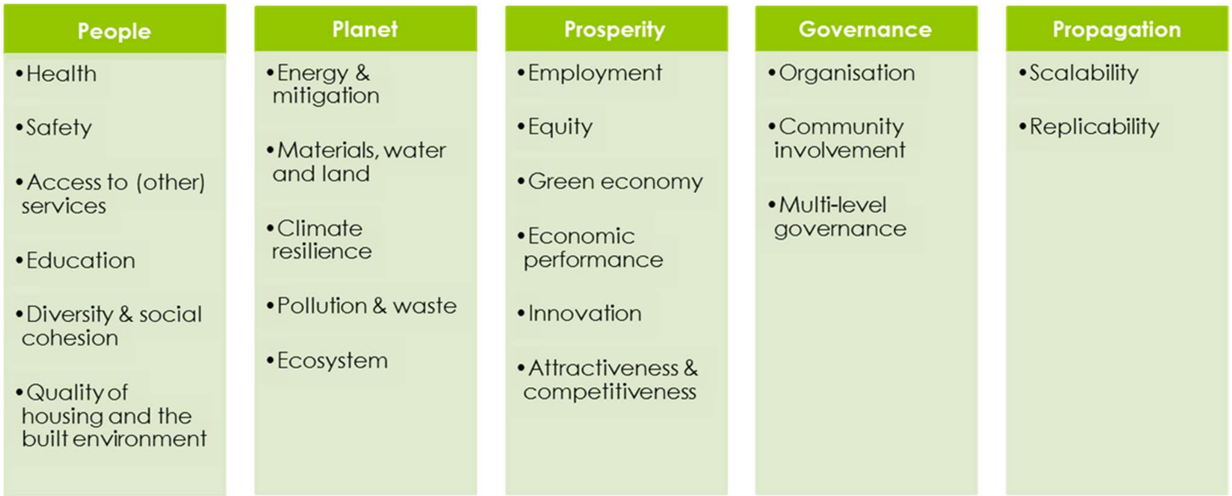
A subdivision of the evaluation framework in impact categories allows for more flexibility than a subdivision in driving forces, actors or sectors. In addition, as smart city projects in various sectors all contribute to the same impacts there will be fewer double indicators (such as 'energy savings' or 'emission of carbon dioxide'). Indicators that are relevant for a specific sector can easily be in- 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 these are not all 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 we have arranged these policy goals under the major theme headings. For instance, under the theme People, subthemes conforming to policy ambitions are created (see Fig.1): 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.

The following paragraphs provide succinct definitions of the themes and subthemes.



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 1: The CITYkeys indicator framework

1.2.1.1 People

Definition of People: The People side of sustainability refers to the long term attractiveness of cities for a wide range of inhabitants and users. Aspects include quality of living for everyone, especially for the most vulnerable citizens, education, health care, social inclusion, etc.

Subtheme definitions

- Health: improving the quality and accessibility of the public health system for everyone and encouraging a healthy lifestyle
- Safety: lowering the rate of crime and accidents
- Access to (other) services: providing better access for everyone to transport, amenities and affordable services in physical and virtual space
- Education: improving accessibility and quality of education for everyone
- Diversity and social cohesion; promoting diversity, community engagement and social cohesion to increase the sense of community.
- Quality of housing and the built environment: encourage mixed-income areas, ensure high quality and quantity of public spaces and recreational areas, and improve the affordability and accessibility to good housing for everyone.

1.2.1.2 Planet

Definition of Planet: The ”Planet” aspect of sustainability in the first place refers to contributing to a ‘cleaner’ city with a higher resource efficiency and biodiversity and being better adapted to impacts of future climate change such as (in Europe) increased flooding risk, more frequent heat waves and droughts. Included in this theme are thus less consumption of fossil fuels and more generation and use of renewable energy, lower waste generation and less air pollution. As our planet extends beyond the city boundary, impacts of urban consumption in other parts of the world, are explicitly included.

Subtheme definitions

- Energy and mitigation: Reduce energy consumption, use waste energy and produce renewable energy
- Materials, water and land: Creating a society that treats its resources (materials, water, food and land) more efficiently and sustainably, among others by decreasing consumption and increasing recycling and renewable production (thereby considering ‘spill-overs’ to other resources).
- Climate resilience: Adapting to climate change by increasing the resilience of vulnerable areas/elements.
- Pollution and waste: Decreasing the emissions to the environment (in the city or elsewhere) (e.g. waste, noise and pollution to air, water and soil).
- Ecosystem: stimulating biodiversity and nature conservation

1.2.1.3 Prosperity

Definition of Prosperity: Contributing to a prosperous and equal society and supporting affordable, green and smart solutions. On the project level Prosperity stands for economic viability and the value of a smart city project for a neighbourhood, for its users and its stakeholders, and even its indirect economic effect on other entities. Economic or financial indicators often need to be accompanied with an in-depth description of the business case, as single indicators are insufficient to evaluate e.g. the distribution of costs and investments.

Subtheme definitions

- Employment: Improving local employment opportunities and skills
- Equity: decreasing poverty and income inequality
- Green economy: improving the circular and sharing economy and sustainable/local consumption and production.
- Economic performance: increasing GDP and project performance (*internal performance)*
- Competitiveness and attractiveness: Improving the appeal of the city for residents and businesses.
- Innovation: facilitates innovation and creativity (through e.g. open data, knowledge sharing and cyber resilience).

1.2.1.4 Governance

Definition of Governance: Contributes to a successful process of project implementation as well as to a city with an efficient administration and a well-developed local democracy, thereby engaging citizens proactively in innovative ways.

Subtheme definitions

- Multilevel governance: Increasing support for smart city initiatives by providing smart city policies and budget at different government levels.
- Organisation: Facilitate the implementation of (integrated) smart city policies by improving the organisation of the project/city with regards to;
    - The composition, structure and quality of the project team/city administration;
    - The quality of the implementation process;
    - Sound leadership by the project leader(s) and city politicians;
    - Transparency of the organisation.
- Community involvement: increasing citizen participation and enhancing the active involvement of end-users, the community and professional stakeholders in city developments.

1.2.1.5 Propagation

Definition of Propagation: Improving the replicability and scalability of smart city project solutions at wider city scale. Propagation is about the *potential* for dissemination to other locations, other contexts and other cities. Propagation (both transfer to other locations and countries, and up-scaling from small single projects) depends in the first place on inherent characteristics of the (innovative) smart city project. In practice propagation also depends on external factors such as market conditions.

Subtheme definitions

- Scalability: Increasing the potential for scaling up successful SC solutions (considering both geographic scale and thematic integration potential) to achieve wider impact in the city.
- Replicability: Increasing the potential for replicating successful SC solutions in other cities.

2. INDICATORS

2.1 Key Performance Indicators

The origin of Key Performance Indicators (KPIs) is in business administration. Key Performance Indicators provide businesses with a tool for measurement (DEFRA, 2006). They are quantifiable metrics (values that can be measured) that reflect the performance of a business in the context of achieving its wider goals and objectives. KPIs help businesses to implement strategies by linking various levels of an organisation or a project with clearly defined targets and benchmarks. Gradually the use of the term Key Performance Indicators has extended beyond business and industry to government administrations.

The difference between all kinds of other indicators or progress measures is that Key Performance Indicators are directly related to an organization's strategy and are critical for its successful execution of its strategy (Kellen, 2003). KPIs are always tied to a goal, a target or an objective.

In essence two questions are leading for the definition of KPIs in organisations (Artley and Stroh, 2001) and also for smart city project implementation:

- Are we doing the right things? Or how effective is the organization in reaching its impacts, whereby the indicator reflects the degree to which smart city projects conform to the requirements or expectations;
- Are we doing things right? Or, how efficient is the organization, whereby the indicator reflects the degree to which smart city projects deliver the expected impact at minimum resource costs.

As KPIs focus on these 'key' measures that are important for understanding the impacts of smart city projects, they prevent lengthy reports on many less relevant aspects. Moreover, this assures that the CITYkeys framework will be able to process future developments just as well as current developments.

2.2 Types of indicators

For evaluating smart city projects we are interested in the degree to which these projects contribute to reaching city targets (societal goals- ”doing the right things”) with regard to smart sustainable development. That means that the primary focus is on impact indicators (see box 1).

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 taken/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 (in addition to limiting the measures to be implemented and the risk of being outdated when better technological solutions are found) 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 favorable/sustainable impacts. CITYkeys will in its testing phase in 2016 evaluate a number of projects, thereby also implementing the ITU-T L.1440 methodology to evaluate the environmental footprint of various smart city solutions.

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)[1].

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.

The CITYkeys evaluations will be based on either 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[2]

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, 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, 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.

Example: the outcome of an thermal isolation programme could be the number of well-isolated dwellings as percentage of the total number of dwellings covered by the programme.

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[1] A number of specific sector oriented indicator frameworks are available and have been used in the inventory of existing indicator frameworks (see section 2.2 and 2.3). For example for urban transport: Rooijen et al. (2013) and AECOM (2015); or for energy: Stengel (2012); or for ICT Symons and Wolfram (2011) and ITU (2014).

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

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).

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.

However, the huge variety of smart city projects creates a nearly endless collection of measures describing all kinds of project inputs and outputs. Box 2 lists, without being exhaustive, input and output indicators that are typical of smart city projects with an IT component. For a set of key indicators it is not desirable to have a large list of indicators that will cover all types of interventions in cities. Hence, for the CITYkeys indicators we have looked for generalised definitions that would be able to cover many different projects. These indicators are mentioned in italics in Box 2 (they are further defined in Chapter 5 and 6).

Box 2: Input, process, output and outcome indicators for smart city projects/smart cities

This box lists suggestions received in our consultations on indicators referring to "smart" initiatives and projects in cities. Each category is concluded with (in italics) the CITYkeys indicators that provide a "generalised" measure in the same category.

Input indicators for smart city projects/cities:

Availability of real time traffic data

Project costs/Staff involved

Associated generalised CITYkeys indicators:

--(development of)smart city policy,

--smart city expenditures

--cross departmental integration of smart city policies,

--establishment within the administration,

--monitoring and evaluation of smart city projects,

Process indicators for smart city projects/cities:

Number of ways in which citizens can communicate with the municipality (e.g. phone, mail, social media, etc.)

Increased computer literacy of elderly people

Presence of demand-based pricing (e.g. congestion pricing, variably priced toll lanes, variably priced parking spaces)

Use of standard interfaces

Associated generalised CITYkeys indicators:

--interoperability;

--cyber security;

--privacy

--*improved digital literacy;*

Output indicators for smart city projects/cities:

Proportion of homes using smart home monitoring systems

Share of households with smart meters (broken down by energy networks/water)

Percentage of electric vehicles (broken down by type or 'operated by the city')

Number of public EV charging stations

Integrated fare system for public transport

Availability of multi-modal transit app with at least 3 services integrated

Nr of vehicles enrolled in GIS tracking of rental e-bikes and e-cars

Proportion of public parking connected to the parking management system

Proportion of traffic lights connected to the traffic management system

Coverage of roads sensing terminals connected to a control system

Coverage of parking guidance systems

Share of city's solid waste disposal managed with ICT measures

Heavy rain / flood control monitoring by means of ICT measures

Sewage discharge management/water pollution control with ICT measures

Number of infrastructure components with installed sensors. 1 point for each: traffic, public transit demand, parking, waste, water, public lighting

Number of services integrated in a singular operations center delivering real-time data. 1 point for each: ambulance, emergency/disaster response, fire, police, weather, transit, air quality

Number of technologies in use to assist with crime prevention, 1 point for each of the following: livestreaming video cameras, taxi apps, predictive crime software technologies

Number of smart apps developed using open data platforms.

Associated generalised CITYkeys output indicators:

--online services,

--number of open datasets;

--quality of open datasets;

--number of innovation hubs in the city

Outcome indicators for smart city projects/cities:

Internet penetration rate

Share of intelligent buildings

Share of municipal energy networks with real-time information for customers

Share of municipal energy networks permitting distributed generation

Use of Smart mobility apps/The share of electric car owners in the district which participate.

Use of e-bike / e-car rental schemes

The share of car owners which have a device suited for running the application

Number of recharges at EV charging stations

kWh recharged in the EV charging stations

% of total revenue from public transit obtained via unified smart cards systems

Associated generalised CITYkeys outcome indicators:

--access to high speed internet;

--access to public WIFI internet connection;

--people reached by the project

2.3 The CITYkeys framework and lighthouse project evaluation

If not included in the standard list of indicators, there are essentially two ways to deal with specific information on inputs and outputs of a project:

In an assessment of any project, the project description will contain the information on the characteristics of the project, accompanied by a description of input variables (investment, operating costs, efforts to plan, design and realise the project) and of outputs (e.g. number of buildings retrofitted, number of smart meters installed, number of apps linked to smart meters, capacity battery storage units, number of smart street lights, number of bus stops with real time departure information, etc., depending on the precise nature of the project), since that type of output/outcome information is often needed to calculate impact results.

Cities may also choose to include specific input and output indicators in their local set of smart city (project) indicators, if they execute multiple comparable projects for which it is useful to monitor this information. In this respect the list in Box 2 may serve as a source of inspiration.

A typical example could be the assessment of the implementation of the lighthouse projects. In the case of comparable projects, simple output indicators (such as number of smart meters installed) are useful. However, to assess how well the ultimate goals (such as reduced greenhouse gas emissions) are achieved, impact indicators are the most appropriate.

Table 1 illustrates how CITYkeys indicators can be used to evaluate the impacts of measures typical for smart city lighthouse projects, highlighting the link between typical "enabling" smart city project indicators and CITYkeys impact indicators. The examples of enabling lighthouse project indicators are based on draft material provided by three lighthouse projects (TRIAGULUM, REMOURBAN and SMARTER TOGETHER).

Table 1. How CITYkeys indicators can be used to evaluate the impacts of measures implemented in lighthouse (or other smart city) projects

Typical "enabling" smart city project indicators used in some lighthouse projects	**CITYkeys indicators used to evaluate the associated impacts**
Number of smart meters installed	Reduction in annual final energy consumption (by buildings) Reduction in life cycle energy use Reduction of embodied energy of products and services used in the project
Proportion of homes using smart monitoring	Reduction in annual final energy

systems Percentage of intelligent buildings	consumption (by buildings) Reduction in life cycle energy use Reduction of embodied energy of products and services used in the project Financial benefit for the end-user Payback period
Solid waste disposal management with ICT measures	Reduction in the amount of solid waste collected
Number of electric vehicles Number of electric vehicle charging stations	Reduction in annual final energy consumption (by transport) Reduction in life cycle energy use Carbon dioxide emission reduction Reduction in lifecycle CO2 emissions Decreased emissions of Nitrogen dioxides
Coverage of roads sensing terminals Proportion of traffic lights connected to the traffic management system	Reduction of traffic accidents Decreased delay by traffic congestion
Use of ICT in public transport Availability of multi-modal transit app with at least 3 services integrated	Quality of public transport Public transport use
Existence of official citywide privacy policy to protect confidential citizen data	Improved data privacy Improved cybersecurity

2.4 Criteria for selecting indicators

In general, indicators (and even more so KPI's) should express as precisely as possible to what extent an aim, a goal or a standard has been reached or even surpassed. Data that are 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 evaluative purposes. Often, however, various indicators are available to assess the progression towards a certain goal. Scanning the existing indicators sets for CITYkeys resulted in longlists of potential indicators per subtheme. To arrive at a shortlist of indicators for discussion with partners, a set of critera was 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.
   Further the indicators should be selected and defined in such a way that the implementation of the smart city project will provide a clear signal in the change of the indicator value. Indicators that are influenced by other factors than the implementation of the evaluated project are not suited. Indicators that provide an ambiguous signal (if there is doubt on the interpretation of e.g. an increase in the indicator value) are equally not suited.

2. COMPLETENESS; The set of indicators should consider all aspects of the implementation of smart city projects. KPI's can be selected according to the People, Planet, Prosperity and Governance themes (and for project indicators also from the Propagation theme), which framework is fairly 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. The current selection contains, however, a few footprint type indicators that might be expected to become common in the near future (e.g. reduction in indirect CO2 emissions).

   A few indicators have been added that score very high on relevance, as they touch upon topics that are high on the political agenda, but for which data availability at the moment is low (e.g urban food production). They are on the list as 'aspirational' indicators, for which it is expected that the data situation may change soon.

4. MEASURABILITY; The identified indicators should be capable of being measured, preferably as objectively as possible. For the majority of indicators in the People, Governance and Propagation themes, quantitative measurability is limited. Social sciences provide approaches to deal with qualitative information in a semi-quantitative way (Abeyasekera, 2005).

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

6. FAMILIARITY; The indicators should be easy to understand by the users. For a large number of indicators we have relied on indicators from existing indicator sets, that generally comply with this requirement. For new indicators a definition has been developed that 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. In general we have kept to this principle, but given the political attention for both improving energy efficiency and reducing carbon dioxide emissions, we have included both indicators. As the current energy system is still largely based on fossil fuels, 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.

The longlist of project indicators derived from existing frameworks and respective scores on these criteria can be obtained from the authors.

2.5 Applicability, relevancy and data availability of the indicators

As mentioned in Section 4.1, the CITYkeys indicators were selected to be applicable for assessing a wide range of smart city projects. However, not all indicators are equally suited for the full range of smart city projects (on the project level) or smart city policy focus (on the city level). Indicators on air polluting emissions are less relevant for building projects, but highly relevant for transport projects, for example. Therefore, the applicability of each indicator is depicted in Appendix 1 with one or more of the following icons :

Built environment

Transportation

ICT

In reporting the assessment of a project or on the outcomes of city indicators, indicators are to be rated "Not applicable" if the indicator is not suitable for the *type* of project or policy focus (i.e. transport specific indicators for residential developments). Indicators are to be marked "Not relevant" if they are applicable to the type of project or policy focus, but are not relevant for the assessment due to deviating circumstances or contexts. If insufficient data could be obtained for a score or an approximation, indicators are to be marked as "Not available".

3. CITYKEYS INDICATORS FOR SMART CITY PROJECTS

A long- and shortlist of project indicators has been debated with all partners over various teleconferences and meetings to finally arrive at the list discussed in next paragraphs. The tables of indicators include the title, the unit, a short description, the source framework(s) and the type of indicator.

- The title of the project indicator is phrased as 'improving' something, whether increasing something you want to stimulate, or decreasing something less favourable, comparing the before (or business-as-usual) and after (or expected results) situation.
- Important in the choice for the unit of the indicator is the comparability of indicators across a variety of projects differing in type, size, etc. Absolute values, like kg CO2 emitted, are therefore not suitable. Consequently, most project indicators are defined as '% change' or use a Likert scale[3], for instance, % reduction in CO2-emissions. It follows that these indicators will require some understanding of the context in which the project is taken place, or the reference situation against which the project should be assessed.
- The short description explains the indicator into more detail. Many indicators are aggregated indicators, inherently combining various elements. The description will provide some examples of elements that can be taken into account at the evaluation phase.
- As far as possible, existing indicators of already developed frameworks have been used for the CITYkeys framework. For these indicators, the original frameworks are mentioned in the description as the 'source framework'. In addition, new indicators have been developed by the consortium members when they felt this was necessary for performing a complete evaluation of smart city projects. The indicator titles of these indicators are marked in red. Paragraph 5.6 will analyse this difference between already available indicators and newly developed ones for CITYkeys objectives.

In total, 99 project indicators have been defined so far. In the list in Section 5.2 and further, the indicators that are not derived from existing frameworks, thus newly developed for this project, are indicated in a red font. These indicators are listed separately in Section 5.1. Not every indicator will be relevant for each type of project: i.e. air quality indicators may typically apply to transport projects. The sector scope of the indicator can be found in the more elaborate descriptions of the project indicators in Appendix 1.

3.1 Response to the gap analysis: new indicators

In the discussions with the cities a number of new project indicators have been added to the selection of indicators from existing indicator frameworks:

People

1. Encouraging a healthy lifestyle
2. Waiting time
3. Quality of public transport
4. Improved flexibility in delivery services
5. Increased environmental awareness
6. Improved digital literacy
7. People reached

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[3] A Likert scale is a five (or seven) point scale which is used to allow the individual to express how much they agree or disagree with a particular statement. In the CITYkeys evaluation Likert scales are used to express the analyst or independent expert estimate on the indicator.

8. Increased participation of vulnerable groups
9. Increased use of groundfloors

Planet

1. Life time extension
2. Reduction in water consumption
3. Self-suffiency – Water
4. Self-suffiency – Food

Prosperity

1. Certified companies involved in the project
2. Green public procurement
3. Stimulating an innovation environment
4. Quality of open data

Governance

1. Involvement of the city administration
2. Bottom-up or top-down initiative
3. Participatory governance

Propagation

1. Smart city project visitors

Many of the ‘new’ indicators are related to specific goals of smart city projects, such as ‘people reached’, ‘quality of open data’, ‘local community involvement in implementation phase’. Some of the ‘new’ indicators are reformulations or combinations of existing indicators, such as ‘improved quality of public transport’.

3.2 People

3.2.1 Health

Indicator title	Indicator unit	Definition	Source
Improved access to basic health care services	Likert	The extent to which the project has increased accessibility to basic health care	Rotterdam SCP; SCI
Encouraging a healthy lifestyle	Likert	The extent to which the project encourages a healthy lifestyle	
Waiting time	% in hours	Percentage reduction in waiting time due to project	

3.2.2 Safety

Indicator title	Indicator unit	Definition	Source
Reduction of traffic accidents	% of fatalities	Percentage reduction of transportation fatalities due to the project	Civitas; 2DECIDE
Reduction in crime rate	% of crimes	Percentage reduction in number of violences, annoyances and crimes due to the project	Rotterdam SCP; Smart city Wheel; European Smart Cities v1.0 (2007); SCI
Improved cybersecurity	Likert	The extent to which the project ensures cybersecurity	ITU
Improved data privacy	Likert	The extent to which data collected by the project is protected	ITU

3.2.3 Access to (other) services

Indicator title	Indicator unit	Definition	Source
Access to public transport	Likert scale	The extent to which public transport stops are available within 500m	Eurbanlab; Rotterdam SCP; Covenant of mayors; OECD; LEED; DGNB
Quality of public transport	Likert scale	The perception of users on the quality of the public transport service	
Improved access to vehicle sharing solutions	Likert scale	Improved accessibility to vehicle sharing solutions	LEED; DGNB
Extending the bike route network	% in km	Percentage increase of the length of cycling roads	FIN Indicators; Transform; OECD; UNECE; Covenant of Mayors; European Green Capital Award study
Access to public amenities	Likert scale	The extent to which public amenities are available within 500m	Smart city Profiles; RFSC; FIN indicators; Eurbanlab; 2000Watt; SCI; Rotterdam SCP; Eco-Districts
Access to commercial amenities	Likert scale	The extent to which commercial amenities are available within 500m	Eurbanlab, OECD; Rotterdam SCP
Increase in online government services	Likert scale	The extent to which access to online services provided by the city was improved by the project	Triple Helix Model, Smart city Wheel
Improved flexibility in delivery services	Likert scale	The extent to which flexibility in delivery services was improved by the project.	

3.2.4 Education

Indicator title	Indicator unit	Definition	Source
Improved access to educational resources	Likert	The extent to which the project improves accessibility to educational resources	ITU
Increased environmental awareness	Likert	The extent to which the project has used opportunities for increasing environmental awareness and educating about sustainability and the environment	
Improved digital literacy	Likert	The extent to which the project has attempted to increase digital	

		literacy	

3.2.5 Diversity and social cohesion

Indicator title	Indicator unit	Definition	Source
People reached	% of people	Percentage of people in the target group that have been reached and/or are activated by the project	
Increased consciousness of citizenship	Likert	The extent to which the project has contributed in increasing consciousness of citizenship	ITU
Increased participation of vulnerable groups	Likert	The extent to which project has led to an increased participation of groups that are not well represented in the society	

3.2.6 Quality of housing and the built environment

Indicator title	Indicator unit	Definition	Source
Diversity of housing	Simpson Diversity Index/Social Housing	Simpson Diversity Index of total housing stock in the project area OR Percentage of social dwellings as share of total housing stock in the project area	Eurbanlab; LEED
Connection to the existing cultural heritage	Likert scale	The extent to which making a connection to the existing cultural heritage was considered in the design of the project	Eurbanlab; LEED; DGNB
Design for a sense of place	Likert scale	The extent to which a 'sense of place' was included in the design of the project	Eurbanlab
Increased use of groundfloors	% in m2	Increase in ground floor space for commercial or public use due to the project as percentage of total ground floor surface	
Increased access to urban public outdoor recreation space	m2	Increase in public outdoor recreation space (m2) within 500m	OECD; Rotterdam SCP
Increased access to green space	m2	Increase in green space (m2) within 500m	LEED; DGNB; Smart city Wheel; Triple Helix Model; ISO 37151

3.3 Planet

3.3.1 Energy & mitigation

Indicator title	Indicator unit	Definition	Source
Reduction in annual final energy consumption	% in kWh	Percentage change in annual final energy consumption due to the project for all uses and forms of energy	Eurbanlab; Concerto; CIVIS, DGNB
Reduction in lifcycle energy use	% in kWh	Reduction in life cycle energy use achieved by the project (%)	Eurbanlab
Reduction of embodied energy of products and services used in the project	Likert	The extent to which measures have been taken to reduce the embodied energy of products used in the project	Eurbanlab
Increase in local renewable energy production	% in kWh	Percentage increase in the share of local renewable energy due to the project	Eurbanlab; Eco-Districts, Concerto; LEED: CIVIS; IDEAS
Carbon dioxide emission reduction	% in tonnes	Percentage reduction in direct (operational) CO2 emissions achieved by the project.	Eurbanlab;CIVIS; Concerto; 2 Decide; DGNB
Reduction in lifecycle CO2 emissions	% in tonnes	Percentage peduction in lifecycle CO2 emissions achieved by the project	CIVIS; DGNB
Maximum Hourly Deficit	MHDx	The maximum yearly value of how much the hourly local demand overrides the local renewable supply during one single hour	IDEAS
Local freight transport fuel mix	% in kms	The ratio of renewable fuels in the local freight transport fuel mix in the project.	CIVITAS 2DECIDE

3.3.2 Materials, water and land

Indicator title	Indicator unit	Definition	Source
Materials			
Increased efficiency of resources consumption	% in tonnes	Percentage reduction in material consumption of the project	Eurbanlab; ISO 37151; DGNB

Share of recycled input materials	% in tonnes	Share of recycled and re-used materials used by the project	Eurbanlab; LEED
Share of renewable materials	% in tonnes	Share of renewable materials used by the project	Eurbanlab
Share of materials recyclable	% in tonnes	Share of materials used by the project that are practically retrievable for recycling after the life time	Eurbanlab
Life time extension	Likert	The extent to which the project attempted to prolonge the service lifetime of products	
Water			
Reduction in water consumption	% in m3	Percentage reduction in water consumption brought about by the project	
Increase in water re-used	% in m3	Increase in percentage of rain and grey water re-used to replace potable water	LEED; OECD
Self-sufficiency - Water	% in m3	Increased share of local water resources	
Land			
Increase in compactness	% of people or workplaces	Percentage increase in the number of people or workplaces situated in the project area	FIN Indicators
Self-sufficiency - Food	% in tonnes	Increase in the share of local food production due to the project	

3.3.3 Climate resilience

Indicator title	Indicator unit	Definition	Source
Climate resilience measures	Likert scale	The extent to which adaptation options have been considered in the project	Eurbanlab

3.3.4 Pollution & waste

Indicator title	Indicator unit	Definition	Source
Decreased emissions of Nitrogen oxides (NOx)	% in tonnes	Percentage reduction in NOx emissions (NO and NO2) achieved by the project	Eurbanlab; Civitas; 2Decide

Decreased emissions of Particulate matter (PM2,5)	% in tonnes	Percentage rduction in PM2,5 emissions achieved by the project	Eurbanlab; Civitas
Reduced exposure to noise pollution	% in dB	Percentage reduction of noise level at night measured at the receiver	ISO 37120; FIN Indicators; Rotterdam SCP; OECD; ClimateCon; European Green Capital Award study; DGNB
Reduction in the amount of solid waste collected	% in tonnes	Percentage reduction in the amount of waste collected due to the project	Siemens Green City Index; Smart city Profiles; Rotterdam SCP; Transform; Desire; OECD; ClimateCon; SCI; European Green Capital Award study; City Protocol

3.3.5 Ecosystem

Indicator title	Indicator unit	Definition	Source
Increase in green and blue space	% in m2	Percentage icrease of green and blue spaces due to the project	
Increased ecosystem quality and biodiversity	Likert	The extent to which ecosystem quality and biodiversity aspects have been taken into account	

3.4 Prosperity

3.4.1 Employment

Indicator title	Indicator unit	Definition	Source
Increased use of local workforce	% in euros	Share in the total project costs that has been spent on local suppliers, contractors and service providers.	Eurbanlab
Local job creation	# of jobs	Number of jobs created by the project	

3.4.2 Equity

Indicator title	Indicator unit	Definition	Source

Fuel poverty	%-points in euros	Change in percentage points of (gross) household income spent on energy bills	Eurbanlab
Costs of housing	% in euros	The percentage of gross household income spent on housing	Eurbanlab; LEED

3.4.3 Green economy

Indicator title	Indicator unit	Definition	Source
Certified companies involved in the project	% of companies	Share of the companies involved in the project holding an ISO 14001 certificate	
Green public procurement	Likert scale	The extent to which GPP criteria where taken into account for the procurement processes related to the project	
CO2 reduction cost efficiency	€/ton CO2 saved/year	Costs in euro's per ton of CO2 saved per year	Eurbanlab

3.4.4 Economic performance

Indicator title	Indicator unit	Definition	Source
Financial benefit for the end-user	€/household/yr	Total cost savings in euros for end-users per household per year	DGNB; Eurbanlab
Net Present Value (NPV)	€	The Net Present Value of the project calculated over the lifetime	Urbgrade; Eurbanlab; Concerto; 2DECIDE
Internal rate of return (IRR)	% (interest)	The interest rate at which the NPV of the investment is zero	Urbgrade; 2DECIDE
Payback Period	Yrs	The number of years at which the net present value of costs (negative cash flows) of the investment equals the net present value of the benefits (positive cash flows) of the investment	Urbgrade, Eurbanlab; Concerto
Total cost vs. subsidies	% in euros	The percentage of subsidies as share of total investment of the project	Eurbanlab

3.4.5 Innovation

Indicator title	Indicator unit	Definition	Source
Involvement of extraordinary professionals	Likert	The extent to which the project involved professionals normally not encountered in these type of projects	Smart city Wheel
Stimulating an innovative environment	Likert scale	The extent to which the project is part of or stimulates an innovative environment	
Quality of open data	# stars	The extent to which the quality of the open data produced by the project was increased	
New startups	# of startups	The number of startups resulting from the project	Smart city Wheel
Improved interoperability	Likert scale	The extent to which the project has increased interoperability between systems	ISO 37151

3.4.6 Attractiveness & competitiveness

Indicator title	Indicator unit	Definition	Source
Decreased travel time	% in hours	Percentage decrease in travel time due to the project	2DECIDE

3.5 Governance

3.5.1 Organisation

Indicator title	Indicator unit	Definition	Source
Leadership	Likert scale	The extent to which the leadership of the project is successful in creating support for the project.	Eurbanlab
Balanced project team	Likert scale	The extent to which the project team included all relevant experts and stakeholders from the start	Eurbanlab; DGNB
Involvement of the city administration	Likert scale	The extent to which the local authority is involved in the development of the project, other than financial, and how many departments are contributing	
Clear division of responsibility	Yes/no	Has the responsibility for achieving the social and sustainability targets been clearly assigned to (a) specific actor(s) in the project?	Eurbanlab; LEED
Continued monitoring and reporting	Likert scale	The extent to which the progress towards project goals and compliance with requirements is being monitored and reported	Eurbanlab
Market orientation	Likert scale	The extent to which the project was planned on the basis of a market analysis	DGNB

3.5.2 Community involvement

Indicator title	Indicator unit	Definition	Source
Professional stakeholder involvement	Likert scale	The extent to which professional stakeholders outside the project team have been involved in planning and execution	Eurbanlab; Green Digital Charter
Bottom-up or top-down initiative	Yes/no	Has the project idea originated from the local community?	
Local community involvement in planning phase	Likert scale	The extent to which residents/users have been involved in the planning process	Eurbanlab; Green Digital Charter

Local community involvement in implementation phase	Likert scale	The extent to which residents/users have been involved in the implementation process	
Participatory governance	% of people	Share of population participating in online platforms	

3.5.3 Multi-level governance

Indicator title	Indicator unit	Definition	Source
Smart city policy	Likert scale	The extent to which the project has benefitted from a governmental smart city policy	Eurbanlab
Municipal involvement - Financial support	Likert scale	The extent to which the local authority provides financial support to the project	DGNB

3.6 Propagation

3.6.1 Replicability & scalability

Indicator title	Indicator unit	Definition and extensive description	Source
Social compatibility	Likert scale	The extent to which the project's solution fits with people's 'frame of mind' and does not negatively challenge people's values or the ways they are used to do things.	Eurbanlab
Technical compatibility	Likert scale	The extent to which the smart city solution fits with the current existing technological standards/infrastructures	Eurbanlab
Ease of use for end users of the solution	Likert scale	The extent to which the solution is perceived as difficult to understand and use for potential end-users	Eurbanlab
Ease of use for professional stakeholders	Likert scale	The extent to which the innovation is perceived as difficult to understand, implement and use for professional users of the solution	Eurbanlab
Trialability	Likert scale	The extent to which the solution can be experimented with on a limited basis in the local context before full implementation	Eurbanlab
Advantages for end users	Likert scale	The extent to which the project offers clear advantages for end users	Eurbanlab; 2DECIDE; CIVITAS; ISO 37151; Civitas
Advantages for stakeholders	Likert scale	The extent to which the project offers clear advantages for stakeholders	Eurbanlab
Visibility of Results	Likert scale	The extent to which the results of the project are visible to external actors	Eurbanlab
Solution(s) to development issues	Likert scale	The extent to which the project offers a solution to problems which are common to European cities	Eurbanlab
Market demand	Likert scale	The extent to which there is a general market demand for the solution	Eurbanlab

3.6.2 Factors of success

Indicator title	Indicator unit	Definition and extensive description	Source
Changing professional norms	Likert scale	The extent to which the project changes the professional 'state of the art'	Eurbanlab
Changing societal norms	Likert scale	The extent to which the project changes the norms and values of the society	Eurbanlab
Diffusion to other locations	Likert scale	The extent to which the project is copied in other cities and regions	Eurbanlab
Diffusion to other actors	Likert scale	The extent to which theproject is copied by other parties	Eurbanlab
Change in rules and regulations	Likert scale	The extent to which the project has contributed to, or inspired, changes in rules and regulations	Eurbanlab
Change in public procurement	Likert scale	The extent to which the project has contributed to, or inspired, new forms of public procurement procedures	Eurbanlab
New forms of financing	Likert scale	The extent to which the project has contributed to, or inspired, the development of new forms of financing	Eurbanlab
Smart city project visitors	# of visitors	The number of visitors to the physical project site or to the website hosting the smart city project	

4. CITYKEYS INDICATORS FOR SMART CITIES

Because a strong focus of the CITYkeys framework is on the relation between project and city indicators, the selection of project indicators as discussed in chapter 5 has formed the basis for defining city indicators. From the longlist of city indicators, derived from existing frameworks, an indicator was chosen, in consultation with all project partners,that has the closest resemblance with one of the selected project indicators. If several indicators were equally suitable, the preference went to an indicator that cities already use and/or are familiar with. In the next paragraphs, the tables of selected city indicators are shown, discussing the title, the unit, a short description, the source framework(s) and the type of indicator.

- The title of the city indicator is phrased as evaluating a static situation. A static indicator, assessing the situation at a certain recurrence in time, will allow monitoring over various time periods.
- Important in the choice for the unit of the indicator is the comparability of indicators across a variety of cities differing in size, demography, dominant type of companies/sectors, etc. Here too, absolute values are not suitable. Consequently, most city indicators are defined as '%' or use a Likert scale, for instance, the share of population with good access to public transport expressed in percentage.
- It should be noted that in the project indicator set several indicators have been defined as qualitative indicators expressing for instance the quality of public transport connections, while on the city level a more conventional quantitative indicator was selected (such as the share of population with a public transport stop within 500 m). The reason is that on the project level a simple quantitative indicator was judged as insufficient for expressing the impact of the project, while for the city indicator set the traditional quantitative indicator was judged more feasible.
- The short description explains the indicator into more detail. More elaborate descriptions of the city indicators can be found in Appendix 2.
- Also for city indicators, existing indicators of already developed frameworks have been used for the CITYkeys framework when available. For these indicators, the original frameworks are mentioned in the description as the 'source framework'. In addition, new indicators have been developed by the consortium members when they felt this was necessary for performing a complete evaluation of Smart Cities. The indicator titles of these indicators are marked in red. Paragraph 6.6 will analyse this difference between already available indicators and newly developed ones for CITYkeys objectives.

In total, 76 city indicators have been defined so far. Similar to the project indicators, those indicators that are newly defined for this project, and not derived from existing frameworks, are indicated in a red font in Section 6.2 and further (they are listed separately in the next Section).

4.1 Response to the gap analysis: new indicators

On the city level fewer new indicators have been added than on the project level. This is largely due to the fact that there are many more city level indicators readily available, and because not all indicators can be aggregated from the project level to the city level (while for the assessment of projects the newly proposed indicators were deemed necessary).

People

1. Encouraging a healthy lifestyle
2. Flexibility in delivery services

3. Digital literacy
4. Ground floor usage
5. Cuber security
6. Data privacy

Planet

1. Domestic material consumption
2. Brownfield use
3. Local food production
4. Urban heat island

Prosperity

1. Share of certified companies
2. Innovation hubs in the city
3. Open data

Governance

1. Smart city policy

4.2 People

4.2.1 Health

Indicator title	Indicator unit	Definition	Source
Access to basic health care services	% of people	Share of population with access to basic health care services within 500m	Rotterdam SCP; SCI
Encouraging a healthy lifestyle	Likert	The extent to which policy efforts are undertaken to encourage a healthy lifestyle	

4.2.2 Safety

Indicator title	Indicator unit	Definition	Source
Traffic accidents	#/100.000	Number of transportation fatalities per 100.000 population	Civitas; Rotterdam SCP; European Green Capital Award study; 2Decide; CASBEE_City_2012; UNECE; ,GCIF; COMIND; URBES
Crime rate	#/100.000	Number of violence, annoyances and crimes per 100.000 population	Rotterdam SCP; Smart city Wheel; European Smart Cities v1.0 (2007); SCI; City Protocol; GCIF
Cybersecurity	Likert	The level of cybersecurity of the cities' systems	
Data privacy	Likert	The level of data protection by the city	

4.2.3 Access to (other)services

Indicator title	Indicator unit	Definition	Source
Access to public transport	% of people	Share of population with access to a public transport stop within 500m	Rotterdam SCP; Covenant of mayors; OECD; City Protocol; GCIF; 2000-Watt;
Access to vehicle sharing solutions for city travel	#/100.000	Number of vehicles available for sharing per 100.000 inhabitants	LEED; DGNB
Length of bike route network	% in km	% of bicycle paths and lanes in relation to the length of streets (excluding motorways)	FIN Indicators; Transform; OECD; UNECE; Covenant of Mayors; European Green Capital Award study; City Protocol; URBES; ISO 37120
Access to public amenities	% of people	Share of population with access to at least one type of public amenity within 500m	Smart city Profiles; RFSC; FIN indicators; Eurbanlab; 2000Watt; SCI; Rotterdam SCP; City Protocol
Access to commercial amenities	% of people	Share of population with access to at least six types of commercial amenities providing goods for daily use within 500m	Eurbanlab ,OECD, Rotterdam SCP; City Protocol
Access to high speed internet	#/100	Fixed (wired)-broadband subscriptions per 100 inhabitants	ISO 37120; RFSC; Rotterdam SCP; Transform; UNECE; ITU; Green Digital Charter; European Green Capital Award study; City Protocol; GCIF; URBES; Smart city Wheel; Triple Helix Model; European Smart Cities v1.0 (2007);
Access to public free WiFi	% of m2	Public space Wi-Fi coverage	City Protocol
Flexibility in delivery services	Likert	The extent to which there is flexibility in delivery services	

4.2.4 Education

Indicator title	Indicator unit	Definition	Source
Access to educational resources	Likert	The extent to which the city provides easy access (either physically or digitally) to a wide coverage of educational resources	Adapted from project definition
Environmental education	% of schools	The percentage of schools with environmental education programs	SCI
Digital literacy	% of people	Percentage of target group reached	

4.2.5 Diversity and social cohesion

No indicators identified at city level.

4.2.6 Quality of housing and the built environment

Indicator title	Indicator unit	Definition	Source
Diversity of housing	Simpson Diversity Index/Social housing	Simpson Diversity Index of total housing stock in the project area OR Percentage of social dwellings as share of total housing stock in the project area	LEED; UNECE; City Protocol; Eurbanlab; SCI
Preservation of cultural heritage	Likert	The extent to which preservation of cultural heritage of the city is considered in urban planning	Eurbanlab; CASBEE_Urban development_2014
Ground floor usage	% of m2	Percentage of ground floor surface of buildings that is used for commercial or public purposes as percentage of total ground floor surface	
Public outdoor recreation space	m2/cap	Square meters of public outdoor recreation space per capita	OECD; Rotterdam SCP; City Protocol
Green space	hectares/100.000	Green area (hectares) per 100.000 population	UNECE; ClimateCon; OECD; SCI; European Green Capital Award study; City Protocol; GCIF; URBES; Rotterdam SCP

4.3 Planet

4.3.1 Energy & mitigation

Indicator title	Indicator unit	Definition	Source
Energy consumption/demand			
Annual final energy consumption	MWh/cap/yr	Annual final energy consumption for all uses and forms of energy	Eurbanlab; Transform
Renewable energy production			

Renewable energy generated within the city	% of MWh	The percentage of total energy derived from renewable sources, as a share of the city's total energy consumption	Eurbanlab; Transform; OECD; UNECE; READY
CO2 –emissions			
CO2 emissions	t CO2/cap/yr	CO2 emissions in tonnes per capita per year	ISO 37120; Smart city Wheel; SCI; FIN indicators; DESIRE; RFSC; UNECE; European Green Capital Award study; City Protocol; GCIF
Local freight transport fuel mix	% in kms	The ratio of renewable fuels in the local freight transport fuel mix.	2DECIDE CIVITAS

4.3.2 Materials, water and land

Indicator title	Indicator unit	Definition	Source
Materials			
Domestic material consumption	t/cap/year	The total amount of material directly used in the city per capita	
Water			
Water consumption	liters/cap/year	Total water consumption per capita per day	Siemens Green City Index; FIN Indicators; European Green Capital Award study; UNECE; OECD; ClimateCon; Rotterdam SCP; City protocol; GCIF; COMIND
Grey and rain water use	% of houses	Percentage of houses equipped to reuse grey and rain water	OECD
Water Exploitation Index	% of m3	Annual total water abstraction as a percentage of available long-term freshwater resources in the geographically relevant area (basin) from which the city gets its water	DESIRE
Water losses	% of m3	Percentage of water loss of the total water consumption	Siemens Green City Index; UNECE; FIN Indicators; City Protocol; GCIF; URBES
Land			
Population density	#/km2	Number of people per km2	FIN Indicators

Local food production	% of tonnes	Share of food consumption produced within a radius of 100 km	
Brownfield use	% of km2	Share of brownfield area that has been redeveloped in the past period as percentage of total brownfield area	

4.3.3 Climate resilience

Indicator title	Indicator unit	Definition	Source
Climate resilience strategy	Likert scale	The extent to which the city has developed and implemented a climate resilient strategy	Eurbanlab
Urban Heat Island	°C UHImax	Maximum difference in air temperature within the city compared to the countryside during the summer months	

4.3.4 Pollution & waste

Indicator title	Indicator unit	Definition	Source
Air quality			
Nitrogen oxide emissions (NOx)	g/cap	Annual nitrogen oxide emissions (NO and NO2) per capita	Siemens Green City Index; European Green Capital Award study
Fine particulate matter emissions (PM2.5)	g/cap	Annual particulate matter emissions (PM 2,5) per capita	Siemens Green City Index; European Smart Cities v1.0 (2007); European Green Capital Award study; Civitas
Air quality index	Index	Annual concentration of relevant air pollutants	RFSC; FIN Indicators; Rotterdam SCP; OECD; COMIND
Miscellaneous			
Noise pollution	% of people	Share of the population affected by noise >55 dB(a) at night time	ISO 37120; FIN Indicators; Rotterdam SCP; OECD; ClimateCon; European Green Capital Award study; City Protocol; URBES
Waste			

Municipal solid waste	t/cap/yr	The amount of municipal solid waste generated per capita annually	Siemens Green City Index; Smart city Profiles; Rotterdam SCP; Transform; Desire; OECD; ClimateCon; SCI; European Green Capital Award study; City Protocol
Recycling rate	% of tonnes	Percentage of city's solid waste that is recycled	Siemens Green City Index; Smart city Profiles; Rotterdam SCP; Desire; OECD; ClimateCon; CASBEE_City_2012; SCI; City Protocol; GCIF; 2000-Watt

4.3.5 Ecosystem

Indicator title	Indicator unit	Definition	Source
Share of green and water spaces	% in km2	Share of green and water surface area as percentage of total land area	CASBEE_City_2012
Change in number of native species	# of species	Net change in number of native species	City Protocol

4.4 Prosperity

4.4.1 Employment

Indicator title	Indicator unit	Definition	Source
Uneployment rate	% of people	Percentage of the labour force unemployed	ISO 37120, ClimateCon; SCI; European Green Capital Award study; City Protocol; UN HABITAT CPI; GCIF; Triple Helix Model; SCI; European Green Capital Award study; COMIND; RFSC; UNECE
Youth unemployment rate	% of people	Percentage of youth labour force unemployed	ISO 37120; European Green Capital Award study; City Protocol

4.4.2 Equity

Indicator title	Indicator unit	Definition	Source
Fuel poverty	% of households	The percentage of households unable to afford the most basic levels of energy	Eurbanlab; Transform

Affordability of housing	% of people	% of population living in affordable housing	Eurbanlab; UNECE; SCI

4.4.3 Green economy

Indicator title	Indicator unit	Definition	Source
Share of certified companies	% of companies	Share of companies based in the city holding an ISO 14001 certificate	
Share of Green Public Procurement	% in €	Percentage annual procurement using environmental criteria as share of total annual procurement of the city administration	FIN Indicators
Green jobs	% of jobs	Share of jobs related to environmental service activities that contribute substantially to preserving or restoring environmental quality	Green Digital Charter; SCI; Transform
Freight movement	# of movements	Freight movement is defined as the number of freight vehicles moving into an area (e.g. the city)	2DECIDE CIVITAS

4.4.4 Economic performance

Indicator title	Indicator unit	Definition	Source
Gross Domestic Product	€/cap	City's gross domestic product per capita	Triple Helix Model; Green Digital Charter; ClimateCon; City Protocol; UN Habitat CPI; GCIF; READY; UNECE
New business registered	#/100.000	Number of new businesses per 100,000 population	Triple Helix Model; European Green Capital Award study; City Protocol
Median disposable Income	€/household	Median disposable annual household income	ClimateCon; European Green Capital Award study; GCIF; COMIND; Triple Helix Model

4.4.5 Innovation

Indicator title	Indicator unit	Definition	Source

Creative industry	% of people	Share of people working in creative industries	Triple Helix Model; European Green Capital Award study; Smart city Wheel
Innovation hubs in the city	#/100.000	# of innovation hubs in the city, whether private or public, per 100.000 inhabitants	
Accessibility of open data sets	# stars	The extent to which the open city data are easy to use	City Protocol
Research intensity	% in euros	R&D expenditure as percentage of city's GDP	Triple Helix Model; ITU; UNECE; Smart city Wheel; European Smart Cities v1.0 (2007)
Open data	#/100.000	# of open government datasets per 100.000 inhabitants	

4.4.6 Attractiveness & competitiveness

Indicator title	Indicator unit	Definition	Source
Congestion	% in hours	Increase in overall travel times when compared to free flow situation (uncongested situation)	IDEAS; European Green Capital Award study; City protocol; 2Decide
Public transport use	#/cap/year	Annual number of public transport trips per capita	City Protocol; ISO 37120; GCIF
Net migration	#/1000	Rate of population change due to migration per 1000 inhabitants	CASBEE_City_2012; European Green Capital Award study
Population Dependency Ratio	#/100	Number of economically dependent persons (net consumers) per 100 economically active persons (net producers)	GCIF
International Events Hold	#/100.000	The number of international events per 100.000 inhabitants	Smart city Wheel
Tourism intensity	#/100.000	Number of tourist nights per year per 100.000 inhabitants	UNECE; European Green Capital Award study; Triple Helix Model

4.5 Governance

4.5.1 Organisation

Indicator title	Indicator unit	Definition	Source

Cross-departmental integration	Likert	The extent to which administrative departments contribute to “smart city” initiatives and management	Transform
Establishment within the administration	Likert	The extent to which the smart city strategy has been assigned to one department/director and staff resources have been allocated	Smart city Profiles
Monitoring and evaluation	Likert	The extent to which the progress towards a smart city and compliance with requirements is being monitored and reported	RFSC
Availability of government data	Likert	The extent to which government information is published	ITU

4.5.2 Community involvement

Indicator title	Indicator unit	Definition	Source
Citizen participation	% of projects	The number of projects in which citizens actively participated as a percentage of the total projects executed	Transform
Open public participation	#/100.000	Number of public participation processes per 100.000 per year	City Protocol
Voter participation	% of people	% of people that voted in the last municipal election as share of total population eligible to vote	ISO 37120; European Smart Cities v1.0 (2007); UNECE; European Green Capital Award study; City protocol; GCIF; COMIND

4.5.3 Multi-level governance

Indicator title	Indicator unit	Definition	Source
Strategies and policies			
Smart city policy	Likert	The extent to which the city has a supportive smart city policy	
Budget			
Expenditures by the municipality for a transition towards a smart city	€/capita	Annual expenditures by the municipality for a transition towards a smart city	Smart city Profiles

Multilevel			
Multilevel government	Likert	The extent to which the city cooperates with other authorities from different levels	RFSC

4.6 Propagation

As the potential for dissemination of smart city projects to other contexts or other cities is only relevent on the project level, indicators on propagation are not included on the city level.

5. CONCLUSIONS

5.1 Summary of achievements

Based on the inventory of indicators from 43 existing indicator sets for evaluating project and urban sustainability a set of indicators for assessing the impacts of smart city projects has been designed for CITYkeys. The majority of indicators in the set are derived from existing urban indicator frameworks. 25 project indicators and 15 city indicators have been newly formulated to fit the aims of CITYkeys.

The indicator selection for evaluating smart city projects has been linked with corresponding indicators on city level. Of the 99 project indicators, there are only 20 that can be quantitatively related (or aggregated) to a corresponding indicator on the city level. For 43 indicators on project level no corresponding city indicator could be found: all the (19) propagation indicators belong to this category, because this theme is only relevant for projects. Also several other indicators are useful for measuring the success of a project, but are too specific to be used on the city level.

This means that the possibilities to aggregate quantitatively from project to city level are limited. The majority of these indicators concern energy use, emissions from CO_2 and air pollutants, and waste generation, with some possibilities in the people and prosperity themes.

The resulting indicator selection responds to the wishes of cities and citizens for the coverage of their priorities and reflects city (sustainability) goals. Due to the multitude of different smart city projects, the CITYkeys indicator set focuses on impact indicators[4], as these can be used for all types of interventions. In addition, a limited number of generalised input, output and outcome indicators have been added that reflect the degree of smartness of a city (or a project).

5.2 Relation to continued developments

The current report reflects the state of development of the CITYkeys indicators. All indicators have been described in detail, with an indication of expected datasources. They have been tested in the Citykeys partner cities. Results form the testing have been incorporated in the selection of the indicators and their definitions[5].

5.3 Other conclusions and lessons learned

The intensive consultation process with partner cities and Lighthouse projects has contributed to a reasonably complete and comprehensive set of indicators, without confusing details, and which is reasonably balanced with regard to the city's objectives, certainly on the project level.

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[4] See Section 4.2 for definitions of types of indicators.

[5] Testing results are given in Aapo Huovila et al., 2016. Deliverable 2.4 Report on the case studies, CITYkeys report.

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APPENDICES

Further information is described in related background documents:

Appendix 1: Description of the project indicators (D1.3-A1; available to partners in the project intranet).

Appendix 2: Description of the city indicators (D1.3-A2; available to partners in the project intranet).

Appendix 3: Relation between city and project indicators (D1.3-A3; available to partners in the project intranet).

APPENDIX 1: DESCRIPTION OF THE PROJECT INDICATORS

People

Health

Improved access to basic health care services	
Description incl. justification	Health care access — as measured by the ease and timeliness with which people obtain medical services — is a key indicator of quality of care. Increased accessibility to basic health care is assumed to have social and economic benefits, because healthy people function better in society, are more productive at work etc.. Basic health care includes: - General practicioners - Hospitals, including emergency and chronic treatments - Baby/youth clinics - Pharmacies Accessibility includes e.g. to physical distance (<500m), 24hrs availability, e-health services, overcoming literacy and language barriers.
Definition	The extent to which the project has increased accessibility to basic health care
Calculation	Likert scale: No improvement – 1 — 2 — 3 — 4 — 5 — Very high improvement. 1. Not at all: the access to basic health care services was not improved. 2. Poor: there was little improvement in the accessibility of basic health care services. 3. Somewhat: access to basic health care services was improved, including a few important amenities such as a general practitioner or a pharmacy. 4. Good: access to a sufficient number of health care services are widely available offline and online (i.e. repeat prescriptions) was improved. 5. Excellent: access to a wide variety of basic health care services are widely available offline and online (i.e. first aid apps) was improved.
Strengths and weaknesses	Strengths: Easy to evaluate regarding distance and availability; indicator is relevant to the subtheme Health Weaknesses: Having access to a doctor is no guarantee for access to

	care. Although it is tried to make scoring the indicator as objectively as possible, a certain amount of subjectivity is present.
Scoring	Multiply Likert scale value by 2
Data requirements	
Expected data source	To be derived from project documentation and/or interviews with project leader or others involved in the project
Expected availability	If the smart city project has a health care component, it is expected that this information will be available. If there is no documentation available, the project leader should be able to provide insight upon which the assessor can base the score
Collection interval	After the project, but can also be used ex-ante to evaluate plans
Expected reliability	Because of the subjectivity that cannot be excluded, this indicator is not 100% reliable
Expected accessibility	If the smart city project concerns has a health care component, it is expected that this information will be accessible (no sensitivities).
References	
• http://healthland.time.com/2012/01/23/does-better-access-to-health-care-really-help-lower-costs/	

Encouraging a healthy lifestyle	
Description incl. justification	Simply telling people to change unhealthy behaviors doesn’t work. We often rely on automatic behaviors to get us through the day. People change if unhealthy behaviors become too inconvenient: making bad choices harder is actually the best way to help people get healthier. For example programming elevator doors to close really slowly actually motivates more people to climb stairs. Little changes like these reach everyone—not just the people targeted with a health message. And 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
Definition	The extent to which the project encourages 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 it is tried to make scoring the indicator as objectively as possible, a certain amount of subjectivity is present. Acceptance by people may be uncertain.
Scoring	Multiply Likert scale value by 2
Data requirements	
Expected data source	To be derived from project documentation and/or interviews with project leader
Expected availability	If the smart city project has a healthy lifestyle component, it is expected that this information will be available. If there is no documentation available, the project leader should be able to provide insight upon which the assessor can base the score.
Collection interval	After the project, but can also be used ex-ante to evaluate plans
Expected reliability	Because of the subjectivity that cannot be excluded, this indicator is not 100% reliable.
Expected accessibility	If the smart city project has a healthy lifestyle component, 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/	

Waiting time	
Description incl. justification	Reduction of waiting time is used as an indicator for the quality of health services. Patients may need to wait for health services for a number of reasons, including a lack of medical equipment or no available hospital beds, short-staffing, or inefficiencies in the organisation of services. Excessive waiting times to see a doctor or for non-emergency surgery can sometimes lead to adverse health effects such as stress, anxiety or pain. Dissatisfaction and strained patient-doctor relationships also damage public perceptions of the health system. While in some countries waiting times are a major health policy concern, others report no significant waiting times at all. Waiting times can vary per region, gender and socio-economic status.

	Waiting time is defined as: the days or weeks the patient had to wait to get an appointment when sick, or in need of medical attention from a doctor or nurse. Waiting times for specialist and elective surgery was the time between the patient being advised that they needed care and the appointment.
Definition	Percentage reduction in waiting time due to project
Calculation	(Waiting time in hours after project/waiting time in hours before project)*100 Note: Optimum waiting times are not necessarily zero. It can be cost-effective to maintain short queues of elective patients because the adverse health consequences of short delays are minimal, and there are savings in hospital capacity from allowing queues to form (Siciliani and Hurst, 2003). They may also deter patients who stand to gain only small health benefits from demanding treatment (Laudicella et al., 2010).
Strengths and weaknesses	Strengths: Reduction of waiting time is considered a success factor regarding health care and wellbeing, and as such is relevant to the subtheme health Weaknesses: Quality of health care is dependent of many more aspects than just waiting time. Waiting time seems to be too quantitative for such a complex ”service” like ”health service”
Scoring	Theoretically a project could reduce the waiting time to zero. However, in practice it is expected that a waiting time reduction of more than 50% is already very good and therefore awarded with a 10.

Normalisation	
Improvement	Score
0-1%	1
1-3%	2
3-5%	3
5-7%	4
7-10%	5
10-15%	6
15-20%	7
20-30%	8
30-50%	9
50-100%	10

Data requirements	
Expected data source	To be derived from project documentation and/or interviews with project leader
Expected availability	If the smart city project has a health care component, it is expected that this information will be available. If there is no documentation available, the project leader should be able to provide insight upon which the assessor can base the score.
Collection interval	After the project, but can also be used ex-ante to evaluate plans
Expected reliability	This indicator should be highly reliable. Since most countries use their own definitions, collecting comparable data on waiting times is difficult.
Expected accessibility	If the smart city project has a health care component, it is expected that this information will be accessible (no sensitivities)
References	
• http://www.oecd-ilibrary.org/sites/health_glance-2011-en/06/08/index.html;jsessionid=1r4hqfilepbgl.x-oecd-live-03?itemId=/content/chapter/health_glance-2011-59-en&_csp_=484d3d91b843a9804bc912701c46682d	

Safety

Reduction of traffic accidents	🚗 💻
Description incl. justification	Traffic accident rates and, specifically, fatality rates, can serve as indicators for the overall safety of the transportation system, the complexity and congestion of the roadway and transport network, the amount and effectiveness of traffic law enforcement, the quality of the transportation fleet (public and private), and the condition of the roads themselves (ISO/DIS 37120, 2013). Traffic deaths represent the most severe type of traffic safety failure, allowing cities to focus on their most urgent traffic safety needs. This indicator includes deaths due to any transportation-related proximate causes in any mode of travel (automobile, public transport, walking, bicycling, etc.): any death directly related to a transportation incident, even if death does not occur at the site of the incident, but is directly attributable to the accident. This indicator is particularly urgent in Central-Eastern European countries, where improvements in traffic infrastructures have not kept up with the rapidly growing traffic density. Transportation fatalities are used here as a proxy for all transportation injuries. Whereas many minor injuries are never reported—and thus cannot be measured— deaths are almost always reported. It is also worth noting that differences in the quality of the roadway, the quality of motorized vehicles, and the nature of law enforcement can change the relationship between injury and fatality. Cities and countries may have different definitions of

<table>
<tr><td></td><td>causality, specifically related to the amount of time that can elapse between a traffic incident and a death.</td></tr>
<tr><td>Definition</td><td>Percentage reduction of transportation fatalities due to the project</td></tr>
<tr><td>Calculation</td><td>((transportation fatalities after project/transportation fatalities before project)*100)-100</td></tr>
<tr><td>Strengths and weaknesses</td><td>Strengths:

Weaknesses: Traffic accidents without fatalities are not taken into account.</td></tr>
<tr><td>Scoring</td><td>Theoretically a project could reduce traffic accidents to zero. However, in practice it is expected that a reduction of more than 50% is already very good and therefore awarded with a 10.
<table>
<tr><th colspan="2">Normalisation</th></tr>
<tr><td>Improvement</td><td>Score</td></tr>
<tr><td>0-1%</td><td>1</td></tr>
<tr><td>1-3%</td><td>2</td></tr>
<tr><td>3-5%</td><td>3</td></tr>
<tr><td>5-7%</td><td>4</td></tr>
<tr><td>7-10%</td><td>5</td></tr>
<tr><td>10-15%</td><td>6</td></tr>
<tr><td>15-20%</td><td>7</td></tr>
<tr><td>20-30%</td><td>8</td></tr>
<tr><td>30-50%</td><td>9</td></tr>
<tr><td>50-100%</td><td>10</td></tr>
</table>
</td></tr>
<tr><td colspan="2">Data requirements</td></tr>
<tr><td>Expected data source</td><td>To be derived from traffic/accident statistics at city police departments and project documentation or interviews with project leader.</td></tr>
<tr><td>Expected availability</td><td>If the project concerns itself with traffic safety the information on accident hot spots and statistics of accidents should be available.</td></tr>
<tr><td>Collection interval</td><td>After the project , but can also be used ex-ante to evaluate plans</td></tr>
<tr><td>Expected reliability</td><td>This indicator should be highly reliable.</td></tr>
<tr><td>Expected accessibility</td><td>No sensitivities expected</td></tr>
<tr><td colspan="2">References</td></tr>
<tr><td colspan="2">• ISO/DIS 37120 (2013). Sustainable development and resilience of communities — Indicators for city services and quality of life. ICS 13.020.20
• http://ec.europa.eu/transport/road_safety/index_en.htm</td></tr>
</table>

<table>
<tr><td colspan="2">Reduction in crime rate</td></tr>
<tr><td>Description incl. justification</td><td>The number of violence, annoyances and crimes is a lead indicator of feelings of personal safety (ISO/DIS 37120, 2013). Violence is the intentional use of physical force or power, threatened or actual, against oneself, another person or against a group or community, that either results in or has a high likelihood of resulting in injury, death, psychological harm, maldevelopment or deprivation (e.g. murder). Crime refers to illegal acts in general (e.g. car radio theft). Annoyances are not necessarily illegal, but do cause hinder (e.g. littering).</td></tr>
<tr><td>Definition</td><td>Percentage reduction in number of violences, annoyances and crimes due to the project</td></tr>
<tr><td>Calculation</td><td>((crimes after project/crimes before project)*100)-100</td></tr>
<tr><td>Strengths and weaknesses</td><td>Strengths:
Weaknesses: Not all crime is reported.</td></tr>
<tr><td>Scoring</td><td>Theoretically a project could reduce crime to zero. However, in practice it is expected that a reduction of more than 50% is already very good and therefore awarded with a 10.
<table>
<tr><th colspan="2">Normalisation</th></tr>
<tr><td>Improvement</td><td>Score</td></tr>
<tr><td>0-1%</td><td>1</td></tr>
<tr><td>1-3%</td><td>2</td></tr>
<tr><td>3-5%</td><td>3</td></tr>
<tr><td>5-7%</td><td>4</td></tr>
<tr><td>7-10%</td><td>5</td></tr>
<tr><td>10-15%</td><td>6</td></tr>
<tr><td>15-20%</td><td>7</td></tr>
<tr><td>20-30%</td><td>8</td></tr>
<tr><td>30-50%</td><td>9</td></tr>
<tr><td>50-100%</td><td>10</td></tr>
</table>
</td></tr>
<tr><td colspan="2">Data requirements</td></tr>
<tr><td>Expected data source</td><td>To be derived from crime statistics of police departments, project documentation and/or interviews with project leader.</td></tr>
<tr><td>Expected availability</td><td>Information on crime rates should be readily available with the above sources. The influence of the project on the crime rate is more difficult to estimate.</td></tr>
<tr><td>Collection interval</td><td>After the project , but can also be used ex-ante to evaluate plans</td></tr>
<tr><td>Expected reliability</td><td>It might be difficult to establish a reliable connection between the project and the crime rate.</td></tr>
</table>

Expected accessibility	Crime rates are public information
References	
• ISO/DIS 37120 (2013). Sustainable development and resilience of communities — Indicators for city services and quality of life. ICS 13.020.20	

Improved cybersecurity	💻
Description incl. justification	Cybersecurity is defined as “the discipline of ensuring that ICT systems are protected from attacks and incidents, whether malicious or accidental, threatening the integrity of data, their availability or confidentiality, including attempts to illegally ‘exfiltrate’ sensitive data or information out of the boundaries of an organization” (ITU, 2015). Cybersecurity will certainly gain importance in the near future because of increased digitalisation and the development of the Internet of Things (IoT) and highly increasing number of cyberattacks (Symantec, 2014). Cybersecurity is important for smart cities because smart cities with ICT as key enabler mean increasing generation of data, ICT complexity and hyper-connectivity which will also mean increasing vulnerability, both to malicious attacks and unintentional incidents. This indicator analyses the effort made in the project to ensure and/or improve cybersecurity, for instance the extent to which the project is prepared to handle risks in cybersecurity (i.e. has made a risk assessment), is prepared to manage possible disturbances (has a contingency plan and means to implement it) and use secure information systems (certified and accredited prior to deployment).
Definition	The extent to which the project ensures cybersecurity
Calculation	Likert scale Not at all — 1 — 2 — 3 — 4 — 5 — Very high 1. Not at all: Cybersecurity hasn’t received any attention in the project planning, even though the project involves the use of ICT. 2. Low: A risk assessment on cybersecurity has been made for the project but there is either no contingency plan or high risks remain present. 3. Moderate: A risk assessment on cybersecurity has been made for the project and there is a contingency plan for it. 4. High: A risk assessment on cybersecurity has been made for the project and there is a contingency plan for it. Risks on cyber security are low. 5. Very high A risk assessment on cybersecurity has been made for the project and there is a contingency plan for it. Risks on

	cyber security are low. The project uses only information systems with security assessment approvals (certified and accredited prior to deployment).
Strengths and weaknesses	Strengths: It is expected that this indicator is easy and quick to evaluate. Weaknesses: In some cases all information related to cybersecurity can be confidential and therefore not easily accessible. However, the information needed to evaluate this indicator is kept at high level and is therefore not expected to be confidential. Although it is tried to make scoring the indicator as objectively as possible, a certain amount of subjectivity is present.
Scoring	Multiply Likert scale value by 2
Data requirements	
Expected data source	To be derived from project documentation or interviews with project leader.
Expected availability	The information should be available with the above sources.
Collection interval	After project completion, but can also be used ex-ante to evaluate plans.
Expected reliability	Because of the subjectivity that cannot be excluded, this indicator is not 100% reliable
Expected accessibility	Good. In some cases all information related to cybersecurity can be confidential and therefore not easily accessible. However, the information needed to evaluate this indicator is kept at high level and is therefore not expected to be confidential.
References	
• ITU, 2015. “Cybersecurity, data protection and cyber resilience in smart sustainable cities”. ITU-T FG-SSC Technical report. • Symantec, 2014. Internet security threat report 2014 – Volume 19. Available at: http://www.symantec.com/content/en/us/enterprise/other_resources/b-istr_main_report_v19_21291018.en-us.pdf • ITU, 2014. ”A cybersecurity indicator of risk to enhance confidence and security in the use of telecommunication/information and communication technologies”. Recommendation ITU-T X.1208 of SERIES X: Data networks, open system communications and security. Cyberspace security – Cybersecurity.	

Improved data privacy	💻
Description incl. justification	Data privacy, or information privacy, is the privacy of personal information and usually relates to personal data stored on computer systems (Technopedia). Privacy concerns exist wherever personally identifiable information or other sensitive information is collected and stored – in digital form or otherwise. If personal data is being collected, the purpose of data collection

	should be known and the collected data shouldn't be used for any other purpose. The owner of the data i.e. the administrator of the register should also be defined. If a smart city project uses private data (e.g. on energy consumption), authorisations from the end-users need to be acquired. It is recommended that such authorisations are made in form of a written agreement that clearly specifies the data to be collected, collection interval, use purpose and that the data won't be used for other purposes, and who will have access to the data. It is to be noted that information based on personal or private data can often be anonymised e.g. through aggregation. This indicator analyses the extent to which the project has protected data, for instance, by following regulations on data protection and implementing proper procedures to protect personal or private data. Data protection refers to the tools and processes used to store data relevant to a certain ICT system or environment, as well as recover lost data in case of an incident – be it fraudulent, accidental or caused by a natural disaster. One critical element about data is the concept of data ownership, which refers to who is in charge of data, who can authorize or deny access to certain data, and is responsible for its accuracy and integrity, in particular personally identifiable information (PII) . (ITU, 2015)
Definition	The extent to which data collected by the project is protected
Calculation	Likert scale Not at all — 1 — 2 — 3 — 4 — 5 — Very high 1. Project involves use of personal or private data but national regulations/laws on its protection are not followed. 2. National regulations/laws on protection of personal data are followed. 3. National regulations on protection of personal data and EU Directive on the Protection of Personal Data (95/46/EG) are followed. 4. Relevant national and European regulations on data protection are followed and written agreements are made for use of end-users' private/personal data. 5. Relevant national and European regulations on data protection are followed and written agreements are made for use of end-users' private/personal data. Possibly collected personal/private data is accessed only by agreed persons and is heavily protected from others (e.g. locked or database on internal server with firewalls and restricted access).
Strengths and weaknesses	Strengths: Weaknesses: Although it is tried to make scoring the indicator as objectively as possible, a certain amount of subjectivity is present.
Scoring	Multiply Likert scale value by 2

Data requirements	
Expected data source	To be derived from project documentation or interviews with project leader.
Expected availability	The information will be readily available with the above sources
Collection interval	After project completion, but can also be used ex-ante to evaluate plans.
Expected reliability	Because of the subjectivity that cannot be excluded, this indicator is not 100% reliable
Expected accessibility	Good. In some cases all information related to cybersecurity can be confidential and therefore not easily accessible. However, the information needed to evaluate this indicator is kept at high level and is therefore not expected to be confidential.

References

- ITU, 2015. “Cybersecurity, data protection and cyber resilience in smart sustainable cities”. ITU-T FG-SSC Technical report.
- Technopedia. https://www.techopedia.com/definition/10380/information-privacy

Access to (other) services

Access to public transport	🚗
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..
Definition	The extent to which public transport stops are available within 500m
Calculation	Likert scale: No stops – 1 — 2 — 3 — 4 — 5 — Many stops 1. No stops 2. Relatively few stops 3. A relatively reasonable number of stops

	4. A relatively sufficient number of stops 5. Relatively many stops of public transport 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 500m of said building. A point of access is defined as the location where a mode of transportation can be accessed.
Strengths and weaknesses	Strengths: 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 (1). Although it is tried to make scoring the indicator as objectively as possible, a certain amount of subjectivity is present.
Scoring	Multiply Likert scale value by 2
Data requirements	
Expected data source	Routing and schedule plans of public transport and/or project documentation or interviews with the project leader
Expected availability	The required information should be readily available from above sources.
Collection interval	After the project, but can also be used ex-ante to evaluate plans
Expected reliability	Because of the subjectivity that cannot be excluded, this indicator is not 100% reliable.
Expected accessibility	No sensitivities expected
References	
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Quality of public transport	
Description incl. justification	The overall quality of transport services (Level of Service, or LOS) encompasses a variety of aspects - comfort, travel time, reliability, safety, privacy, etc. - but travellers usually share a holistic concept of quality, which this indicator seeks to measure. Public transport is in continuous competition with other transport modes, particularly the private car, and the (general perception of the) overall public transport quality is one of the aspects influencing individual choices. Evaluating the performance of the public transport system avoids multiple separate quantitative subindicators analyzing the various aspects of the system. And because public transport operators

	regularly perform customer surveys, this indicator uses the results of the surveys to assess the perception of public transport quality.
Definition	The perception of users on the quality of the public transport service
Calculation	Likert scale Dissatisfied – 1 – 2 – 3 – 4 – 5 – Very satisfied 1. Very dissatisfied 2. Somewhat dissatisfied 3. Neither dissatisfied nor satisfied 4. Somewhat satisfied 5. Very satisfied Note: The answer depends very much on the formulation of the question adopted. The question to be asked could be for instance "How do you rate the quality of public transport in your city?" Each target group must be represented by the survey.
Strengths and weaknesses	Strenghts: Weaknesses: The rating is subjective.
Scoring	Multiply Likert scale value by 2
Data requirements	
Expected data source	Public transport operators usually perform surveys on aspects of service quality on which this indicator can be based.
Expected availability	Information on the perceived quality of public transport services is not a standard feature in project documentations. Thus, for the near future it will be usually necessary to conduct a survey to get the data, in cooperation with the public transport operators.
Collection interval	After the project, but can also be used ex-ante to evaluate plans
Expected reliability	Depending on sample size; sufficient data should be collected to give a good representation of the target groups identified. Because of the subjectivity that cannot be excluded, this indicator is not 100% reliable.
Expected accessibility	The survey data will be in possession of the public transport operators. It is uncertain to what extent they are willing to share the outcome of the survey.
References	
• CIVITAS D4.10 – Applied framework for evaluation in CIVITAS Plus II • For other approaches to evaluate the quality of public transport, see VTPI 2015: Multi-Modal Level-of-Service Indicators. Tools For Evaluating The Quality of Transport Services and Facilities, available online at http://www.vtpi.org/tdm/tdm129.htm	

Improved access to vehicle sharing solutions	

Description incl. justification	Providing opportunities for sharing vehicles like (e-)bicycles, (e-)cars and (e-)scooters, can decrease the need for and use of private cars, thereby contributing to an accessible, green and healthy neighbourhood. Cycling is a healthy, flexible, cheap and sustainable way to get from a to b over a short distance. Many European cities therefore would like to stimulate cycling, but in countries without a cycling culture there is limited private ownership of bikes. Car-sharing is about not owning a car, but renting it from a car-sharing company or sharing the car with friends, family, neighbours or co-workers (1,2). Car-sharing is an attractive option for people who drive less than 10.000 km a year. Car-sharers are more likely to travel by bike, saving on car use and improving their health. Car-sharing also decreases the need for parking space, less vehicles are on the road and less pollution is emitted. Car sharing may furthermore improve social cohesion in the neighborhood. This indicator assesses whether the possibilities for vehicle sharing have been improved due to the project. Improvements include more vehicle sharing locations, shorter distance to the nearest location, increased number of vehicles available and to ICT solutions that provide easy access to information on vehicle sharing options.
Definition	Improved accessibility to vehicle sharing solutions
Calculation	Likert scale: No improvement – 1 — 2 — 3 — 4 — 5 — Very high improvement. 1. Not at all: the possibilities for vehicle sharing were not improved. 2. Poor: there was little improvement in the possibilities for vehicle sharing. 3. Somewhat: the possibilities for vehicle sharing were somewhat improved. 4. Good: the possibilities for vehicle sharing were sufficiently improved. 5. Excellent: the prossibilities for vehicle sharing were very much improved.
Strengths and weaknesses	Strengths: Weaknesses: although it is tried to make scoring the indicator as objectively as possible, a certain amount of subjectivity is present. Other factors that are usually considered relevant for the choice of a specific transport mode (e.g. service prices, travel speed, access to attractive destinations) are not considered.
Scoring	Multiply Likert scale value by 2
Data requirements	
Expected data	project documentation and/or interviews with project leader, open

source	data platforms, vehicle sharing operators.
Expected availability	Data is scattered, but should be easily available.
Collection interval	After the project, but can also be used ex-ante to evaluate plans
Expected reliability	Because of the subjectivity that cannot be excluded, this indicator is not 100% reliable.
Expected accessibility	It is not expected that the vehicle sharing companies will consider the number of vehicles as secret information.

References

- http://utrechtdeelt.nl/daarom-autodelen/wat-is-autodelen/
- http://utrechtdeelt.nl/daarom-autodelen/de-voordelen/
- IDP oJ: The Bike Sharing Planning Guide
- DGNBn 2012: Handbook Urban Neighborhoods

Extending the bike route network	
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	Percentage increase of the length of cycling roads
Calculation	((km’s cycling roads after the project/km’s cycling roads before the project)*100)-100
Strengths and weaknesses	Strengths: possibility to trigger cycling activities, this indicator is relevant to the subtheme access to services as well as health and the planet-theme. 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).
Scoring	Theoretically a project could increase the length of cycling roads with 100% or more. However, in practice it is expected that an increase of more than 50% is already very good and therefore

awarded with a 10.

Normalisation	
Improvement	Score
0-1%	1
1-3%	2
3-5%	3
5-7%	4
7-10%	5
10-15%	6
15-20%	7
20-30%	8
30-50%	9
>50%	10

Data requirements	
Expected data source	Project documentation and/or interviews with project leader
Expected availability	The information will be readily available with the above sources
Collection interval	After the project, but can also be used ex-ante to evaluate plans
Expected reliability	This indicator should be highly reliable.
Expected accessibility	No sensitivities expected

References

- ISO/DIS 37120 (2013). Sustainable development and resilience of communities — Indicators for city services and quality of life. ICS 13.020.20

Access to public amenities	
Description incl. justification	It is presumed that nearby availability of amenities leads to a lively neighbourhood and less car use. Amenities in the urban environment make an area more enjoyable and contribute to its desirability. It is assumed that these factors contribute to the success of smart city projects. Public amenities are services/facilities which are provided by the government or town/city councils for the general public to use, with or without charge. Examples of the types of public amenities considered here are social welfare points, social meeting centers, theatres and libraries. (note: other public amenities such as green

	spaces, public recreation and healthcare facilities are already covered in separate indicators). Access to public amenities is an indicator which partially exposes the mix and distribution of different uses in an urban area, indicating the availability of public services in a close proximity of residential location of inhabitants.
Definition	The extent to which public amenities are available within 500m
Calculation	Likert scale: No public amenities – 1 — 2 — 3 — 4 — 5 — Relatively many public amenities. 1. No amenities: no public amenities whatsoever are available (e.g. no basic nor additional). 2. Relatively few amenities: only few basic public amenities are available (e.g. a small park). 3. A reasonable number of amenities: basic public amenities are available including a few important amenities such as a park and a community center. 4. A sufficient number of amenities: basic public amenities are widely available (e.g. open green spaces, public recreation) as well as many important public amenities (theatres). 5. Relatively many amenities: the area surrounding the project's central living area includes a wide variety of public amenities including numerous basic amenities (e.g. green spaces, public recreation facilities) as well as numerous important public amenities (e.g. theatres, zoos). The evaluator may also take into account the type of amenities, i.e. the availability of public recreation is more important than the availability of drinking fountains.
Strengths and weaknesses	Strengths: the indicator is relevant to access to services, with a link to quality of the built environment. Weaknesses: although it is tried to make scoring the indicator as objectively as possible, a certain amount of subjectivity is present. Moreover, the indicator does not take into account the quality of the public amenities, nor the user acceptance
Scoring	Multiply Likert scale value by 2
Data requirements	
Expected data source	Google maps; project documentation and/or interviews with project leader, planning documents
Expected availability	High (everyone can access google maps); other relevant information should be available at the city planning office
Collection interval	After the project, but can also be used ex-ante to evaluate plans

Expected reliability	Because of the subjectivity that cannot be excluded, this indicator is not 100% reliable.
Expected accessibility	As a component of a successful project and selling point in a marketing sense, it is expected that this information will be accessible. No sensitivities expected.
References	
• Eurbanlab (2014). The Eurbanlab Selection of Indicators. Version 4.	

Access to commercial amenities	
Description incl. justification	It is presumed that availability of amenities leads to a lively neighbourhood and less car use. Amenities in the urban environment make an area more enjoyable and contribute to its desirability. It is assumed that these factors contribute to the success of smart city projects. Commercial amenities are services/goods for daily use provided by private actors. Typical commercial amenities include shops for bread, fish, meat, fruits and vegetables, general food shops (i.e. supermarkets), press, and pharmaceutical products (City Protocol (2015)). Access to commercial amenities is an indicator which partially exposes the mix and distribution of different uses in an urban area, indicating the availability of commercial amenities in a close proximity of residential location of inhabitants.
Definition	The extent to which commercial amenities are available within 500m
Calculation	Likert scale: 1. No amenities: not even the day to day basic amenities are present (e.g. no supermarkets, shops). Residents will need to leave the area for all other. 2. Relatively few amenities: A few of the day to day basic amenities are present (small grocery store, kiosk). Residents will need to leave the area to find most other amenities (e.g. sports, restaurants etc.). 3. A relatively reasonable number of amenities: day to day basics are reasonably present including a few additional (e.g. restaurants/bars and services). 4. A relatively sufficient number of amenities: day to day basics are sufficiently present, including many additional (e.g. shopping malls, variety of shops, restaurants etc.). 5. Relatively many amenities: the area includes a wide variety of commercial amenities, making it a vibrant center of the

	region where there is little need to leave the area. NB. The evaluator may also take into account the type of amenities and their relative importance.
Strengths and weaknesses	Strengths: the indicator is relevant to access to services, with a link to quality of the built environment. Weaknesses: although it is tried to make scoring the indicator as objectively as possible, a certain amount of subjectivity is present. The indicator does not take into account the quality of the commercial amenities, nor the user acceptance.
Scoring	Multiply Likert scale value by 2
Data requirements	
Expected data source	Google maps; project documentation and/or interviews with project leader
Expected availability	High (everyone can access google maps)
Collection interval	After the project, but can also be used ex-ante to evaluate plans
Expected reliability	Because of the subjectivity that cannot be excluded, this indicator is not 100% reliable.
Expected accessibility	No sensitivities expected.
References	
• Eurbanlab (2014). The Eurbanlab Selection of Indicators. Version 4. • City Protocol (2015). CPWD - [-] 002 Anatomy Indicators- City Indicators. City Protocol Agreement (CPWD-[-]002)	

Increase in online government services	💻
Description incl. justification	The internet has proven to be an important enabler. Not only for sharing information, but more and more for online services such as shopping, but also for municipal services such as making an appointment for a new passport or report something stolen to the police. This indicator analyses the improvement in providing online government services.
Definition	The extent to which access to online services provided by the city was improved by the project.
Calculation	Likert scale: No improvement – 1 — 2 — 3 — 4 — 5 — Very much improved. 1. Not at all: access to online services was not at all improved. 2. Poor: there was little improvement of access to online services, such as a basic municipal web site. 3. Somewhat: there was some improvement of access to

	online services, such as the possibility to schedule appointments online 4. Good: a sufficient improvement of access to online services, such as reporting minor issues to the police (i.e. passport loss, stolen goods). 5. Excellent: access to online services were extensively improved, including open data platforms.
Strengths and weaknesses	Strengths: Weaknesses: specific indicator applicable to few projects; although it is tried to make scoring the indicator as objectively as possible, a certain amount of subjectivity is present.
Scoring	Multiply Likert scale value by 2
Data requirements	
Expected data source	Project documentation and/or interviews with project leader
Expected availability	It is expected that the information is available, if the project concerns itself with access to online services.
Collection interval	After the project, but can also be used ex-ante to evaluate plans
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	
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Improved flexibility in delivery services	
Description incl. justification	The internet has proven to be an important enabler. Not only for sharing information, but more and more for online services such as shopping. It provides the flexibility of shopping when it is convenient for the consumer, since web stores never close. However, all these online orders need to be delivered as well. This indicator analyses the improvement in providing flexibility in delivery services. Examples of improved delivery options: • Possibility to reschedule the delivery appointment to a more convenient time; • Possibility to have the package accepted by a neighbor; • Possibility to pick up the package at a distribution point near the home (such as a post office or a super market).
Definition	The extent to which flexibility in delivery services was improved by the project.

Calculation	Likert scale: No improvement – 1 — 2 — 3 — 4 — 5 — Very much improved. 1. Not at all: flexibility in delivery services was not at all improved. Receiving a package requires the consumer to be home during regular business hours (the default). 2. Poor: there was little improvement of flexibility in delivery services, providing one additional option to the default. 3. Somewhat: there was some improvement of flexibility in delivery services, providing two additional options to the default. 4. Good: a sufficient improvement of flexibility in delivery services, providing three additional options to the default. 5. Excellent: flexibility in delivery services was extensively improved, providing more than three additional options to the default.
Strengths and weaknesses	Strengths: Weaknesses: specific indicator applicable to few projects; although it is tried to make scoring the indicator as objectively as possible, a certain amount of subjectivity is present.
Scoring	Multiply Likert scale value by 2
Data requirements	
Expected data source	Project documentation and/or interviews with project leader; interviews with end users.
Expected availability	It is expected that the information is available, if the project concerns itself with flexibility in delivery services.
Collection interval	After the project, but can also be used ex-ante to evaluate plans
Expected reliability	Because of the subjectivity that cannot be excluded, this indicator is not 100% reliable.
Expected accessibility	No sensitivities expected.
References	
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Education

Improved access to educational resources	🚗 💻 🏢
Description incl. justification	Education and training is critical to enhance human creativity and social quality and to prevent social exclusion (ITU, 2014). Next to traditional education, i.e. primary, secondary and tertiary

	educational facilities, this indicator also emphasizes the importance of life-long learning. 'Lifelong learning' is the "ongoing, voluntary, and self-motivated" pursuit of knowledge for either personal or professional reasons. Therefore, it not only enhances social inclusion, active citizenship, and personal development, but also self-sustainability, rather than competitiveness and employability (EC, 2006). In addition, the number of years of education is strongly associated with the health of populations in both developed and developing countries (ITU, 2014). This indicator analyses the effort made by the project to improve access for all to adequate and affordable educational services. This access includes: physical access to educational institutions, e.g. schools, universities, libraries (number and distance), and digital access (e-learning) to education resources (e.g. open, well-documented and well-indexed).
Definition	The extent to which the project improves accessibility to educational resources
Calculation	Likert scale: Not at all – 1 – 2 – 3 – 4 – 5 – very much improved access 1. Not at all: the access to educational resources was not improved. 2. Poor: there was little improvement in the accessibility to educational resources. 3. Somewhat: access to basic educational resources was physically improved, including a few important amenities such as a primary school or a library in the neighbourhood (<500m). 4. Good: access to a sufficient number of educational resources widely available offline (schools, libraries) and online (i.e. registration for courses) was improved. 5. Excellent: access to a wide variety of educational resources widely available offline (schools, libraries, universities, museums) and online (i.e. Massive Open Online Courses) was improved.
Strengths and weaknesses	Strengths: providing education for all is an important policy objective Weaknesses: access to education says nothing about quality or uptake. Limited applicability. Although it is tried to make scoring the indicator as objectively as possible, a certain amount of subjectivity is present.
Scoring	Multiply Likert scale value by 2
Data requirements	
Expected data source	To be derived from project documentation and/or interviews with project leader

Expected availability	It is expected that the required information can be provided by the above sources
Collection interval	After the project, but can also be used ex-ante to evaluate plans
Expected reliability	Because of the subjectivity that cannot be excluded, this indicator is not 100% reliable.
Expected accessibility	No sensitivities expected.
References	
• ITU (2014). Key performance indicators (KPIs) definitions for Smart Sustainable Cities. SSC-0162-rev3 • Commission of the European Communities (2006). "Adult learning: It is never too late to learn". COM(2006) 614 final. Brussels, 23.10.2006.	

Increased environmental awareness	
Description incl. justification	Awareness of environmental problems is important for creating support for environmental projects and programs. This indicator, therefore, assesses the extent to which the project has used opportunities for increasing environmental awareness and educating about sustainability and the environment.
Definition	The extent to which the project has used opportunities for increasing environmental awareness and educating about sustainability and the environment.
Calculation	Likert scale: Not at all – 1 – 2 – 3 – 4 – 5 – very much 1. Not at all: opportunities to increase environmental awareness were not taken into account in the project communication 2. Poor: opportunities to increase environmental awareness were slightly taken into account in the project communication. 3. Somewhat: opportunities to increase environmental awareness were somewhat taken into account in the project communication, at key moments in the project there was attention for this issue. 4. Good: opportunities to increase environmental awareness were sufficiently taken into account in the project communication, the project utilized many possibilities to address this issue in their communications. 5. Excellent: opportunities to increase environmental awareness were taken into account in the project communication, the project utilized every possibility to address this issue both in online and offline communications.

Strengths and weaknesses	Strengths: Weaknesses: although it is tried to make scoring the indicator as objectively as possible, a certain amount of subjectivity is present.
Scoring	Multiply Likert scale value by 2
Data requirements	
Expected data source	To be derived from project documentation and interviews with the project leader and possibly other project partners.
Expected availability	If the project has paid special attention to environmental education, this will be reflected in the project documents and activities undertaken will be known to the project leader.
Collection interval	After project completion, or to be used ex-ante to evaluate plans
Expected reliability	Because of the subjectivity that cannot be excluded, this indicator is not 100% reliable.
Expected accessibility	No sensitivities expected
References	
●	

Improved digital literacy	💻
Description incl. justification	The European Commission has acknowledged digital competence as a key skill for lifelong learning and essential for participating in our increasingly digitalized society (EC, 2013). The ECDL foundation states that digital literacy is now a critical factor in supporting the overall growth of an economy and development of society (ECDL, 2009). Digital competence can be broadly defined as the confident, critical and creative use of ICT to achieve certain goals. Digital competence is a transversal key competence which, as such, enables us to acquire other key competences (e.g. language, mathematics, learning to learn, cultural awareness). However, in practice many people currently lack digital capabilities. The four main components of the digital divide are access, affordability, relevancy of content and skills (ECDL, 2009). Many national and international policies and investments focus on addressing the first 3 components, often to the detriment of a structured focus on skills. It appears very difficult to measure the actual increase in digital literacy (ECDL, 2009). Therefore, the assessment will focus on the intention of the project and the effort made to improve digital literacy, taking into account the 5 main competence areas information, communication, content-creation, safety and problem-

	solving (EC, 2013).
Definition	The extent to which the project has attempted to increase digital literacy
Calculation	The indicator provides a qualitative measure and is rated on a five-point Likert scale: No at all – 1 — 2 — 3 — 4 — 5 — Very much 1. No increase: the project has paid no attention to digital literacy. 2. Small increase: Digital literacy has received some attention in the project proposal, but not as an important element. 3. Some increase: some measures, like a training, programme or a theme week, have been taken to increase digital literacy. 4. Significant increase: Increasing digital literacy is an important element of the project and various measures have been taken. 5. High increase: digital literacy was a main aim of the project and has received broad attention.
Strengths and weaknesses	Strengths: the indicator allows the evaluation and comparability of a wide range of types of project and of (still to-be-developed) solutions. Weaknesses: although it is tried to make scoring the indicator as objectively as possible, a certain amount of subjectivity is present. The actual increase in digital literacy is not evaluated.
Scoring	Multiply Likert scale value by 2
Data requirements	
Expected data source	To be derived from project documentation, an interview with the project leader and stakeholder consultation (including citizens).
Expected availability	The intention will be readily available in project documentation. The actual effort made by the project can easily be provided by the project leader with a consistency check with other stakeholders.
Collection interval	After project completion, or to be used ex-ante to evaluate plans
Expected reliability	Because of the subjectivity that cannot be excluded, 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

- European Commission (2013). DIGCOMP: A Framework for Developing and Understanding Digital Competence in Europe. JRC Scientific and Policy Reports, JRC83167. EUR 26035 EN, ISBN 978-92-79-31465-0 (pdf), ISSN 1831-9424 (online), doi:10.2788/52966
- ECDL Foundation (2009). Digital Literacy Report.

Diversity and Social cohesion

<table>
<tr><th colspan="2">People reached</th><th></th></tr>
<tr><td>Description incl. justification</td><td colspan="2">A Smart City project is usually most successful if the entire target group of a service participates. For example if all electrical car owners join in optimizing their battery use to improve the energy system efficiency of the district. In addition, a high score on people reached can be seen as a signal of increased community engagement due to the project. The effort the project will make towards reaching the full extend of its target group can vary and with it the size of the target audience. Therefore, this effort and target audience have to be clearly defined before assessing the indicator.</td></tr>
<tr><td>Definition</td><td colspan="2">Percentage of people in the target group that have been reached and/or are activated by the project</td></tr>
<tr><td>Calculation</td><td colspan="2">(number of citizens reached/total number of citizens considered as the total target group of the project) * 100%</td></tr>
<tr><td>Strengths and weaknesses</td><td colspan="2">Strengths: key indicator with regard the indicator is relevant to assess the output of a project with regard to social cohesion
Weaknesses: target audience has to be clearly defined before assessing the indicator. The indicator does not describe availability (the degree to which the target group has the means to be reached by the project [do they all have smart phones that can run a required app?]).</td></tr>
<tr><td>Scoring</td><td colspan="2">Theoretically a project could reach the total target group. However, in practice it proves more difficult and points are already awarded for small steps up to 40% .
<table>
<tr><th colspan="2">Normalisation</th></tr>
<tr><td>Improvement</td><td>Score</td></tr>
<tr><td>0-5%</td><td>1</td></tr>
<tr><td>5-10%</td><td>2</td></tr>
<tr><td>10-15%</td><td>3</td></tr>
<tr><td>15-20%</td><td>4</td></tr>
<tr><td>25-30%</td><td>5</td></tr>
</table>
</td></tr>
</table>

30-35%	6
35-40%	7
40-60%	8
60-80%	9
80-100%	10

Data requirements

Expected data source	To be derived from project documentation and/or interviews with the project leader
Expected availability	Since this is related to the success of the project, it is expected that this information will be available (or can be estimated).
Collection interval	After the project, but can also be used ex-ante to evaluate plans
Expected reliability	The percentage is reliable, the challenge is in the definitions.
Expected accessibility	Since this is related to the success of the project, it is expected that this information will be accessible

References

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Increased consciousness of citizenship

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. <u>Personal identity and citizenship</u>: awareness, pride, obedience to the law, equality 2. <u>National identity</u>: respect for the national authorities, belief in the current political system, development of the country 3. <u>Moral consciousness</u>: being a good citizen in public and private, trusting that others are too 4. <u>Ecological consciousness</u>: awareness of the finite nature of resources, thinking about environmental consequences of actions 5. <u>Social citizenship</u>: family values and virtues, actively concerned with others at home and abroad

Definition	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 increase – 1 — 2 — 3 — 4 — 5 — High increase 1. None: The project has made no effort to increase civic consciousness. 2. Little: The project has made a small effort to increase civic consciousness. 3. Somewhat: The project has developed some initiatives to increase civic consciousness. 4. Significant: The project has executed several activities to increase civic consciousness 5. High: increasing civic consciousness was (one of) the main goals of the project 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. Weaknesses: although it is tried to make scoring the indicator as objectively as possible, a certain amount of subjectivity is present.
Scoring	Multiply Likert scale value by 2
Data requirements	
Expected data source	To be derived from project documentation and interviews with the project leader and other partners involved.
Expected availability	The intention will be readily available in project documentation. The actual effort made by the project can easily be provided by the project leader with a consistency check with other project partners.
Collection interval	After project completion, or to be used ex-ante to evaluate plans
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	

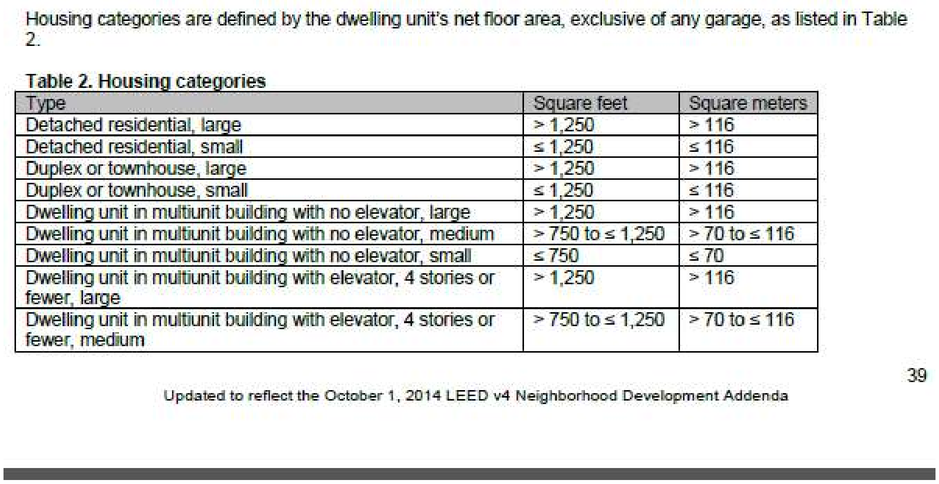
Increased participation of vulnerable groups	
Description incl. justification	Vulnerable and other groups whose opinions or contributions are not reflected well enough in our society (like women, minorities and the disabled), require special attention to be included in the community, thereby enhancing social cohesion and diversity and tapping into underdeveloped social capital. One can think of many ways to increase this participation, for instance: - Physical, e.g. improved accessibility for wheelchairs; - Digital, e.g. facilitating online access or providing information pages online - Financial, e.g. financial aid to participate in sports or cultural activities - Organisational, e.g. through quotums on participation of underrepresented groups (for example in the workforce, although this is considered controversial by some)
Definition	The extent to which project has led to an increased participation of groups that are not well represented in the society
Calculation	The indicator provides a qualitative measure and is rated on a five-point Likert scale: No at all – 1 — 2 — 3 — 4 — 5 — Excellent 1. Not at all: the project has not increased participation of groups not well represented in society. 2. Poor: the project has achieved little when it comes to participation of groups not well represented in society . 3. Fair: the project has somewhat increased the participation of groups not well represented in society 4. Good: the project has significantly increased the participation of groups not well represented in society 5. Excellent: Participation of groups not well represented in society has clearly been hugely improved due to the project.
Strengths and weaknesses	Strengths: the indicator allows the evaluation and comparability of a wide range of types of project and of (still to-be-developed) solutions and is relevant to the subtheme diversity & social cohesion. Weaknesses: although it is tried to make scoring the indicator as objectively as possible, a certain amount of subjectivity is present.
Scoring	Multiply Likert scale value by 2
Data requirements	
Expected data source	To be derived from project documentation and interviews with the project leader and stakeholders (including representatives of the groups targeted).

Expected availability	Information on this indicator is diverse and it will be difficult to get a clear and complete picture of the actual increase in participation.
Collection interval	After project completion, or to be used ex-ante to evaluate plans
Expected reliability	Because of the subjectivity that cannot be excluded, this indicator is not 100% reliable.
Expected accessibility	No problems are expected with the accessibility of the information. Increased participation would be a selling point for the project or solution.
References	
•	

Quality of housing and the built environment

Diversity of housing	
Description incl. justification	It is presumed that a mix of housing types (houses of different sizes, different forms of ownership) is beneficial for the diversity in the city and its neighbourhoods. Jane Jacobs, for example, in her book 'The death and life of great American cities'(1961), strongly emphasized the importance of diversity and a mixture of uses as a prerequisite for urban success. Jacobs identified four 'generators of diversity' that "create effective economic pools of use": 1. The district must serve more than one primary use, and preferably more than two, activating streets at different times of the day 2. Most blocks must be short, allowing high pedestrian permeability and interpersonal contact at street corners. 3. Buildings must be mingled in their age, condition, and required economic yield. 4. A dense concentration of people. Though her theories were very influential, they have not been verified. However, they have recently been applied to the City of Seoul, who found that they "provided important theoretical viewpoints and implications for promoting a vital urban life in contemporary Seoul" (Sung et al., 2015). This case study also translated the theories into indicators which, after further investigation, might be relevant for uptake in CITYkeys indicators at a later stage. At the moment, this indicator focuses on diversity of housing (targeting mainly Jacob's third generator). Below, two calculation methodologies are proposed that focus on one aspect of diversity in buildings; housing types (Simpson Diversity Index) and ownership variety (Social housing, which is less datademanding, but not applicable in all countries). Nb. The indicators 'access to public and commercial amenities' partly contribute to Jacob's first generator.
Definition	**Simpson Diversity Index**

	Simpson Diversity Index of total housing stock in the project area **Social Housing** Percentage of social dwellings as share of total housing stock in the project area
Calculation	Below, two options to calculate the diversity in housing types are listed and explained. Because of the direct and coherent calculation, the Simpson Diversity Index is the preferred method. However, this Index is perceived as difficult to calculate. As an alternative, this diversity in housing can be approached by assessing the variety in ownership. **Simpson Diversity Index** The Simpson Diversity Index calculates the probability that any two randomly selected dwelling units in a project will be of a different type. (LEED, 2014). $\text{Score} = 1- \sum (n/N)\square^{2]}$ Where n = the total number of dwelling units in a single category, and N = the total number of dwelling units in all categories. The housing categories are defined in the table below (LEED, 2014).



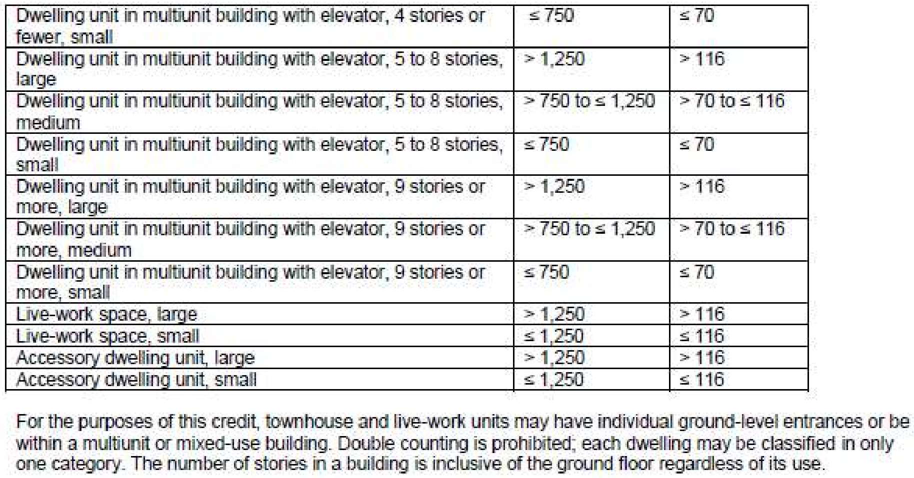
Housing categories are defined by the dwelling unit's net floor area, exclusive of any garage, as listed in Table 2.

Table 2. Housing categories

Type	Square feet	Square meters
Detached residential, large	> 1,250	> 116
Detached residential, small	≤ 1,250	≤ 116
Duplex or townhouse, large	> 1,250	> 116
Duplex or townhouse, small	≤ 1,250	≤ 116
Dwelling unit in multiunit building with no elevator, large	> 1,250	> 116
Dwelling unit in multiunit building with no elevator, medium	> 750 to ≤ 1,250	> 70 to ≤ 116
Dwelling unit in multiunit building with no elevator, small	≤ 750	≤ 70
Dwelling unit in multiunit building with elevator, 4 stories or fewer, large	> 1,250	> 116
Dwelling unit in multiunit building with elevator, 4 stories or fewer, medium	> 750 to ≤ 1,250	> 70 to ≤ 116

39

Updated to reflect the October 1, 2014 LEED v4 Neighborhood Development Addenda



Dwelling unit in multiunit building with elevator, 4 stories or fewer, small	≤ 750	≤ 70
Dwelling unit in multiunit building with elevator, 5 to 8 stories, large	> 1,250	> 116
Dwelling unit in multiunit building with elevator, 5 to 8 stories, medium	> 750 to ≤ 1,250	> 70 to ≤ 116
Dwelling unit in multiunit building with elevator, 5 to 8 stories, small	≤ 750	≤ 70
Dwelling unit in multiunit building with elevator, 9 stories or more, large	> 1,250	> 116
Dwelling unit in multiunit building with elevator, 9 stories or more, medium	> 750 to ≤ 1,250	> 70 to ≤ 116
Dwelling unit in multiunit building with elevator, 9 stories or more, small	≤ 750	≤ 70
Live-work space, large	> 1,250	> 116
Live-work space, small	≤ 1,250	≤ 116
Accessory dwelling unit, large	> 1,250	> 116
Accessory dwelling unit, small	≤ 1,250	≤ 116

For the purposes of this credit, townhouse and live-work units may have individual ground-level entrances or be within a multiunit or mixed-use building. Double counting is prohibited; each dwelling may be classified in only one category. The number of stories in a building is inclusive of the ground floor regardless of its use.

Social housing

The indicator 'social housing' focuses on variety in ownership, rather than housing types. There is, however, no single formal definition of social housing amongst the different European countries (Whitehead and Scanlon 2007). In some countries, social housing is related to ownership – as for example in the Netherlands where social housing often refers to housing in ownership of local authorities. In others, social housing relates to the actor who constructs the dwellings (e.g. Austria and France), or whether or not the rents are below market levels (e.g. England).

In most countries, however, social housing is a supportive measure which is directed at those who cannot serve their own housing needs (ibid). Moreover, sometimes this entails social rented dwellings (e.g. the Netherlands), and sometimes the concept entails social housing that is privately owned (e.g. Spain).

This variety in definitions and interpretations of social housing means that it is virtually impossible to provide strictly comparable figures on the supply of social housing in urban innovations. The indicator is therefore to be used in

<table>
<tr><td></td><td>the context of the country specific interpretation of social housing, as well as its importance in the national housing stock.

Following Dutch social housing policy, for example, 10-90% social housing as share of the total is considered acceptable. In other countries margins are very different. In the UK, more than 75% of social housing is considered too much.

Note: when the country in question has a social housing share of less than 10% in the total housing stock, the assessor can opt to qualify this indicator as “not applicable”.</td></tr>
<tr><td>Strengths and weaknesses</td><td>Simpson Diversity Index

Strengths: The indicator can easily be compared between cities and countries.

Weaknesses: This indicator requires detailed calculations.

Social housing

Strengths: Data are easily available

Weaknesses: It is not easy to determine a reference value on what a good share of social housing is. The definition of ‘social housing’ can be different in various countries. The share considered ‘correct’ can vary between countries</td></tr>
<tr><td>Scoring</td><td>Simpson Diversity Index
An index score greater than 0,5 is considered preferable.

<table>
<tr><td><0,05</td><td>1</td></tr>
<tr><td>0,10-0,05</td><td>2</td></tr>
<tr><td>0,15-0,20</td><td>3</td></tr>
<tr><td>0,20-0,25</td><td>4</td></tr>
<tr><td>0,25-0,30</td><td>5</td></tr>
<tr><td>0,30-0,35</td><td>6</td></tr>
<tr><td>0,35-0,40</td><td>7</td></tr>
<tr><td>0,40-0,45</td><td>8</td></tr>
<tr><td>0,45-0,50</td><td>9</td></tr>
<tr><td>>0,50</td><td>10</td></tr>
</table>

Social Housing
Normalisation classes:

<table>
<tr><td>0-10%</td><td>2</td></tr>
<tr><td>10-20%</td><td>4</td></tr>
<tr><td>20-30%</td><td>7</td></tr>
<tr><td>30-40%</td><td>7</td></tr>
<tr><td>40-50%</td><td>7</td></tr>
<tr><td>50-60%</td><td>7</td></tr>
<tr><td>60-70%</td><td>7</td></tr>
<tr><td>70-80%</td><td>7</td></tr>
<tr><td>80-90%</td><td>4</td></tr>
</table></td></tr>
</table>

90-100%	2

Data requirements

Expected data source	Housing categories for existing neighbourhoods can be derived from city administration/planning documents, for new buildings the project documentation can be consulted, as well as interviews with the project leader
Expected availability	Uncertain
Collection interval	Before and after the project, or to be used ex-ante to evaluate plans
Expected reliability	Good
Expected accessibility	No sensitivities expected

References

- City protocol (2015). City Anatomy - City Indicators. CPWD-PR_002_Anatomy_Indicators
- LEED (2014). LEED v4 for Neighbourhood development.
- http://www.newgeography.com/content/002711-on-jane-jacobs-generating-and-preserving-diversity
- CECODHAS Housing Europe (European Federation of Public, Cooperative & Social Housing), 2007.
- Hyungun Sung, Sugie Lee, and SangHyun Cheon (2015). Operationalizing Jane Jacobs's Urban Design Theory: Empirical Verification from the Great City of Seoul, Korea. Journal of Planning Education and Research 1 –14.

Connection to the existing cultural heritage

Description incl. justification	An important aspect in promoting the feeling of community/home is 'place-making'; the creation of place and identity. This identity can be created by building on local and regional history, culture and character.This entails integrating urban design and heritage conservation so that it enhances or connects to the existing character of the place, e.g. preservation and/or adaptive re-use of historic buildings and cultural landscapes. Keeping these location's special identity could also bring economic as well as other benefits to the area.
Definition	The extent to which making a connection to the existing cultural heritage was considered in the design of the project
Calculation	The indicator provides a qualitative measure and is rated on a five-

	point Likert scale: Not at all – 1 — 2 — 3 — 4 — 5 — Very much 1. Not at all: no attention has been paid to existing cultural heritage. 2. Fair: heritage places have received some attention in the project, but not as an important element. 3. Moderate: some attention has been given to the conservation of heritage places. 4. Much: heritage places are reflected in the project design 5. Very much: heritage places are included in the project as clear and recognizable landmarks.
Strengths and weaknesses	Strengths: the indicator allows the evaluation and comparability of a wide range of types of project, of (still to-be-developed) solutions and cultural heritage. Weaknesses: although it is tried to make scoring the indicator as objectively as possible, a certain amount of subjectivity is present.
Scoring	Multiply Likert scale value by 2
Data requirements	
Expected data source	To be derived from interviews with the project leader and the department for urban planning of the local government, and possibly from project documentation.
Expected availability	It will be fairly easy to retrieve information on cultural heritage from interviews
Collection interval	After project completion, or to be used ex-ante to evaluate plans
Expected reliability	Because of the subjectivity that cannot be excluded, this indicator is not 100% reliable.
Expected accessibility	Cultural heritage is public information, no problems are expected with regards to access
References	
• Eurbanlab (2014). The Eurbanlab Selection of Indicators. Version 4.	

Design for a sense of place	🔌 💻 🏢
Description incl. justification	The term “design for a sense of place” is used to indicate details in the design that make a place distinctive (create an identity) which fosters a sense of authentic human attachment and create a feeling of belonging. Design principles for a sense of place include preserving existing elements, ensure safety and are geared towards the creation of places that: - Respond to, or express the values of groups in the community for whom the place is designed, and are welcoming to them; - Consist of several milieus for events and activities that make

	places culturally relevant and pleasant to occupy; - Are of a scale and proportion to facilitate easy navigation, interaction and overview by the users; - and include identifiable features, landmarks or historical places to improve frontage and orientation.
Definition	The extent to which a 'sense of place' was included in the design of the project
Calculation	The indicator is qualitative and rated on a five-point Likert scale: Not at all – 1 — 2 — 3 — 4 — 5 — Very much 1. Poor: no attention has been paid to the idea of creating a "sense of place" in the design of the project, even residents are not able identify any elements. 2. Fair: the idea of creating a "sense of place" has received some attention in the project, but not as an important element. 3. Average: some attention has been given in the design to the idea of creating a "sense of place". 4. Good: Much attention has been given to the idea of creating a "sense of place" in the project design. 5. Very good: The attention paid to the aim of creating a "sense of place" in the design is clearly and recognizably present in the project, even for outsiders.
Strengths and weaknesses	Strengths: the indicator allows the evaluation and comparability of a wide range of types of project, of (still to-be-developed) solutions and design options. Weaknesses: - although it is tried to make scoring the indicator as objectively as possible, a certain amount of subjectivity is present. - 'Sense of place' is a very broad description and can be interpreted differently Overlap with the indicator 'existing cultural heritage', as this is one element to create an identity
Scoring	Multiply Likert scale value by 2
Data requirements	
Expected data source	To be derived from interviews with the project leader, the department for urban planning of the local government and the community, and possibly from project documentation.
Expected availability	It will be fairly easy to retrieve information on the design for a 'sense of place' from interviews
Collection interval	After project completion, or to be used ex-ante to evaluate plans
Expected reliability	Because of the subjectivity that cannot be excluded, this indicator is not 100% reliable.

<table>
<tr><td>Expected accessibility</td><td>Information on a ‘Sense of place’ is not company sensitive information, so no problems are expected with regards to access</td></tr>
<tr><td colspan="2">References</td></tr>
<tr><td colspan="2">Eurbanlab (2014). The Eurbanlab Selection of Indicators. Version 4.</td></tr>
</table>

<table>
<tr><td colspan="2">Increased use of ground floors</td></tr>
<tr><td>Description incl. justification</td><td>Making use of ground floors for commercial and public purposes can increase the liveability and atmosphere of a neighbourhood. Also, an interesting public realm will enhance the consumer’s experience and support the endeavors of small businesses and retailers thereby adding to successful retail and commerce (Arlington, 2014). One can think of a variety of uses suitable for the ground floor, dependent on the location, including retail, personal and business services, retail equivalents such as educational and conferencing facilities, and arts and cultural resources. The potential for increasing the use for ground floor space lies mostly within residential and office buildings.</td></tr>
<tr><td>Definition</td><td>Increase in ground floor space for commercial or public use due to the project as percentage of total ground floor surface</td></tr>
<tr><td>Calculation</td><td>(extra ground floor space used commercially/publically created by the project (in m2)/current total ground floor space (in m2) *100%</td></tr>
<tr><td>Strengths and weaknesses</td><td>Strengths: Absolute and objective value for ground floor usage.
Weaknesses: Data are scattered. Definitions of public and commercial spaces can vary between cities.
Alternative: Are there strategies to activate vacant ground floor space?</td></tr>
<tr><td>Scoring</td><td>Theoretically a project could use all the ground floor space for commercial or public use, so the scale is evenly distributed in steps of 10%.
<table>
<tr><th colspan="2">Normalisation</th></tr>
<tr><td>Improvement</td><td>Score</td></tr>
<tr><td>0-10%</td><td>1</td></tr>
<tr><td>10-20%</td><td>2</td></tr>
<tr><td>20-30%</td><td>3</td></tr>
<tr><td>30-40%</td><td>4</td></tr>
<tr><td>40-50%</td><td>5</td></tr>
<tr><td>50-60%</td><td>6</td></tr>
<tr><td>60-70%</td><td>7</td></tr>
<tr><td>70-80%</td><td>8</td></tr>
</table></td></tr>
</table>

80-90%	9
90-100%	10

Data requirements

Expected data source	To be derived from design plans and from interviews with the project leader and with the department for urban planning within the local government.
Expected availability	It will be fairly easy to retrieve information on ground floor use from interviews and design plans
Collection interval	After project completion, or to be used ex-ante to evaluate plans
Expected reliability	Because of the subjectivity that cannot be excluded, this indicator is not 100% reliable.
Expected accessibility	Information on ground floor usage is specified in development plans, so no problems are expected with regards to access

References

- Arlington County - Arlington Economic Development (2014). Ground Floor Retail & Commerce: Policy Guidelines and Action Plan for Arlington’s Urban Villages.

Increased access to public outdoor recreation space

Description incl. justification	Recreation is an important aspect of city life, contributing to the health of citizens, the vitality of the city and community participation. Recreation is a service that many cities provide through a parks and recreation department or related office (ISO/DIS 37120, 2013). Public recreation space is defined broadly to mean land and open space available to the public for recreation. Recreation space shall include only space that primarily serves a recreation purpose. Outdoor recreation space should include: a) city-owned or maintained land; b) other-recreation lands within the city not owned or operated by the city, provided they are open to the public. This category may include state or provincially owned lands, school and college grounds, as well as non-profit. If cities report only city-owned recreation space, this shall be noted. For multi-use facilities, only the portion of the land devoted to recreation shall be counted (the play areas at a school or college, for example, not the entire school site). Double counting shall be avoided. For example, do not include indoor facilities on parkland. The area of the entire outdoor recreation site shall be included

	(including, for example woodedareas of parks, building maintenance and utility areas) but shall exclude parking areas.
Definition	Increase in public outdoor recreation space (m2) within 500m
Calculation	(Public outdoor recreation space (m2) within 500 m after the project/ Public outdoor recreation space (m2) within 500 m before the project)*100%
Strengths and weaknesses	Strengths: the indicator allows the evaluation and comparability of a wide range of project types and (still to-be-developed) solutions. Weaknesses:
Scoring	This indicator depends heavily on the reference situation, and a project may even decrease the public outdoor recreation space.

Improvement	Score
<0%	1
0-10%	2
10-20%	3
20-30%	4
30-40%	5
40-50%	6
50-60%	7
60-70%	8
70-80%	9
>80%	10

Data requirements

Expected data source	To be derived from design plans and from interviews with the project leader and with the department for urban planning within the local government.
Expected availability	Data on number, surface area and distance to dwellings will be available, but have to be gathered, combined and analysed to be able to make a judgement call on the increased accessibility to urban public space.
Collection interval	After project completion, or to be used ex-ante to evaluate plans
Expected reliability	Because of the subjectivity that cannot be excluded, this indicator is not 100% reliable.
Expected accessibility	Information on urban public space is specified in development plans which are publicly available.

References

- ISO/DIS 37120 (2013). Sustainable development and resilience of communities — Indicators for city services and quality of life. ICS 13.020.20

<table>
<tr><td colspan="2">Increased access to green space</td></tr>
<tr><td>Description incl. justification</td><td>The amount of green area, natural and semi-natural, parks and other open space is an indicator of how much green space a city has. Green areas perform important environmental functions in an urban setting (ISO/DIS 37120, 2013). They improve the urban climate, capture atmospheric pollutants and improve quality of life by providing recreation for urban inhabitants.

Research has shown that green neighbourhoods improve the health of their inhabitants (Van den Berg & Van den Berg, 2015). Urban vegetation can also reduce heat in the built environment by providing shade and evaporative cooling (Steeneveld et al., 2011; Heusinkveld et al., 2014; Van Hove et al., 2015). In addition, green elements have a significant positive influence on the human perception of temperature (Klemm et al., 2013).

This indicator reflects green area, publicly or privately owned, that is “publicly accessible” as opposed to whether or not the green area is protected.

Note: Green area is broader than recreation space (clause 13 ISO/DIS 37120, 2013).</td></tr>
<tr><td>Definition</td><td>Increase in green space (m2) within 500m</td></tr>
<tr><td>Calculation</td><td>(Green space (m2) within 500 m after the project/ Green space (m2) within 500 m before the project)*100%</td></tr>
<tr><td>Strengths and weaknesses</td><td>Strengths: the indicator allows the evaluation and comparability of a wide range of project types and (still to-be-developed) solutions.

Weaknesses:</td></tr>
<tr><td>Scoring</td><td>This indicator depends heavily on the reference situation, and a project may even decrease the green space.

<table>
<tr><td>Improvement</td><td>Score</td></tr>
<tr><td><0%</td><td>1</td></tr>
<tr><td>0-10%</td><td>2</td></tr>
<tr><td>10-20%</td><td>3</td></tr>
<tr><td>20-30%</td><td>4</td></tr>
<tr><td>30-40%</td><td>5</td></tr>
<tr><td>40-50%</td><td>6</td></tr>
<tr><td>50-60%</td><td>7</td></tr>
<tr><td>60-70%</td><td>8</td></tr>
<tr><td>70-80%</td><td>9</td></tr>
<tr><td>>80%</td><td>10</td></tr>
</table>
</td></tr>
<tr><td colspan="2">Data requirements</td></tr>
<tr><td>Expected data</td><td>To be derived from design plans and from interviews with the</td></tr>
</table>

source	project leader and from municipal recreation and parks departments, planning departments, forestry departments and census
Expected availability	Data on number of green/recreational spaces, its surface area and distance to dwellings will be available, but have to be gathered, combined and analysed to be able to make a judgement call on the increased accessibility to green space.
Collection interval	After project completion, or to be used ex-ante to evaluate plans
Expected reliability	Because of the subjectivity that cannot be excluded, this indicator is not 100% reliable.
Expected accessibility	Information on green space is specified in development plans which are publicly available.

References

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- ISO/TS 37151 (2014).Smart community infrastructures - Principles and requirements for performance metrics. ISO/TC 268/SC 1/WG 1-Infrastructure metrics.Steeneveld, G.J., Koopmans,S., Heusinkveld, B.G., van Hove, L.W.A., Holtslag, A.A.M. (2011). Quantifying urban heat island effects and human comfort for cities of variable size and urban morphology in the Netherlands. J. Geophys. Res.116, D20129, 14pp., doi: 10.1029/2011 JDO15988.
- Van Hove, L.W.A., Jacobs, C.M.J., Heusinkveld B.G., Elbers, J.A., van Driel, B.L., and Holtslag, A.A.M. (2015). Temporal and spatial variability of urban heat island and thermal comfort within the Rotterdam agglomeration. Building and Environment . DOI: 10.1016/j.buildenv.2014.08.029
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- Klemm, W., Lenzholzer, S., Heusinkveld, B., Hove, B. van (2013). Towards green design guidelines for thermally comfortable streets. In PLEA 2013.
- ISO/TS 37151 (2014).Smart community infrastructures - Principles and requirements for performance metrics. ISO/TC 268/SC 1/WG 1-Infrastructure metrics.

Planet

Energy & Mitigation

Reduction in annual final energy consumption	🚗 💻 🏢
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 of the project taking into account all forms of energy (e.g. electricity, gas,

	heat/cold, fuels) and for all functions (transport, buildings, 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	Percentage change in annual final energy consumption due to the project for all uses and forms of energy
Calculation	The percentage of the decrease in energy consumption caused by the project is calculated as the difference between the total use of energy per year (kWh) on-site or within the project boundaries before and after the project (numerator) divided by the total use of energy per year (kWh) on-site before the project (denominator). The result (numerator/denominator) is multiplied by 100 in order to present the outcome as a percentage. The indicator expresses the percentual reduction of energy consumption due to actions taken within the project. 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, m3), 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). Note: All calculations need to be thoroughly recorded for transparency. 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).

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. Thus calculation after the first year of operation does not provide objective data.
Scoring	Less than 20% improvement is regarded as not ambitious, and gets the lowest score. 90-100% improvement, meaning (nearly) energy neutral is awarded by a 9. While 10 is more than 100% improvement indicating that the project site has become a net energy producer.

Normalisation	
Improvement	Score
<20%	1
20-30%	2
30-40%	3
40-50%	4
50-60%	5
60-70%	6
70-80%	7
80-90%	8
90-100%	9
>100%	10

Data requirements	
Expected data source	Data from monitoring equipment provided by the project owner, 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
Expected availability	High, as many projects have an energy component these data are generally available.
Collection interval	Before and after the project (preferably one year after the

	implementation).
Expected reliability	The reliability varies depending on the kind of energy consumption.
Expected accessibility	High. For buildings data for (central) heating and cooling maybe more easily accessible then consumption for appliances.

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)

Reduction in life cycle energy use	
Description incl. justification	Measures for the provision of energy from renewable energy sources, for increasing energy efficiency and the use of ICT are of double-edged nature. On the one side they have a positive environmental impact by reducing the use of fossil fuels, decreasing energy use and enable efficiencies in lifestyle and economy. On the other hand these measures involve energy use during their lifecycle in their production, operation and disposal phase. In this regard three levels of impact are being distinguished (ITU-T L.1410: 2014): - First order effects – environmental load – impacts created by the physical existence of the measures and the processes involved - Second order effects – actual or potential environmental load reduction – the impacts and opportunities created by the use and application of the measures - Other effects – impacts and opportunities created by the aggregated effects on societal structural changes and rebound effects The first order effect of a smart city project is covered by the previous indicator: Reduction in annual final energy consumption. For the second order effect a life cycle assessment of project measures is necessary. Similar to the reduction in direct energy consumption, also the second order effects are assessed in comparison with a reference scenario (state-of-the-art / business-as-usual measures). A full life cycle assessment of the project's second order effects inherently includes the first order effects of the project and of the reference scenario. (ITU-T L1430: 2013) The indicator should express the difference between the situation with the project to the situation before or (in case of new developments) to a state-of-the-art or business-as-usual option.
Definition	Reduction in life cycle energy use achieved by the project (%)
Calculation	The percentual reduction in life-cycle energy use is calculated as: the

<table>
<tr><td></td><td>difference between the life cycle energy use of the reference scenario (business-as-usual measures) and life cycle energy use when the project is applied. Then the result is divided by the life cycle energy use of the reference scenario and multiplied by 100 to express it as a percentage. The indicator should express the difference between comparing project development to a state-of-the-art or business-as-usual option.
Boundaries of the life cycle analysis need to be clearly stated, as well as the used LCA method (process-LCA, industry/commodity level input/output (I/O) modelling or hybrid-LCA). [Rebitzer et al, 2004]</td></tr>
<tr><td>Strengths and weaknesses</td><td>Strengths: More complete assessment of the effects of the project on the total consumption of energy; enables to distinguish projects with a lower overall energy efficiency.
Weaknesses: Limitations in data granularity; LCA assumptions, boundaries and used methods need to be stated clearly. Different project calculations might not be directly comparable due to different calculation methods.</td></tr>
<tr><td>Scoring</td><td>The lifecycle energy of a project can’t be reduced to zero, for if you would just want to re-use materials or products, you will at least need some energy for transportation. Therefore, a 50% reduction in embodied energy is already awarded a score of 10.
<table>
<tr><th colspan="2">Normalisation</th></tr>
<tr><td>Improvement</td><td>Score</td></tr>
<tr><td><5%</td><td>1</td></tr>
<tr><td>5-10%</td><td>2</td></tr>
<tr><td>10-15%</td><td>3</td></tr>
<tr><td>15-20%</td><td>4</td></tr>
<tr><td>20-25%</td><td>5</td></tr>
<tr><td>25-30%</td><td>6</td></tr>
<tr><td>35-40%</td><td>7</td></tr>
<tr><td>40-45%</td><td>8</td></tr>
<tr><td>45-50%</td><td>9</td></tr>
<tr><td>>50%</td><td>10</td></tr>
</table>
</td></tr>
<tr><td colspan="2">Data requirements</td></tr>
<tr><td>Expected data source</td><td>Project owner, project developers, suppliers. LCA data bases, such as EPD, EcoInvent, and national material data bases.</td></tr>
<tr><td>Expected availability</td><td>Very low. In most cases specific studies are needed to compile the indicator.</td></tr>
</table>

Collection interval	Before and after the project implementation
Expected reliability	In case the life cycle assesment is performed according to a standardized procedure and verified by a third party the reliability is high. In other cases the reliability depends on the extent of the assessment and quality of the input data.
Expected accessibility	In case the availability is ensured, there should be no major issues with the accessibility of the data.
References - ITU-T L.1410 (2014) - International Standard ISO 14040 (1997) on principles and framework. - International Standard ISO 14041 (1998) on goal and scope definition and inventory analysis. - International Standard ISO 14042 (2000) on life cycle impact assessment. - International Standard SO 14043 (2000) on life cycle interpretation. - G. Rebitzer, T. Ekvallb, R. Frischknechtc, D. Hunkelerd, G. Norrise, T. Rydbergf, W.-P. Schmidtg, S. Suhh, B.P. Weidemai, D.W. Pennington, 2004: Life cycle assessment - Part 1: Framework, goal and scope definition, inventory analysis, and applications. Environment International 30 (2004) 701– 720.	

Reduction of embodied energy of products and services used in the project	
Description incl. justification	With buildings and equipment becoming more and more energy efficient, the amount of energy embodied in the materials used becomes an important criterion to distinguish options. There are still very few examples where, for example architects, keep track of the embodied energy of the materials that they employ in their designs. Also standard lists of embodied energy of materials, products and services are not widely available. Therefore this indicator has been defined in a qualitative way: it tells to what extent measures have been considered to reduce the embodied energy of products used in the project. In this way, the indicator can be considered a “light”, qualitative version of the previous indicator ‘Reduction of lifecycle energy use’.
Definition	The extent to which measures have been taken to reduce the embodied energy of products used in the project.
Calculation	Likert scale, in which respondents are asked to evaluate the measures taken to reduce the embodied energy of materials, products and services. Reduction of embodied energy has not been considered in the project – 1 — 2 — 3 — 4 — 5 — Reduction of embodied energy has been extensively considered throughout the whole project Guideline for the ‘reduction of embodied energy’ 1. Not considered: The project did not consider measures for

	the reduction of embodied energy. 2. Low extent: The project considered recommendations to reduce embodied energy of materials or such recommendations have been developed and applied. These recommendations are applied for the implementation and procurement process of the project. 3. Moderate: Specific life cycle analysis has been developed and performed. Results of the analysis are applied within the procurement and implementation processes of the project. 4. High: Life cycle analysis has been developed and performed. Results of the analysis are applied within the procurement and implementation processes of the project. A monitoring plan has been developed and is being implemented. 5. Very high: Specific life cycle analysis has been developed and performed. Results of the analysis are applied within the procurement and implementation processes of the project. A monitoring plan has been developed and implemented. An independent third-party validation and verification has been conducted.
Strengths and weaknesses	Strengths: Use of the likert scale enables easy information collection. Standards and recommendations of standardisation organisations (e.g. ISO, ITU-T, ETSU) provide well guidance how to implement measures to reduce embodied energy and perform life cycle assessment. Weaknesses: If the project proponent makes public claiming conformance to recommendations of standardisation organisations certain requirements apply, e.g. an independent third-party validation and verification statement. (as in ITU-T L.1430 (2014))
Scoring	Multiply Likert scale value by 2
Data requirements	
Expected data source	Project owner, project developers.
Expected availability	No limitations expected.
Collection interval	Once, survey before or after the project.
Expected reliability	The Likert scale distinguishes clearly the different levels to which extent the measures have been considered. Given the measures are performed accordingly (adherence of standardised processes is recommended) the reliability is ensured.
Expected accessibility	No limitations expected.

References

- ITU-T L.1410 (2014)
- ITU-T L.1430 (2013)

Increase in local renewable energy generation	
Description incl. justification	The promotion of renewable energy sources is a high priority for sustainable development, for reasons such as the security and diversification of energy supply and for environmental protection. (ISO/DIS 37120, 2013). The share of renewable energy production in itself gives an idea of the rate of self-consumption of locally produced energy, which is an indicator of the flexibility potential of the local energy system. The indicator should account for the increase of the renewable energy generation due to the project. In case biomass is used to generate energy, the transport distance is limited to 100 km. Renewable energy shall include both combustible and non-combustible renewables (ISO/DIS 37120, 2013). Noncombustible renewables include geothermal, solar, wind, hydro, tide and wave energy. For geothermal energy, the energy quantity is the enthalpy of the geothermal heat entering the process. For solar, wind, hydro, tide and wave energy, the quantities entering electricity generation are equal to the electrical energy generated. The combustible renewables include biomass (fuelwood, vegetal waste, ethanol) and animal products (animal materials/waste and sulphite lyes). Municipal waste (waste produced by the residential, commercial and public service sectors that are collected by local authorities for disposal in a central location for the production of heat and/or power) and industrial waste are not considered a renewable source for energy production.
Definition	Percentage increase in the share of local renewable energy due to the project
Calculation	The percentage of the increase in local renewable energy production caused by the project is calculated as the difference between the annual renewable energy generation related to the project before and after project completion (or as the difference between the annual renewable energy generation related to the project compared to BAU). The result will be divided by the annual total energy consumption related to the project, and then it is multiplied by 100 to express the result as a percentage. 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:. Weaknesses:
Scoring	All energy consumption can in principle be provided by renewable energy, so the scale for normalization is equally divided in steps of 10%.

Normalisation	
Improvement	Score
0-10%	1
10-20%	2
20-30%	3
30-40%	4
40-50%	5
50-60%	6
60-70%	7
70-80%	8
80-90%	9
90-100%	10

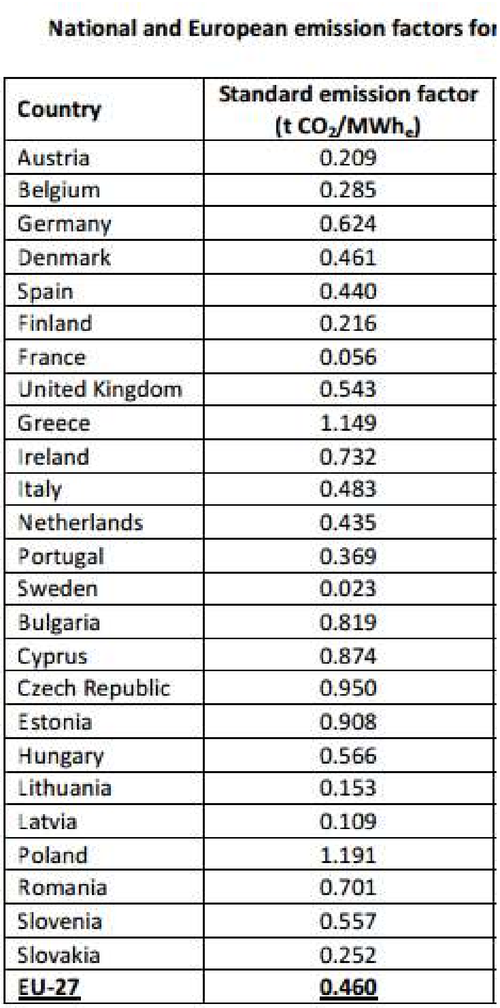
Data requirements

Expected data source	Project owner, energy utility or provider in case these are involved in the project
Expected availability	Good
Collection interval	Before and after the project. Ideally monitored continuously.
Expected reliability	Monitoring data are expected to have high reliability.
Expected accessibility	No sensitivities are foreseen.

References

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

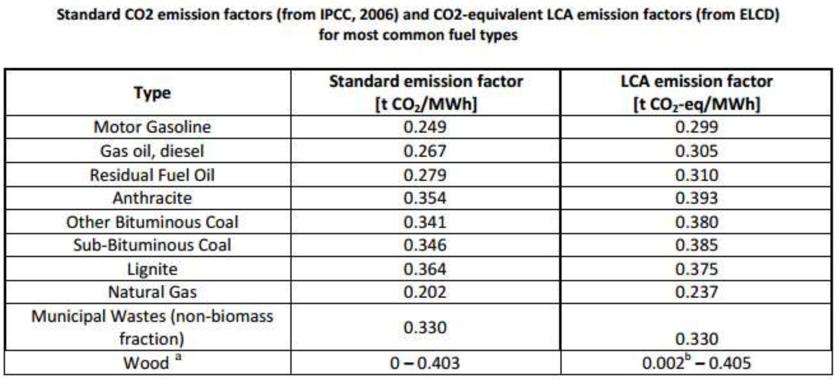
Carbon dioxide emission reduction	
Description incl. justification	Greenhouse gases (GHGs) are gases in the atmosphere that absorb infrared radiation that would otherwise escape to space; thereby contributing to rising surface temperatures. There are six major GHGs: carbon dioxide (CO_2), methane (CH_4), 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 Green House Gas 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. 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	The indicator is calculated as the direct (operational) reduction of the CO_2 emissions over a calender year: before the project and after 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 CO2 emission figures by using conversion factors for different energy forms as described in below tables. National and European emission factors for consumed <u>electricity</u> (Covenant of Mayor) 

National and European emission factors fo

Country	Standard emission factor (t CO_2/MWh_e)
Austria	0.209
Belgium	0.285
Germany	0.624
Denmark	0.461
Spain	0.440
Finland	0.216
France	0.056
United Kingdom	0.543
Greece	1.149
Ireland	0.732
Italy	0.483
Netherlands	0.435
Portugal	0.369
Sweden	0.023
Bulgaria	0.819
Cyprus	0.874
Czech Republic	0.950
Estonia	0.908
Hungary	0.566
Lithuania	0.153
Latvia	0.109
Poland	1.191
Romania	0.701
Slovenia	0.557
Slovakia	0.252
<u>EU-27</u>	**<u>0.460</u>**

Standard Emission factors for fuel combustion – most common fuel types (IPCC, 2006)



Standard CO2 emission factors (from IPCC, 2006) and CO2-equivalent LCA emission factors (from ELCD) for most common fuel types

Type	Standard emission factor [t CO_2/MWh]	LCA emission factor [t CO_2-eq/MWh]
Motor Gasoline	0.249	0.299
Gas oil, diesel	0.267	0.305
Residual Fuel Oil	0.279	0.310
Anthracite	0.354	0.393
Other Bituminous Coal	0.341	0.380
Sub-Bituminous Coal	0.346	0.385
Lignite	0.364	0.375
Natural Gas	0.202	0.237
Municipal Wastes (non-biomass fraction)	0.330	0.330
Wood [a]	0 – 0.403	0.002[b] – 0.405

Strengths and weaknesses	Strengths: high policy relevance linked to EU, national and local policies Weaknesses: documentation of used CO_2 emission factors is needed.
Scoring	Less than 10% improvement is regarded as not ambitious, and gets the lowest score. 90-100% improvement, meaning (nearly) CO2 neutral is awarded by a 10.

Normalisation	
Improvement	Score
0-10%	1
10-20%	2
20-30%	3
30-40%	4
40-50%	5
50-60%	6
60-70%	7
70-80%	8
80-90%	9
90-100%	10

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	After the project, or ex-ante to evaluate plans
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

Reduction in lifecycle CO_2 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 (CO2), methane (CH4), nitrous oxide (N2O), 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. In urban areas CO_2 emissions are the most important. Similarly to energy a distinction is made between direct and indirect (or lifecycle) emissions of carbon dioxide. Direct emissions are covered by the previous indicator 'Reduction in direct (operational) CO_2 emissions achieved by the project'. The current indicator assesses the CO_2 emissions embedded in products and services used in the project. It should express the difference in indirect CO_2 emissions between the situation after the project to the situation before or, in case of new developments, to a state-of-the-art or business-as-usual option.
Definition	Percentage reduction in lifecycle CO_2 emissions achieved by the project
Calculation	The percentual reduction in life-cycle CO_2 emissions is calculated as: the difference between the life cycle CO_2 emissions before the project (or reference scenario) and life cycle CO_2 emissions when the project is applied. Then the result is divided by the life cycle CO_2 emissions before the project (or the reference scenario) and multiplied by 100 to express it as a percentage. Detailed guidelines for the calculation are provided in ITU-T L1430: (2013).
Strengths and weaknesses	Strengths: More complete assessment of the effects of the project on total CO_2 emissions; enables to distinguish projects with a lower

<table>
<tr><td></td><td>overall carbon footprint.

Weaknesses: Limitations in data granularity; LCA assumptions, boundaries and used methods need to be stated clearly. Different project calculations might not be directly comparable due to different calculation methods.</td></tr>
<tr><td>Scoring</td><td>In theory, the lifecycle CO2 emissions of a project can be reduced to zero, because you could produce everything using only renewable energy. However, in practice it is expected that a reduction of more than 50% is already very good and therefore awarded with a 10.

<table>
<tr><th colspan="2">Normalisation</th></tr>
<tr><td>Improvement</td><td>Score</td></tr>
<tr><td><5%</td><td>1</td></tr>
<tr><td>5-10%</td><td>2</td></tr>
<tr><td>10-15%</td><td>3</td></tr>
<tr><td>15-20%</td><td>4</td></tr>
<tr><td>20-25%</td><td>5</td></tr>
<tr><td>25-30%</td><td>6</td></tr>
<tr><td>35-40%</td><td>7</td></tr>
<tr><td>40-45%</td><td>8</td></tr>
<tr><td>45-50%</td><td>9</td></tr>
<tr><td>>50%</td><td>10</td></tr>
</table>
</td></tr>
<tr><td colspan="2">Data requirements</td></tr>
<tr><td>Expected data source</td><td>Project owner, project developers, suppliers. LCA data bases, such as EPD, EcoInvent, and national material data bases.</td></tr>
<tr><td>Expected availability</td><td>Very low. In most cases specific studies are needed to compile the indicator.</td></tr>
<tr><td>Collection interval</td><td>Before and after the project implementation</td></tr>
<tr><td>Expected reliability</td><td>In case the life cycle assesment is performed according to a standardized procedure and verified by a third party the reliability is good. In other cases the reliability depends on the extent of the assessment and quality of the input data.</td></tr>
<tr><td>Expected accessibility</td><td>In case the availability is ensured, there should be no major issues with the accessibility of the data.</td></tr>
</table>

References

- ITU-T L.1430 (2013)
- ISO/DIS 37120 (2013). Sustainable development and resilience of communities — Indicators for city services and quality of life. ICS 13.020.20
- G. Rebitzer, T. Ekvallb, R. Frischknecht, D. Hunkelerd, G. Norrise, T. Rydbergf, W.-P. Schmidtg, S. Suhh, B.P. Weidemai, D.W. Pennington, 2004: Life cycle assessment - Part 1: Framework, goal and scope definition, inventory analysis, and applications. Environment International 30 (2004) 701– 720.
- International Standard ISO 14040 (1997) on principles and framework.
- International Standard ISO 14041 (1998) on goal and scope definition and inventory analysis.
- International Standard ISO 14042 (2000) on life cycle impact assessment.
- International Standard SO 14043 (2000) on life cycle interpretation.

Maximum Hourly Deficit	
Description incl. justification	Smart city projects encouraging local renewable energy generation need to deal with balancing supply and demand over the day, over the week and over seasons. Peaks in production of renewable energy and peaks in consumption patterns often do not coincide. Several indicators have been designed to provide insight in the degree to which smart energy systems in the build environment perform with repect to these balancing issues. In Citykeys the focus is on the degree to which local renewable energy can match demand on the short term. As such this indicator is a specification of the more general and simple indicator ‘Increase in local renewable energy generation’. The Maximum Hourly Deficit (MHDx) indicates the maximum ratio of the difference between load and on-site renewable energy generation (including energy retrieved from local storage to cover the load) to load for each energy type. It is calculated taking the biggest value of those ratios calculated for each hour of the year, for those hours when local renewable supply is smaller than the demand. (Ala-Juusela et al, 2015).
Definition	The maximum yearly value of how much the hourly local electricity demand overrides the local renewable electricity supply during one single hour
Calculation	According to Ala-Juusela et al [2014, Maximum Hourly Deficit is calculated for each energy type, MHDx, indicating the maximum ratio of the difference in load and on-site generation including energy retrieved from local storage to cover the load. It is calculated for t_1 = 0 to t_2= 8760 and dt = 1 hour, for those hours when $\int_{t_1}^{t_2} G_x(t)dt \ < \ \int_{t_1}^{t_2} L_x(t)dt$

<table>
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<td>

$MHDx = \text{Max}\left[\frac{\int_{t_1}^{t_2}[L_x(t) - G_x(t) + S_x(t)]dt}{\int_{t_1}^{t_2} L_x(t)dt}\right]$, where $S_x(t)$ is the storage discharge rate (negative value).

It is easy to see that the Maximum hourly deficit will occur in situations when $\int_{t_1}^{t_2} G_x(t)dt \; < \; \int_{t_1}^{t_2} L_x(t)dt$ and storage is empty (then $S_x(t) = 0$):

$$\frac{\int_{t_1}^{t_2}[L_x(t)-G_x(t)+ S_x(t)]dt}{\int_{t_1}^{t_2} L_x(t)dt} = \frac{\int_{t_1}^{t_2}[L_x(t)-G_x(t)]dt}{\int_{t_1}^{t_2} L_x(t)dt} > 0$$

If $\int_{t_1}^{t_2} G_x(t)dt \; < \; \int_{t_1}^{t_2} L_x(t)dt$ and storage is not empty ($S_x(t) < 0$), the deficit will be fully or partly covered by the stored energy, and the deficit will not reach maximum value.

If $\int_{t_1}^{t_2} G_x(t)dt \; \geq \; \int_{t_1}^{t_2} L_x(t)dt$ then there is no deficit situation.

The target values for MHD are yet to be addressed. The energy matching indicator development and testing is planned to continue in Design4Energy project (http://design4energy.eu/).

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<tr>
<td>Strengths and weaknesses</td>
<td>

Strengths: Suitable for indicating, how much of the energy demand can be covered with local renewable energy and storage on a short term.

Weaknesses: Target values are not yet addressed.

</td>
</tr>
<tr>
<td>Scoring</td>
<td>

If the maximum hourly deficit is high (i.e. not a good match between energy supply and demand throughout the year), then the score is low; if the maximum hourly deficit is low (i.e. good match between energy supply and demand throughout the year), then the score is high.

<table>
<tr><th colspan="2">Normalisation</th></tr>
<tr><th>Improvement</th><th>Score</th></tr>
<tr><td><10%
(more than 7884 h/yr)</td><td>1</td></tr>
<tr><td>10-20%
(7008-7884 h/yr)</td><td>2</td></tr>
<tr><td>20-30%
(6132-7008 h/yr)</td><td>3</td></tr>
<tr><td>30-40%
(5256-6132 h/yr)</td><td>4</td></tr>
</table>

</td>
</tr>
</table>

40-50% (4380-5256 h/yr)	5
50-60% (3504-4380 h/yr)	6
60-70% (2628-3504 h/yr)	7
70-80% (1752-2628 h/yr)	8
80-90% (876-1752 h/yr)	9
>90% (less than 876 h/yr)	10

Data requirements	
Expected data source	Project owner
Expected availability	Unknown. This will be have to become clear in further testing the indicator.
Collection interval	Requires energy demand, renewable energy production and storage use data for each hour of a year.
Expected reliability	good
Expected accessibility	ok

References

- Ala-Juusela Mia, Tracey Crosbie, Mari Sepponen, 2015: Defining and Operationalising the Concept of an Energy Positive Neighbourhood. IDEAS project result. SWEDES2015 Conference proceedings. 10th Conference on Sustainable Development of Energy, Water and Environment Systems on September 27 - October 2, 2015, Dubrovnik, Croatia.
- Ala-Juusela Mia, Tracey Crosbie, Mari Sepponen, 2014: Defining the concept of an Energy Positive Neighbourhood and related KPIs. Conference proceedings. Sustainable places 2014 in Nice, France.

Local freight transport fuel mix	
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	The ratio of renewable fuels in the local freight transport fuel mix in the project.
Calculation	(ton kilometres transported by renewable fuels in the project/total ton kilometers in the project)*100% Please indicate which fuels/energy carriers have been considered. Renewable fuels include: bio-fuels, hydrogen and electricity. Other fuels include: petrol, diesel, liquefied petroleum gas, compressed natural gas, alcohol mixtures.
Strengths and weaknesses	Strengths: Weaknesses: This indicator requires detailed calculations and data.
Scoring	Theoretically, all transport could be fueled with renewables. However, in practice it is expected that more than 50% renewable fuel is already very good and therefore awarded with a 10.

Normalisation	
Improvement	Score
<5%	1
5-10%	2
10-15%	3
15-20%	4
20-25%	5
25-30%	6
35-40%	7
40-45%	8
45-50%	9

<table>
<tr><td></td><td><table><tr><td>>50%</td><td>10</td></tr></table></td></tr>
<tr><td colspan="2">Data requirements</td></tr>
<tr><td>Expected data source</td><td>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.</td></tr>
<tr><td>Expected availability</td><td>If the project has paid attention to this, some figures will be available with the above sources.</td></tr>
<tr><td>Collection interval</td><td>Yearly after the project, or ex-ante to evaluate the project plan</td></tr>
<tr><td>Expected reliability</td><td>Actual increase in renewable fuels might be difficult to measure and have to be estimated.</td></tr>
<tr><td>Expected accessibility</td><td>No sensitivities expected</td></tr>
<tr><td colspan="2">References</td></tr>
<tr><td colspan="2">2DECIDE
CIVITAS</td></tr>
</table>

Materials, water and land

<table>
<tr><td colspan="2">Increased efficiency of resource consumption</td></tr>
<tr><td>Description incl. justification</td><td>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 first step in this logic.</td></tr>
<tr><td>Definition</td><td>Percentage reduction in material consumption of the project</td></tr>
<tr><td>Calculation</td><td>The increased efficiciency of resource consumption resulting from measures taken in the project is calculated as the difference between the baseline material consumption of the project [t] and the final material consumption of the project [t] (numerator) divided by the baseline final material consumption [t] (denominator). The result (numerator/denomoninator) is multiplied by 100 in order to present the outcome as percentage.</td></tr>
<tr><td>Strengths and weaknesses</td><td>Strengths:
Weaknesses:
Commonly, materials consumption is measured in kg or metric tonnes. The meaning of the weight of materials, however, can be debated, since it doesn’t say anything about the required quality for the function. Materials for different functions require different characteristics (density, elasticity, etc.). Also, renewable materials are, in general, lighter than non-renewable materials.</td></tr>
<tr><td>Scoring</td><td>To determine the percentage improvement that should be awarded with a score of 10, we looked at the design for a building in the Netherlands with a strong focus to develop it as light as possible. The weight of that building was estimated to be 550 kg/m2 UFA , while an average Dutch terraced house (built in 2000) will weigh 954 kg/m2 UFA (Rovers 2010). We will therefore assume that a 45% reduction in material consumption is very ambitious and is awarded with a score of 10.
<table>
<tr><th colspan="2">Normalisation</th></tr>
<tr><th>% reduction</th><th>Score</th></tr>
<tr><td>0-5%</td><td>1</td></tr>
<tr><td>5-10%</td><td>2</td></tr>
<tr><td>10-15%</td><td>3</td></tr>
</table>
</td></tr>
</table>

15-20%	4
20-25%	5
25-30%	6
30-35%	7
35-40%	8
40-45%	9
>45%	10

Data requirements

Expected data source	Material accounting by tons should be collected by projects and found in project documents and from an interview with the project leader These sources should also be able to provide the deviations from the business-as-usual situation to be able to define the reduction achieved by the project.
Expected availability	Good. The amount of materials used will be recorded in the project.
Collection interval	After project completion, or ex-ante for evaluating the project plan.
Expected reliability	High
Expected accessibility	No sensitivities expected

References

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

Share of recycled input materials	
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 aluminum). By using recycled materials in the process, the environmental impact will be

<table>
<tr><td></td><td>reduced as less virgin resources have to be exploited/mined and less energy has be 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].</td></tr>
<tr><td>Definition</td><td>Share of recycled and re-used materials used by the project</td></tr>
<tr><td>Calculation</td><td>(recycled materials used by the project (tons)/total material consumption by the project(tons))*100%</td></tr>
<tr><td>Strengths and weaknesses</td><td>Strengths:
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.</td></tr>
<tr><td>Scoring</td><td>In theory, all materials used can be recycled materials, so the scale for normalization is equally divided in steps of 10%.
<table>
<tr><th colspan="2">Normalisation</th></tr>
<tr><th>% of total material consumption</th><th>Score</th></tr>
<tr><td>0-10%</td><td>1</td></tr>
<tr><td>10-20%</td><td>2</td></tr>
<tr><td>20-30%</td><td>3</td></tr>
<tr><td>30-40%</td><td>4</td></tr>
<tr><td>40-50%</td><td>5</td></tr>
<tr><td>50-60%</td><td>6</td></tr>
<tr><td>60-70%</td><td>7</td></tr>
<tr><td>70-80%</td><td>8</td></tr>
<tr><td>80-90%</td><td>9</td></tr>
<tr><td>90-100%</td><td>10</td></tr>
</table>
</td></tr>
<tr><td colspan="2">Data requirements</td></tr>
<tr><td>Expected data source</td><td>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</td></tr>
</table>

	published within material information databases (E-library).
Expected availability	Not every project will record and analyse the share of recycled materials used.
Collection interval	After the project, or ex-ante to evaluate the project plan
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	

<table>
<tr><td>Share of renewable materials</td><td></td></tr>
<tr><td>Description incl. justification</td><td>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 third step in this logic. Renewable materials are natural materials that regrow themselvesand have harvest cycles under 10 years, e.g. bamboo, cork, straw, cotton insulation, agrifiber, natural linoleum (Marmoleum), wool, wheat board and strawboard (LEED; [1]).</td></tr>
<tr><td>Definition</td><td>Share of renewable materials used by the project</td></tr>
<tr><td>Calculation</td><td>(renewable materials used by the project (tons)/total material consumption by the project(tons))*100%</td></tr>
<tr><td>Strengths and weaknesses</td><td>Strengths:
Weaknesses:</td></tr>
<tr><td>Scoring</td><td>In theory, all materials used can be renewable materials. In practice, some material functions are hard to replace (e.g. iron mongery and fittings) and renewable alternatives are difficult to find. In the Netherlands, an attempt is made to construct a modern building entirely out of renewable materials. So far, they've achieved an 82% renewables dwelling in the design (RiBuilT, 2012). So you could also state that a 70-75% share in renewable is already quite an achievement and should be awarded with a score of 10.
<table>
<tr><th colspan="2">Normalisation</th></tr>
<tr><td>% of total material consumption</td><td>Score</td></tr>
</table>
</td></tr>
</table>

0-5%	1
5-10%	2
10-15%	3
15-20%	4
20-25%	5
25-30%	6
30-40%	7
40-50%	8
50-70%	9
>70%	10

Data requirements

Expected data source	Total material amounts and as renewable materials by tons should be collected by project and be found in project documentation or provided by the project leader.
Expected availability	Not every project will record and analyse the share of renewable materials used.
Collection interval	After the project, or ex-ante to evaluate the project plan
Expected reliability	Good
Expected accessibility	No sensitivities expected

References:

- [1]http://www.poplarnetwork.com/topics/rapidly-renewable-materials#sthash.9Oc4g7Ig.dpuf
- Eurbanlab (2014). The Eurbanlab Selection of Indicators. Version 4.
- LEED credit category for materials

Share of materials recyclable

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. Looking into the future, we should therefore already take into

<table>
<tr><td></td><td>account to what extent the used materials can be recycled after the lifetime of the project, in order to enhance re-use and recycling for next projects.
The amount of recyclable materials is for a large part dependent on the design of the asset or product and its elements. Foremost, the materials should be individually separable to be able to retrieve them in their purest form. So not only should the materials be intrinsically recyclable, they should also be practically retrievable. If the materials recyclable can't be separated during demolition, they will not be taken into account in this calculation.</td></tr>
<tr><td>Definition</td><td>Share of materials used by the project that are practically retrievable for recycling after the life time</td></tr>
<tr><td>Calculation</td><td>(materials used by the project that can be recycled after used(tons)/total materials used by the project(tons))*100%</td></tr>
<tr><td>Strengths and weaknesses</td><td>Strengths:
Weaknesses: Recyclable materials might have less service life left than virgin materials.</td></tr>
<tr><td>Scoring</td><td>In principle, all materials can be re-used and recycled, so the scale for normalization is equally divided in steps of 10%.
<table>
<tr><th colspan="2">Normalisation</th></tr>
<tr><th>% of total material consumption</th><th>Score</th></tr>
<tr><td>0-10%</td><td>1</td></tr>
<tr><td>10-20%</td><td>2</td></tr>
<tr><td>20-30%</td><td>3</td></tr>
<tr><td>30-40%</td><td>4</td></tr>
<tr><td>40-50%</td><td>5</td></tr>
<tr><td>50-60%</td><td>6</td></tr>
<tr><td>60-70%</td><td>7</td></tr>
<tr><td>70-80%</td><td>8</td></tr>
<tr><td>80-90%</td><td>9</td></tr>
<tr><td>90-100%</td><td>10</td></tr>
</table>
</td></tr>
<tr><td colspan="2">Data requirements</td></tr>
<tr><td>Expected data source</td><td>Total material amounts and material amount for recycling after the building end of life should be collected by project</td></tr>
<tr><td>Expected availability</td><td>Poor: this information will usually not be recorded and collected in the course of a project.</td></tr>
</table>

Collection interval	After the project, or ex-ante for project evaluation
Expected reliability	It might be difficult to define the share of materials that can be recycled and has to be estimated.
Expected accessibility	No sensitivities expected
References:	
• Eurbanlab (2014). The Eurbanlab Selection of Indicators. Version 4.	

Life time extension	
Description incl. justification	The consumption of materials and resources has an impact on the environment and contributes to the depletion of resources. It is therefore recommended 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 first step in this logic by slowing down resource consumption by prolonging the service lifetime of products and assets compared to the designed service life. Service life is the assumed length of time that a product or asset will be operational.The products or assets concerned depend on the type of project and can be interpreted in a broad sense, e.g. buildings, cars, roads and computers. This indicator is different from the indicator 'Share of recycled input materials ' in that 'Life time extension' is about keeping the product operational as long as possible, before considering recycling at the end of its operational lifetime. There is a variety of measures that can be taken to increase the lifetime; • More durable materials; using higher quality materials, products will last longer; • Partial replacement: instead of replacing the whole product when inoperational, parts can be replaced to extend the lifetime of the whole; • Modular design: In addition to partial replacement, products can already be designed in a modular way and prepared to replace modules when at the end of their lifetime (or possibly when truly outdated); • Flexible design: to allow for future requirements and different functionalities
Definition	The extent to which the project has attempted to prolonge the service lifetime of an asset or product

Calculation	The indicator provides a **qualitative** measure and is rated on a five-point Likert scale: No at all – 1 — 2 — 3 — 4 — 5 — Very high 1. No at all: extending the lifetime has not been addressed in this project and no measures were taken. 2. Little: Service life time has received some attention in the project proposal, but not as an important element. 3. Moderate: the lifetime of one product/asset has been extended. 4. High : Increasing service life time is an important element of the project and various measures have been taken to increase the lifetime of several products or assets. 5. Very high: extending the service life time was a main aim of the project and has been applied to all products and assets relevant to the project.
Strengths and weaknesses	Strengths: Weaknesses: • Some level of subjectivity cannot be avoided in rating this indicator. • The measures taken does not directly reflect the actual lifetime extended
Scoring	Multiply Likert scale value by 2
Data requirements	
Expected data source	Project documents and interview with the project leader
Expected availability	Good
Collection interval	After the project, or ex-ante to evaluate the project plan
Expected reliability	Some level of uncertainty cannot be excluded
Expected accessibility	No sensitivities expected
References:	
•	

Reduction in water consumption	
Description incl. justification	Clean fresh water is essential for our health, for food and biomass production and for healthy ecosystems. Water consumption must be in harmony with water resources to be sustainable (ISO/DIS 37120, 2013). However, there is a growing pressure on the limited supply of

<table>
<tr><td></td><td>fresh water resources. Here too, the logic of ‘trias energetica’ can be applied; reduce water consumption, re-use (waste) water and use ‘renewable’ water. This indicator targets the first step in this logic and addresses the decrease in water consumption by the project and/or in general (households, public, commercial, industry, etc.).</td></tr>
<tr><td>Definition</td><td>Percentage reduction in water consumption (m3) brought about by the project</td></tr>
<tr><td>Calculation</td><td>$\frac{decrease\ in\ volume\ of\ the\ water\ used\ due\ the\ project}{volume\ of\ total\ water\ consumption\ of\ the\ city} * 100\ \%$
Note: From a smart/sustainable cities perspective, the indicator should include everything that is relevant to water loss. This includes pipe losses, firefighting etc.
However, that information may be difficult to obtain or to allocate since the distribution area of the water company is not necessarily the same as the geographic borders of the city under evaluation.
So if this information is not available or otherwise difficult, the consumption billed can be used as a proxy.</td></tr>
<tr><td>Strengths and weaknesses</td><td>Strengths:
Weaknesses:</td></tr>
<tr><td>Scoring</td><td>It is expected that the effect of a project on total water consumption of the city is small, therefore a higher than 9% reduction is awarded a 10.
<table>
<tr><th colspan="2">Normalisation</th></tr>
<tr><td>Improvement</td><td>Score</td></tr>
<tr><td><1%</td><td>1</td></tr>
<tr><td>1-2%</td><td>2</td></tr>
<tr><td>2-3%</td><td>3</td></tr>
<tr><td>3-4%</td><td>4</td></tr>
<tr><td>4-5%</td><td>5</td></tr>
<tr><td>5-6%</td><td>6</td></tr>
<tr><td>6-7%</td><td>7</td></tr>
<tr><td>7-8%</td><td>8</td></tr>
<tr><td>8-9%</td><td>9</td></tr>
<tr><td>>9%</td><td>10</td></tr>
</table>
</td></tr>
<tr><td colspan="2">**Data requirements**</td></tr>
</table>

Expected data source	Project design documents , metering data, interview with project leader
Expected availability	Good
Collection interval	After the project, or ex-ante to evaluate project plan
Expected reliability	High (metering data)
Expected accessibility	Design documents: Limited to the project team Access to metering data might belimited due to privacy issues, but can be aggregated to overcome this barrier.
References:	
•	

Increase in water re-used	
Description incl. justification	Clean fresh water is essential for our health, for food and biomass production and for healthy ecosystems. Water consumption must be in harmony with water resources to be sustainable (ISO/DIS 37120, 2013). However, there is a growing pressure on the limited supply of fresh water resources. Here too, the logic of 'trias energetica' can be applied; reduce water consumption, re-use (waste) water and use 'renewable' water. This indicator targets the second step in this logic. Re-using grey water and rain water lowers the demand for tap water and improves the balance of the water system. Greywater is wastewater generated in households or office buildings from sources such as water basins, showers**,** baths**,** clothes washing machines or dish washers (streams except for the wastewater from toilets). Grey water and rain water use may be an important aid to significantly decrease the domestic water consumption. The published literatures indicate that the typical volume of grey water varies from 90 to 120 l/p/d depending on lifestyles, living standards and other issues.
Definition	Increase in percentage of rainwater and greywater reused to replace potable water
Calculation	The increase in water re-used on site is calculated as the percentage of the overall water demand of the project in the operation phase covered by grey water and storm water retained on site.
Strengths and weaknesses	Strengths: Weaknesses:
Scoring	Not all potable water can be replaced by grey or rain water, therefore a 45% or higher increase is considered ambitious and awarded a 10.

Normalisation	
Improvement	Score
<5%	1
5-10%	2
10-15%	3
15-20%	4
20-25%	5
25-30%	6
30-35%	7
35-40%	8
40-45%	9
>45%	10

Data requirements

Expected data source	Project documents and interview with project leader
Expected availability	Good
Collection interval	After the project, or ex-ante to evaluate project plan
Expected reliability	High
Expected accessibility	No sensitivities expected

References:

- [1] http://www.usgbc.org/credits/we4
- Alternative Ways of Providing Water Emerging Options and Their Policy Implications. Environment. Advance copy for 5th world water forum. OECD
- http://www.usgbc.org/credits/we4
- ISO/DIS 37120 (2013). Sustainable development and resilience of communities — Indicators for city services and quality of life. ICS 13.020.20

Self-sufficiency - Water	
Description incl. justification	Clean fresh water is essential for our health, for food and biomass production and for healthy ecosystems. Water consumption must be in harmony with water resources to be sustainable (ISO/DIS 37120, 2013). However, there is a growing pressure on the limited supply of fresh water resources. Here too, the logic of ‘trias energetica’ can be

	applied; reduce water consumption, re-use (waste) water and use 'renewable' water. This indicator targets the third step in this logic. Responsible aquifer management and preservation is a key to maintaining a self-sufficient city as many of the city's water related services rely on phreatic resources to function correctly. Knowledge of total groundwater use is related directly to groundwater sources depletion and thus the indicator plays a role in self-sufficiency. This indicator measures how much more of the city's water consumption comes from local aquifers (located within 100km radius from the project's geographical or city's boundaries). Groundwater is underground trapped water, such as that contained in aquifers, which is used for several city services such as automated irrigation or urban cleaning.
Definition	Increased share of local water resources
Calculation	$\frac{\text{increased volume of the water used from local resources}}{\text{volume of total water consumption of the city}} * 100\ \%$
Strengths and weaknesses	Strengths: Weaknesses: Sometimes groundwater use is not desirable because of the low occurrence.
Scoring	It is expected that the effect of a project on total water consumption of the city is small, therefore a higher than 9% reduction is awarded a 10. Normalisation Improvement – Score <1% – 1 1-2% – 2 2-3% – 3 3-4% – 4 4-5% – 5 5-6% – 6 6-7% – 7 7-8% – 8 8-9% – 9 >9% – 10
Data requirements	
Expected data	Project documents and/or interview with the project leader. The

Normalisation

Improvement	Score
<1%	1
1-2%	2
2-3%	3
3-4%	4
4-5%	5
5-6%	6
6-7%	7
7-8%	8
8-9%	9
>9%	10

<table>
<tr><td>source</td><td>city’s water consumption can be found in the city indicator ‘water consumption’.</td></tr>
<tr><td>Expected availability</td><td>Information on the water extraction on local aquifers are not standard features of a project evaluation, thus the data might be difficult to obtain.</td></tr>
<tr><td>Collection interval</td><td>After the project, or ex-ante to evaluate the project plan</td></tr>
<tr><td>Expected reliability</td><td>High</td></tr>
<tr><td>Expected accessibility</td><td>No sensitivities expected</td></tr>
<tr><td colspan="2">References:</td></tr>
<tr><td colspan="2">• ISO/DIS 37120 (2013). Sustainable development and resilience of communities — Indicators for city services and quality of life. ICS 13.020.20</td></tr>
</table>

<table>
<tr><td>Increase in compactness</td><td></td></tr>
<tr><td>Description incl. justification</td><td>Increasing the compactness of cities is considered advantageous because it:
• reduces greenfield development
• decreases energy demand
• creates favourable conditions for the use of green transport modes.
• reduces environmental impact caused by the construction of infrastructures</td></tr>
<tr><td>Definition</td><td>Percentage change in the number of people or workplaces situated in the project area.</td></tr>
<tr><td>Calculation</td><td>Compactness shall be calculated as the increase in the number of inhabitants (#) or the number of work places (#) divided by the project area [ha]. The evaluator should indicate clearly which measure is used. The indicator is expressed as the percentage change comparing before and after the project.
((# of inhabitants or work places after project completion - # of inhabitants or work places before project completion/# of inhabitants or work places before project completion)*100%))-100</td></tr>
<tr><td>Strengths and weaknesses</td><td>Strengths:
Weaknesses: The indicator does not reflect the fact that excessive density may also have negative impacts on the environment and on the well-being of the people living and working in the project area.</td></tr>
<tr><td>Scoring</td><td>This indicator depends heavily on the reference situation, and a project may even decrease the compactness.
<table>
<tr><td>Improvement</td><td>Score</td></tr>
<tr><td><0%</td><td>1</td></tr>
<tr><td>0-10%</td><td>2</td></tr>
</table></td></tr>
</table>

10-20%	3
20-30%	4
30-40%	5
40-50%	6
50-60%	7
60-70%	8
70-80%	9
>80%	10

Data requirements	
Expected data source	Project documentation and/or interviews with the project leader
Expected availability	Good
Collection interval	After the project, or ex-ante to evaluate the project plan
Expected reliability	High
Expected accessibility	No sensitivities expected
References:	

Self-sufficiency – Food	
Description incl. justification	Local food production increases self-reliant and resilient food networks, enhances local economies by connecting food producers and food consumers in the same geographic region, and can improve citizen participation and social cohesion in the area. Local food production is defined as production within 100 km of the city to which the project is related.
Definition	Increase in the share of local food production due to the project
Calculation	(Extra food produced in 100 km radius because of the project (tons) / Total food demand within the project boundaries (tons) within 100 km radius)*100 % * The food demand can be calculated by multiplying the number of inhabitants within the project boundaries (for example a district or neighbourhood) under study with 770 kg (NB. The yearly intake in Europe was 770 kg per person in 2000 (EEA, 2005)).
Strengths and weaknesses	Strenghts: Weaknesses: May result in small numbers. Alternatively the number of people fed by the project (based on a standard intake of 770kg/person) could be used.

Scoring	It is expected that the effect of a project on total food consumption of the city is small, therefore a higher than 9% reduction is awarded a 10.

Normalisation	
Improvement	Score
<1%	1
1-2%	2
2-3%	3
3-4%	4
4-5%	5
5-6%	6
6-7%	7
7-8%	8
8-9%	9
>9%	10

Data requirements

Expected data source	Project documents and interviews with the project leader should reveal whether extra food has been produced locally and if so, how much.
Expected availability	If the project has paid attention to this, some figures will be available with the above sources.
Collection interval	After the project, or ex-ante to evaluate the project plan
Expected reliability	Actual increase in food production might be difficult to measure and have to be estimated.
Expected accessibility	No sensitivities expected

References:

- EEA (2005). Household consumption and the environment. EEA Report No 11/2005.
- Morrison KT et al. (2011) Methods for mapping local food production capacity from agricultural statistics. In: Agricultural Systems 104 (2011), 491–499
- Smith, A & MacKinnon, JB (2007) The 100-mile diet. A year of local eating. New Yort City: Random House. ISBN 0-679-31482-2

Climate resilience

Climate resilience measures	
Description incl. justification	Urban areas in Europe and worldwide are increasingly experiencing the pressures arising from climate change and are projected to face aggravated climate-related impacts in the future. Cities and towns play a significant role in the adaptation to climate change in the EU, which has been recognised by the EU Strategy on adaptation to climate change. Several cities and towns across Europe are already pioneering adaptation action and many others are taking first steps to ensure that European cities remain safe, liveable and attractive centres for innovation, economic activities, culture and social life (climate-adapt.org). To make urban environments resilient to future changes in climate, various measures can be taken to lower the sensitivity to high temperatures during heat waves and to prevent streets and cellars from flooding during extreme rainfall events. In some cases measures need to be taken to prevent flooding from rivers or the sea. Examples of adaptation options are: • Green spaces and trees • Water storage and buffers, like swales, water squares, levees and dikes, air bags in ponds, subterranean infiltration crates, blue roofs, rain cisterns • (semi-)permeable pavement Sufficient dimensioned sewage channels • White roofs • Solar shading • Access to local weather forecast including active warning system (push) To allow for flexibility, this indicator analyses to what extent climate resilience has been considered in the project.
Definition	The extent to which adaptation options have been considered in the the project.
Calculation	The indicator provides a qualitative measure and is rated on a five-point Likert scale: Not at all – 1 — 2 — 3 — 4 — 5 — Very much 1. Not at all: Adaptation options at neighbourhood scale were not taken into consideration. 2. Low: Adaptation options at neighbourhood scale were of minor importance in the project. A gut feeling was followed when making decisions on this topic. 3. Moderate: Adaptation options at neighbourhood scale were

	taken into consideration. Some basic information (e.g. from literature) was followed when making decisions on this topic, for example adding a line of trees to a road. 4. Much: Adaptation options at neighbourhood scale were an important consideration for decisions made in the project. 5. Very much: Adaptation options at neighbourhood scale were a major consideration for decisions made in the project, as adaptation to climate change was a specific goal of the project. Extensive information (e.g. calculations, integral planning etc.) was followed when making decisions on this topic.
Strengths and weaknesses	Strengths: Weaknesses: It is not yet possible to evaluate the impact of implementing adaptation options in a general way.
Scoring	Multiply Likert scale value by 2
Data requirements	
Expected data source	Project documentation and interviews with the project leader and/or other stakeholders
Expected availability	The required information will be readily available with the above sources
Collection interval	At the end of the project, or ex-ante to evaluate the project plan
Expected reliability	Good. A certain amount of subjectivity is present
Expected accessibility	No sensitivities expected
References:	
• Eurbanlab (2014). The Eurbanlab Selection of Indicators. Version 4.	

Pollution & waste

Decreased emissions of Nitrogen oxides (NO_x)	
Description incl. justification	Nitrogen oxides (NO and NO2) are major air pollutants, which can have significant impacts on human health and the environment (ISO/DIS 37120, 2013). NO contributes to ozone layer depletion and, when exposed to oxygen, can transform into NO2. NO2 contributes to the formation of photochemical smog and at raised levels can increase the likelihood of respiratory problems. Nitrogen dioxide inflames the lining of the lungs, and it can reduce immunity to lung infections. This can cause problems such as wheezing, coughing, colds, flu and bronchitis. Increased levels of nitrogen dioxide can have significant impacts on people with asthma because it can cause more frequent and more intense attacks. NO2 chemically transforms

<table>
<tr><td></td><td>into nitric acid and contributes to acid rain. Nitric acid can corrode metals, fade fabrics, and degrade rubber. When deposited, it can also contribute to lake acidification and can damage trees and crops, resulting in substantial losses.</td></tr>
<tr><td>Definition</td><td>Percentage reduction in NO_x emissions (NO and NO2) achieved by the project</td></tr>
<tr><td>Calculation</td><td>

$$\left(\frac{\mathbf{NOx\ emissions}\ \left(\frac{\mathbf{t}}{\mathbf{yr}}\right)\ \mathbf{after\ project}}{\mathbf{NOx\ emissions}\ \left(\frac{\mathbf{t}}{\mathbf{yr}}\right)\ \mathbf{before\ project}}\times \mathbf{100\%}\right) = \mathbf{percentage\ change\ in\ NOx\ emissions}$$

NO_x emissions can be derived from energy use if not directly available. The level of NO_x emissions are varying depending mainly on the energy generation technology and type of fuel.

It would be most convenient to use an average ratio number specific to the combustion process and fuel (e.g. Energy production from coal or diesel combustion engines).

$$\boldsymbol{Energy\ produced} \times \boldsymbol{NOx\_ratio}\ (\boldsymbol{kWh}\times\boldsymbol{NOx}/\boldsymbol{kWh})$$

</td></tr>
<tr><td>Strengths and weaknesses</td><td>Strengths:
Weaknesses: NO_x emissions are directly related to energy use, especially in the transport sector. Double counting with the energy indicators occurs.</td></tr>
<tr><td>Scoring</td><td>In principle, NOx emissions can be reduced to zero. Therefore, the normalization scale is equally divided in 10% steps.
<table>
<tr><td>Normalisation</td><td></td></tr>
<tr><td>% of reduction in NOx emissions</td><td>Score</td></tr>
<tr><td><10%</td><td>1</td></tr>
<tr><td>10-20%</td><td>2</td></tr>
<tr><td>20-30%</td><td>3</td></tr>
<tr><td>30-40%</td><td>4</td></tr>
<tr><td>40-50%</td><td>5</td></tr>
<tr><td>50-60%</td><td>6</td></tr>
<tr><td>60-70%</td><td>7</td></tr>
<tr><td>70-80%</td><td>8</td></tr>
<tr><td>80-90%</td><td>9</td></tr>
<tr><td>90-100%</td><td>10</td></tr>
</table>
</td></tr>
</table>

Data requirements	
Expected data source	Project documentation, measurements or interviews.
Expected availability	For projects with an important air pollution aspect, such as transport projects, information on expected reductions is expected to be included in the project documentation.
Collection interval	After the project, or ex-ante to evaluate project plan
Expected reliability	Emission factors may change from country to country. If results can be based on actual energy/NOx performance and not ex-ante estimations of how the energy balance is expected change, then the results are very reliable. If based on expectations, the results are somewhat reliable.
Expected accessibility	No sensitivities expected
References • ISO/DIS 37120 (2013). Sustainable development and resilience of communities — Indicators for city services and quality of life. ICS 13.020.20	

Decreased emissions of Particulate matter (PM2,5)	
Description incl. justification	Fine particulate matter can cause major health problems in cities (ISO/DIS 37120, 2013). According to the WHO, any concentration of particulate matter (PM) is harmful to human health. PM is carcinogenic and harms the circulatory system as well as the respiratory system. As with many other air pollutants, there is a connection with questions of environmental justice, since often underprivileged citizens may suffer from stronger exposure. The evidence on PM and its public health impact is consistent in showing adverse health effects at exposures that are currently experienced by urban populations in both developed and developing countries. The range of health effects is broad, but are predominantly to the respiratory and cardiovascular systems.
Definition	Percentage rduction in PM2,5 emissions achieved by the project
Calculation	$\left(\frac{\mathbf{PM2,5\ emissions}\ \left(\frac{\mathbf{kg}}{\mathbf{yr}}\right)\ \mathbf{after\ project}}{\mathbf{PM2,5\ emissions}\ (\frac{\mathbf{kg}}{\mathbf{yr}})\ \mathbf{before\ project}} \times \mathbf{10}\ \ \%\right) = \mathbf{percentage\ change\ in\ PM2,5\ emissions}$ Since data for PM2.5 is not readily available, levels are often

	calculated on the basis of PM10 emission and this is reported as a separate indicator. If a reduction in PM10 emissions cannot be found in project reports or elsewhere, a conversion method can used to calculate the PM2,5 emissions in kg from the amount of final energy consumption in the project.
Strengths and weaknesses	Strengths: Weaknesses:
Scoring	In principle, PM10 emissions can be reduced to zero. Therefore, the normalization scale is equally divided in 10%-steps.
Data requirements	
Expected data source	Project documentation, measurements or interviews
Expected availability	For projects with an important air pollution aspect, such as transport projects information on expected reductions is expected to be included in the project documentation.
Collection interval	After the project, or ex-ante to evaluate project plan
Expected reliability	If results can be based on actual energy/PM2.5 performance and not ex-ante estimations of how the energy balance is expected change, then the results are very reliable. If based on expectations, the results are somewhat reliable.
Expected accessibility	No sensitivities expected

Normalisation (within Scoring):

Normalisation	
% of reduction in PM10 emissions	Score
<10%	1
10-20%	2
20-30%	3
30-40%	4
40-50%	5
50-60%	6
60-70%	7
70-80%	8
80-90%	9
90-100%	10

References

- ISO/DIS 37120 (2013). Sustainable development and resilience of communities — Indicators for city services and quality of life. ICS 13.020.20

<table>
<tr><th colspan="2">Reduced exposure to noise pollution</th></tr>
<tr><td>Description incl. justification</td><td>Prolonged exposure to noise can lead to significant health effects, both physical and mental (ISO/DIS 37120, 2013). Environmental noise pollution relates to noise caused by road, rail and airport traffic, industry, construction, as well as some other outdoor activities.</td></tr>
<tr><td>Definition</td><td>Percentage reduction of noise level at night measured at the receiver</td></tr>
<tr><td>Calculation</td><td>The indicator is commonly measured in level of decibels (dB) which means that the reduction can be calculated as:
$$\left(\frac{\textbf{dB level after project}}{\textbf{dB level before project}}\times\mathbf{100}\%\right) = \textbf{percentage change dB level}$$
The noise level should be measured (or modelled) at the object receiving the noise.</td></tr>
<tr><td>Strengths and weaknesses</td><td>Strengths: Easy to measure and obtain data
Weaknesses: -</td></tr>
<tr><td>Scoring</td><td>In principle, noise can be reduced to (almost) zero. Therefore, the normalization scale is equally divided in 10%-steps.
<table>
<tr><th colspan="2">Normalisation</th></tr>
<tr><td>% of reduction in noise</td><td>Score</td></tr>
<tr><td><10%</td><td>1</td></tr>
<tr><td>10-20%</td><td>2</td></tr>
<tr><td>20-30%</td><td>3</td></tr>
<tr><td>30-40%</td><td>4</td></tr>
<tr><td>40-50%</td><td>5</td></tr>
<tr><td>50-60%</td><td>6</td></tr>
<tr><td>60-70%</td><td>7</td></tr>
<tr><td>70-80%</td><td>8</td></tr>
<tr><td>80-90%</td><td>9</td></tr>
<tr><td>90-100%</td><td>10</td></tr>
</table>
</td></tr>
</table>

Data requirements	
Expected data source	Measurements, documentation or interviews.
Expected availability	Member countries of the European Union are committed to the reduction of noise pollution to those levels recommended by the WHO by the year of 2020. Member counties might therefore have measurements of noise pollution for at least official areas.
Collection interval	After the project, or ex-anet to evaluate the project plan
Expected reliability	If the data is based on measurements the results are very reliable. If based on expectations/calculations, the results are somewhat reliable.
Expected accessibility	No sensitivities expected
References • http://ec.europa.eu/environment/noise/directive_en.htm • ISO/DIS 37120 (2013). Sustainable development and resilience of communities — Indicators for city services and quality of life. ICS 13.020.20	

Reduction in the amount of solid waste collected	
Description incl. justification	Higher levels of municipal waste contribute to greater environmentalproblems and therefore levels of collection, and also methods of disposal, of municipal solid waste are an important component of municipal environmental management. Collection of municipal solid waste is also an indicator of city management with regard to cleanliness, health and quality of life. Solid waste systems contribute in many ways to public health, the local economy, the environment, and the social understanding and education about the latter (ISO/DIS 37120, 2013) The proper discharge, transportation and treatment of solid waste is one of the most important components of life in a city and one of the first areas in which governments and institutions should focus. Solid waste systems contribute in many ways to public health, the local economy, the environment, and the social understanding and education about the latter. A proper solid waste system can foster recycling practices that maximize the life cycle of landfills and create recycling micro-economies; and it provides alternative sources of energy that help reduce the consumption of electricity and/or petroleum based fuels. Municipal waste shall refer to waste collected by or on behalf of municipalities. The data shall only refer to the waste flows managed under the responsibility of the local administration including waste

<table>
<tr><td></td><td>collected on behalf of the local authority by private companies or regional associations founded for that purpose. (ISO/DIS 37120, 2013)
Municipal waste should include waste originating from:
households;
commerce and trade, small businesses, office buildings and institutions (e.g. schools, hospitals, government buildings).
The definition should also include:
bulky waste (e.g. white goods, old furniture, mattresses);
garden waste, leaves, grass clippings, street sweepings, the content of litter containers, and market cleansing waste, if managed as waste;
waste from selected municipal services, i.e. waste from park and garden maintenance, waste from street cleaning services (e.g. street sweepings, the content of litter containers, market cleansing waste), if managed as waste.
The definition shall exclude:
waste from municipal sewage network and treatment;
municipal construction and demolition waste.</td></tr>
<tr><td>Definition</td><td>Percentage reduction in the amount of waste collected due to the project</td></tr>
<tr><td>Calculation</td><td>The reduction can be accounted for when looking at the levels before and after the project. And the reduction is calculated by:
$$\left(\frac{\textbf{Solid waste}\left(\frac{\textbf{t}}{\textbf{timeperiod}}\right)\textbf{after project}}{\textbf{Solid waste}\left(\frac{\textbf{t}}{\textbf{timeperiod}}\right)\textbf{before project}}\times\textbf{100}\%\right) = \textbf{percentage change in Solid waste}$$</td></tr>
<tr><td>Strengths and weaknesses</td><td>Strengths: Clear unit that is easily understandable and measurable
Weaknesses: -</td></tr>
<tr><td>Scoring</td><td>In principle, waste can be reduced to (almost) zero. Therefore, the normalization scale is equally divided in 10%-steps.
<table>
<tr><th colspan="2">Normalisation</th></tr>
<tr><td>% of waste reduction</td><td>Score</td></tr>
<tr><td><10%</td><td>1</td></tr>
<tr><td>10-20%</td><td>2</td></tr>
<tr><td>20-30%</td><td>3</td></tr>
<tr><td>30-40%</td><td>4</td></tr>
</table></td></tr>
</table>

40-50%	5
50-60%	6
60-70%	7
70-80%	8
80-90%	9
90-100%	10

Data requirements	
Expected data source	Measurements, documentation and interviews.
Expected availability	Projects with explicit aims with regard to waste management are expected to have these data included in the project documentation.
Collection interval	After the project, or ex-ante to evaluate the project plan
Expected reliability	Data quality from municipal waste management might vary amongst EU member states and also amongst cities/municipalities within one state. The data might range from highly reliable to somewhat reliable.
Expected accessibility	No sensitivities expected

References

- http://www.eea.europa.eu/publications/managing-municipal-solid-waste
- ISO/DIS 37120 (2013). Sustainable development and resilience of communities — Indicators for city services and quality of life. ICS 13.020.20

Ecosystem

Increase in green and blue space	
Description incl. justification	Green and water spaces are regarded as an index representing the degree of the nature conservation and improving the public health and quality of life as they are directly related to the natural water circulation, environmental purification and the green network. More green and blue also reduces vulnerability to extreme weather events like urban heat islands and flooding by heavy rainfall. Green areas are forest and park areas that are partly or completely covered with grass, trees, shrubs, or other vegetation. Water areas here meaning lakes, ponds, rivers.
Definition	Percentage increase in green and blue spaces due to the project
Calculation	((blue and green space after project (m2)/blue and green space

	before project(m2))*100)-100
Strengths and weaknesses	Strengths: Weaknesses: This indicator is quite project-specific, and an increase of green and blue spaces may not necessarily mean that the ecosystem quality is better. Overlap with the indicator ‘increased access to green space’.
Scoring	This indicator depends heavily on the reference situation, and a project may even decrease the green space.

Improvement	Score
<0%	1
0-10%	2
10-20%	3
20-30%	4
30-40%	5
40-50%	6
50-60%	7
60-70%	8
70-80%	9
>80%	10

Data requirements

Expected data source	Existing green and blue space areas should be obtained from municipal recreation and parks departments, planning departments, forestry departments and census. Project data collected from project documents and/or interview with the project leader
Expected availability	Good
Collection interval	After the project, or ex-ante to evaluate the project plan
Expected reliability	good
Expected accessibility	No sensitivities expected

References:

-

Increased ecosystem quality and biodiversity	
Description incl. justification	Urbanization affects biodiversity and ecosystem quality through urban sprawl/habitat fragmentation, loss of fertile agricultural lands, and spread of invasive alien species (ISO/DS 37120, 2013). A loss in ecosystem quality and biodiversity threatens food supplies, lessens

	opportunities for recreation and tourism, and impacts a diverse range of medicinal sources, varieties of wood, and energy. It also interferes with essential ecological function, such as carbon sequestration, climate regulation and air filtering. This indicator analyses the efforts that have been taken by the project to increase biodiversity and the quality of the ecosystem. A general increase in ecosystem space has already been accounted for in the indicator ’increase in green and blue spaces’, this indicator specifically addresses the quality of that space.
Definition	The extent to which ecosystem quality and biodiversity aspects have been taken into account
Calculation	The indicator provides a **qualitative** measure and is rated on a five-point Likert scale: Not at all – 1 — 2 — 3 — 4 — 5 — Very high 1. Not at all: The project did not consider ecosystem quality and biodiversity aspects. 2. Low: the project considers Ecosystem quality and biodiversity aspects only in very low extent. 3. : some improvements of Ecosystem quality and biodiversity aspects to current structure have been taken. 4. High: many improvement of Ecosystem quality and biodiversity aspects to current structure have been taken 5. Very high: many major improvements of Ecosystem quality and biodiversity aspects to current structure have been taken.
Strengths and weaknesses	Strengths: Weaknesses: Projects may have limited influence. Although it is tried to make scoring the indicator as objectively as possible, a certain amount of subjectivity is present.
Scoring	Multiply Likert scale value by 2
Data requirements	
Expected data source	Project documents and/or interviews with project leader or others involved
Expected availability	Good. The required information will available with the above sources, especially if this was regarded an important topic in the project.
Collection interval	After project completion, and ex-ante to evaluate project plan
Expected reliability	A certain amount of subjectivity is present and can affect the reliability.
Expected accessibility	No sensitivities expected
References:	
- http://www.greenfacts.org/en/ecosystems/figtableboxes/table2-1-trends-use-	

ecosystems-provisioning.htm

Prosperity

Employment

<table>
<tr><th colspan="2">Use of local workforce</th></tr>
<tr><td>Description incl. justification</td><td>Part of the value created by smart city projects is the contribution to local employment. Therefore, this indicator analyses the percentage of the total project cost spent on local suppliers, contractors and service providers. Local is loosely defined as “from the city or region”, as seen fitting with the situation.
As it is impossible to make a distinction between products and labour, the definition includes all products irrespective of their origin provided by local suppliers. A rough estimate is asked from the respondents. It is not intended that detailed inventories of all expenditures are undertaken. Similarly for planned projects: an impression of the distribution of contracting is asked for.</td></tr>
<tr><td>Definition</td><td>Share in the total project costs that has been spent on local suppliers, contractors and service providers.</td></tr>
<tr><td>Calculation</td><td>(Use of local workforce (project costs) in project/total use of workforce (project costs) in project)*100%</td></tr>
<tr><td>Strengths and weaknesses</td><td><u>Strengths:</u> Addresses one of the main political motivations for smart city and other urban development projects
<u>Weaknesses:</u> The indicator does not measure the job creation itself, but uses the budget share spent for local suppliers as a proxy.</td></tr>
<tr><td>Scoring</td><td><table>
<tr><th colspan="2">Normalisation</th></tr>
<tr><td>% spent on local…</td><td>Score</td></tr>
<tr><td>>80%</td><td>10</td></tr>
<tr><td>60-80%</td><td>8</td></tr>
<tr><td>40-60%</td><td>6</td></tr>
<tr><td>20-40%</td><td>4</td></tr>
<tr><td><20%</td><td>2</td></tr>
</table></td></tr>
<tr><th colspan="2">Data requirements</th></tr>
<tr><td>Expected data source</td><td>To be retrieved from project documentation and/or interviews woth the project leader or other actors involved.</td></tr>
<tr><td>Expected availability</td><td>Documenting the budget share of local suppliers is not a standard</td></tr>
</table>

	procedure, it requires an extra effort.
Collection interval	At the end of the project, or ex-ante to evaluate plans.
Expected reliability	Low, as local job creation effects cannot sufficiently be explained by looking at the amount of money spent on local suppliers
Expected accessibility	Data has to be collected by the project manager and he/she must be willing to share.
References	
• Eurbanlab (2014). The Eurbanlab Selection of Indicators. Version 4.	

<table>
<tr><td>Local job creation</td><td></td></tr>
<tr><td>Description incl. justification</td><td>Creating jobs for local people is a strong motivation for many urban development projects, and especially smart city projects. Estimating the jobs created in a specific local context, however, suggests the project has a direct relation to a certain area, which does not necessarily have to be the case. Therefore, this indicator only assesses the the number of jobs created, without specifying the location.</td></tr>
<tr><td>Definition</td><td># of jobs created by the project</td></tr>
<tr><td>Calculation</td><td></td></tr>
<tr><td>Strengths and weaknesses</td><td>Strenghts: the indicator is relevant to the subtheme employability, with links to the people and planet theme (less traffic from commuters).
Weaknesses: incomparable between projects</td></tr>
<tr><td>Scoring</td><td>Theoretically, it is possible that the project costs jobs. Therefore a score of 0 or less is awarded a 1.
<table>
<tr><td># of jobs created</td><td>Score</td></tr>
<tr><td><0</td><td>1</td></tr>
<tr><td>1-3</td><td>2</td></tr>
<tr><td>3-5</td><td>3</td></tr>
<tr><td>5-7</td><td>4</td></tr>
<tr><td>7-10</td><td>5</td></tr>
<tr><td>10-30</td><td>6</td></tr>
<tr><td>30-50</td><td>7</td></tr>
<tr><td>50-70</td><td>8</td></tr>
<tr><td>70-100</td><td>9</td></tr>
<tr><td>>100</td><td>10</td></tr>
</table>
</td></tr>
<tr><td colspan="2">Data requirements</td></tr>
<tr><td>Expected data</td><td>Project documentation or interviews with the project leader.</td></tr>
</table>

source	
Expected availability	If the project has an impact on this factor this information will likely be available.
Collection interval	After the project, but can also be used ex-ante to evaluate plans
Expected reliability	High.
Expected accessibility	As a component of a successful project and selling point in a marketing sense, it is expected that this information will be accessible if the project has an impact on this factor.
References	
•	

Equity

Fuel poverty	
Description incl. justification	A significant part of a household's income is consumed by housing costs and related expenditures. As such, both are determinants of the extent to which households are at risk of poverty or deprivation. As a large share of the European housing stock consists of buildings in desperate need of refurbishment, particularly in lower income low-energy-efficiency buildings with residents living in fuel poverty, the key to alleviate fuel poverty is to renovate the stock into more energy efficient buildings. Avoiding energy poverty has therefore become an important policy aim in many European countries, for example in the UK, in Austria and in Germany. The CITYkeys indicator is derived from the UK definition, according to which households are considered as energy poor if their energy bill consumes 10% or more of the household income (DECC, 2013). The assessor may need to determine a hypothetical baseline in case of a new construction development.
Definition	Change in percentage points of (gross) household income spent on energy bills
Calculation	((Energy costs before project)/(Gross household income)×100%) - ((Energy costs after project)/(Gross household income)×100%) = percentage point change in income spent on energy Note: Various datamodels for calculations on city level are described in DECC (2013). Note: The energy costs include all building related energy, i.e. for heating/cooling, warm water and electricity.

Strengths and weaknesses	Strenghts: The indicator links energy saving with socio-economic policies. Weaknesss: Definitions and circumstances differ greatly throughout Europe. The ability to pay high energy bills is likely to increase with rising household incomes. This is not reflected by the indicator. Individual circumstances may differ from the calculated average.
Scoring	If costs are reduced, meaning a negative change in percentage points, points will be rewarded according to the following table. If costs increase (positive %point change), a score of 1 will be given. With no change in costs, the score remains 0, which means it will not be taken into account in the calculation of the score.

%point change	Score
<-5	10
-5	9
-4	8
-3	7
-2,5	6
-2	5
-1,5	4
-1	3
-0,5	2
0	0
>0	1

Data requirements

Expected data source	Data on the (average or median) household income may be obtained from the city statistical office if not available for the immediate context of the project. If the project had as an aim to decrease energy consumption or CO_2 emissions, the numbers on the reference situation and after completion of the project can serve as the basis for calculating the change in energy costs. Energy prices (metered prices) can be obtained from the local energy provider(s)
Expected availability	Most difficult will be data on the (average or median) household income in the neighbourhood of the project. Often data are not regularly available in that geographical detail. Estimates or proxies may be used instead. The other data should be easily available.
Collection interval	At the beginning and the end of the project, or ex-ante to evaluate plans
Expected reliability	High

Expected accessibility	It is expected that the data is available (at least in a general sense) if the project aimed to decrease energy use or CO_2 emssions. Privacy / data protection concerns may apply for projects with only few households.

References

- DECC, 2013. The fuel poverty statistics methodology and user manual. UK department of Energy and Climate change. https://www.gov.uk/government/publications/fuel-poverty-methodology-handbook-2013
- Kopatz et al., 2010: Energiearmut. Stand der Forschung, nationale Programme und regionale Modellprojekte in Deutschland, Österreich und Großbritannien. Wuppertal Papers, 184, Wuppertal; http://epub.wupperinst.org/frontdoor/index/index/docId/3606
- Eurbanlab (2014). The Eurbanlab Selection of Indicators. Version 4.

Affordability of housing	
Description incl. justification	Good 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 project area after the project has been executed. 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 projects 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 gross household income spent on housing
Calculation	(Fixed housing costs after the project (€ / year))/(Gross household income (€ / year)) ×100%

<table>
<tr><td></td><td>The housing costs include all fixed expenditures on housing (such as rents and hereditary tenure or mortgage payments), and excludes expenditures for services or utilities</td></tr>
<tr><td>Strengths and weaknesses</td><td>Strength: 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 socialy accepted. The indicator is usually based on averages (for income data often derived from statistics on larger areas) that may compromise accuracy.</td></tr>
<tr><td>Scoring</td><td>If costs are reduced, meaning a negative change in percentage points, points will be rewarded according to the following table. If costs increase (positive %point change), a score of 1 will be given. With no change in costs, the score remains 0, which means it will not be taken into account in the calculation of the score.
<table>
<tr><td>%point change</td><td>Score</td></tr>
<tr><td><-5</td><td>10</td></tr>
<tr><td>-5</td><td>9</td></tr>
<tr><td>-4</td><td>8</td></tr>
<tr><td>-3</td><td>7</td></tr>
<tr><td>-2,5</td><td>6</td></tr>
<tr><td>-2</td><td>5</td></tr>
<tr><td>-1,5</td><td>4</td></tr>
<tr><td>-1</td><td>3</td></tr>
<tr><td>-0,5</td><td>2</td></tr>
<tr><td>0</td><td>0</td></tr>
<tr><td>>0</td><td>1</td></tr>
</table>
</td></tr>
<tr><td colspan="2">**Data requirements**</td></tr>
<tr><td>Expected data source</td><td>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.</td></tr>
<tr><td>Expected availability</td><td>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.</td></tr>
<tr><td>Collection interval</td><td>At the end of the project, or ex-ante to evaluate plans.</td></tr>
<tr><td>Expected reliability</td><td>Depending on the quality of the income data.</td></tr>
<tr><td>Expected accessibility</td><td>No data for individual dwellings will be available for reasons of privacy / data protection</td></tr>
<tr><td colspan="2">**References**</td></tr>
</table>

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

Green Economy

Certified companies involved in the project	
Description incl. justification	More and more organisations have systematic attention for the environmental aspects of their business, including products and services. Often this is the consequence of increasing attention of external parties for the environmental performance of the company. These stakeholders have wishes and demands on the environmental aspects of the company, which need to be taken into account by the company to keep its “license to operate” in the longer term. The ISO 14000 series of norms for environmental management offers guidance for organisations that want to go further than compliance with rules and regulations. The norms are meant for companies that understand that implementing a systematic approach to the environmental aspects of the company and its products will pay itself back, for example through decrease of waste costs; reductions in energy, resources and materials; improving environmental image; better relationships with government; and new market opportunities. If a high share of certified companies are involved in the project implementation process, it can be assumed that the implementation is carried out in a (more) sustainable way.
Definition	Share of the companies involved in the project holding an ISO 14001 certificate.
Calculation	(Number of companies with ISO 140001 certificate/total companies involved)*100%
Strengths and weaknesses	Strenghts: easy to understand. Weakness: Only a minority of companies is certified, and it is possible for non-certified companies to conduct their business in an environmentally sound manner.
Scoring	

Normalisation	
% share with ISO...	Score
>80%	10
60-80%	8
40-60%	6
20-40%	4
<20%	2

Data requirements	
Expected data source	Project documentation, Self-disclosure of the companies involved in the implementation process, ISO registers.
Expected availability	Information has to be provided by subcontractors if it cannot be looked up online.
Collection interval	After the project, or ex-ante to evaluate plans
Expected reliability	ISO 14001 is international standard, so the reliability and comparability of the data is expected to be high.
Expected accessibility	Open access, as companies tend to use this information for the purpose of marketing
References • http://www.iso.org/iso/home/standards/management-standards/iso14000.htm • https://www.nen.nl/NEN-Shop/Vakgebieden/Managementsystemen/Milieumanagement.htm • http://www.isoregister.nl/register.html	

Green public procurement	
Description incl. justification	Not all smart city projects will be executed by public bodies, but some will be and for those this indicator is relevant. Increasingly public authorities are using their purchasing power to choose environmentally friendly goods, services and works, in order to make an important contribution to sustainable consumption and production – what we call Green Public Procurement, or GPP. Although GPP is not mandatory, it has a key role to play in the EU's efforts to become a more resource-efficient economy. It can help stimulate a critical mass of demand for more sustainable goods and services which otherwise would be difficult to get onto the market. GPP is therefore a strong stimulus for eco-innovation. Currently there are no EU wide environmental and sustainability criteria for products and services. Some countries have already introduced national criteria. Because of comparability considerations, the indicator is phrased on the degree to which GPP was taken into account and not on the share in project expenditures. GPP criteria refers to the relevant local or national procurement criteria.
Definition	The extent to which GPP criteria where taken into account for the procurement processes related to the project.
Calculation	Likert scale: Not at all -1 - 2 - 3 – 4 -5-Excellent

	1. Not at all: GPP criteria were not taken into account for the procurement processes related to the project 2. Poor: GPP criteria were to a large extent not taken into account for the procurement processes related to the project 3. Somewhat: GPP criteria were somewhat taken into account for the procurement processes related to the project 4. Good: GPP criteria were to a large extent taken into account for the procurement processes related to the project 5. Excellent: GPP criteria were completely taken into account for the procurement processes related to the project, followed to the letter
Strengths and weaknesses	Strength: The indicator is relevant to green economy. Common European guidelines are available. Weakness: This indicator is only relevant to (partly) government-funded projects; guidelines are extensive; Although it is tried to make scoring the indicator as objectively as possible, a certain amount of subjectivity is present.
Scoring	Multiply Likert scale value by 2
Data requirements	
Expected data source	Records of public procurement authorities, project documentation
Expected availability	Data has to be collected and disclosed by the above parties
Collection interval	During and after the project, or ex-ante to evaluate plans
Expected reliability	Because of the subjectivity that cannot be excluded, this indicator is not 100% reliable
Expected accessibility	Data should be available in most EU countries, as GPP is actively promoted by the EC.
References • http://ec.europa.eu/environment/gpp/eu_gpp_criteria_en.htm • (Source: http://ec.europa.eu/environment/gpp/index_en.htm)	

CO2 reduction cost efficiency	🚗 💻 🏢
Description incl. justification	Many smart city projects are intrinsically aimed at reducing the amount of CO_2 emitted during their lifetime. Those projects which prove to be able to significantly reduce their carbon footprint, whilst keeping the related costs at a minimum, are considered to be interesting projects for upscaling.
Definition	Costs in euro's per ton of CO_2 saved per year

<table>
<tr><td>Calculation</td><td>This indicator is calculated on an annual basis, taking the annual reduction in CO_2 emissions, and the annual costs of the project (which is the annualised investment plus current expenditures for a year).

<u><i>Note:</i></u> Only the additional costs for energy/CO_2 related measures (to the extent discernible) are taken into account in the total costs calculation.</td></tr>
<tr><td>Strengths and weaknesses</td><td>Strenghts:
Weaknesses: Often difficult to split up the innovation into the part that is actually related to the CO2. For example a solar bikepath may cost several million euros to develop and implement, but only a fraction of that cost will related to the incorporation of the PV; while the rest of the costs are related to the bikepath itself.</td></tr>
<tr><td>Scoring</td><td>
<table>
<tr><th colspan="2">Normalisation</th></tr>
<tr><td>Improvement</td><td>Score</td></tr>
<tr><td>>250 €/ton CO2</td><td>1</td></tr>
<tr><td>225-250 €/ton CO2</td><td>2</td></tr>
<tr><td>200-225 €/ton CO2</td><td>3</td></tr>
<tr><td>175-200 €/ton CO2</td><td>4</td></tr>
<tr><td>150-175 €/ton CO2</td><td>5</td></tr>
<tr><td>125-150 €/ton CO2</td><td>6</td></tr>
<tr><td>100-125 €/ton CO2</td><td>7</td></tr>
<tr><td>75-100 €/ton CO2</td><td>8</td></tr>
<tr><td>40-75 €/ton CO2</td><td>9</td></tr>
<tr><td>0-40 €/ton CO2</td><td>10</td></tr>
</table>
</td></tr>
<tr><td colspan="2">Data requirements</td></tr>
<tr><td>Expected data source</td><td>Interviews with the project leader and/or project documentation.</td></tr>
<tr><td>Expected availability</td><td>If the project aims to reduce CO2, it is likely that the estimated emission reduction will be available.</td></tr>
<tr><td>Collection interval</td><td>After the project or ex-ante to evaluate plans</td></tr>
<tr><td>Expected reliability</td><td>It is expected to be reliable, but CO2-emission reduction is a calculation, not an exact measurement.</td></tr>
<tr><td>Expected accessibility</td><td>Likely accessible, but maybe restricted.</td></tr>
</table>

References

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

Economic performance

<table>
<tr><th colspan="2">Financial benefit for the end user</th></tr>
<tr><td>Description incl. justification</td><td>One dimension of value creation by the smart city project is the extent to which the project generated cost savings for end-users. End-users are seen as those people who will be adopting the project and using the techniques or concepts applied in the project. Financial benefit can be an important trigger for the user acceptance and the market uptake of smart city solutions.
Cost savings, can be generated, for example, through a reduction in energy/water use, the generation of renewable energy on site, or reduction in housing costs.
To achieve costs savings, initial investments or other costs might be required, e.g. when purchasing a more efficient heating installation. These costs have to be expressed as yearly costs to be able to determine the real annual cost savings due to the project. Direct revenue created by the project is included in this calculation as avoided costs.</td></tr>
<tr><td>Definition</td><td>Total cost savings in euros for end-users per household per year.</td></tr>
<tr><td>Calculation(suggestion, if available)</td><td>Total (direct) costs before the project- total (direct) costs after the project = cost savings.</td></tr>
<tr><td>Strengths and weaknesses</td><td>Strengths:
Weaknesses: As far as energy-related cost savings are concerned, significant deviations between demand calculations and the actual consumption data is a well-known phenomenon.
Overlap with indicator ‘Advantages for end-user’ under Propagation</td></tr>
<tr><td>Scoring</td><td>Most values are expected in the lower ranges, hence most detail is in the range up to 800 Euro.
<table>
<tr><th>Points</th><th>Cost savings</th></tr>
<tr><td>10</td><td>>1000</td></tr>
<tr><td>9</td><td>801-1000</td></tr>
<tr><td>8</td><td>701-800</td></tr>
<tr><td>7</td><td>601-700</td></tr>
<tr><td>6</td><td>501-600</td></tr>
<tr><td>5</td><td>401-500</td></tr>
<tr><td>4</td><td>301-400</td></tr>
<tr><td>3</td><td>201-300</td></tr>
<tr><td>2</td><td>101-200</td></tr>
<tr><td>1</td><td>0-100</td></tr>
</table>
</td></tr>
</table>

Data requirements	
Expected data source	Project documentation, interviews with project leader and/or with end-users.
Expected availability	As this will often go to the core of why a project is being executed, it is expected that this information will be available with the above sources.
Collection interval	Before and after the project, or ex-ante to evaluate plans
Expected reliability	Many aspects influence the costs and different calculations methods exist to calculate the costs (and revenues), which make the indicator not 100% reliable. With regards to energy cost savings, there is limited reliability of the energy demand calculations due to user behavior (see above).
Expected accessibility	As a selling point in a marketing sense, it is expected that this information will be accessible
References	
- Eurbanlab (2014). The Eurbanlab Selection of Indicators. Version 4.	

Net Present Value (NPV)	🚗 💻 🏢
Description incl. justification	The Net Present Value (NPV) is a measure of financial project performance. The net present value of an investment is defined as the sum of the discounted annual incoming cash-flows related to the investment less the discounted annual outgoing cash flows over a period of time, thereby comparing the present value of money today to the present value of money in future, taking inflation and returns into accountThe discount factor used should always be reported. If the benefits exceed the costs, the NPV is positive and the project is worth pursuing.
Definition	The Net Present Value of the project calculated over the lifetime
Calculation	The NPV is expressed in Euro [€] Calculation: $$NPV = I_0 + \sum_{t=1}^{T} \frac{E_t - A_t}{(1+i)^t}$$ Input parameters: I_0 = Initial investment in t_0 [€] E_t = Cash inflow in t [€]

<table>
<tr><td></td><td>A_{t} = Cash outflow in t [€]
i = discount rate
T = Reference study period [years]
Nb The number of years evaluated could be the mean life time of the project/measure or the time expected to return the inversion by the politic authorities.</td></tr>
<tr><td>Strengths and weaknesses</td><td>Strenghts:
Weaknesses: NPV is very dependent on the chosen interest/discount rate.</td></tr>
<tr><td>Scoring</td><td>Most values are expected in the lower ranges, hence most detail is in the range up to 800 Euro.
<table>
<tr><td>Points</td><td>NPV/m2</td></tr>
<tr><td>10</td><td>>1000</td></tr>
<tr><td>9</td><td>801-1000</td></tr>
<tr><td>8</td><td>701-800</td></tr>
<tr><td>7</td><td>601-700</td></tr>
<tr><td>6</td><td>501-600</td></tr>
<tr><td>5</td><td>401-500</td></tr>
<tr><td>4</td><td>301-400</td></tr>
<tr><td>3</td><td>201-300</td></tr>
<tr><td>2</td><td>101-200</td></tr>
<tr><td>1</td><td>0-100</td></tr>
</table>
</td></tr>
<tr><td colspan="2">Data requirements</td></tr>
<tr><td>Expected data source</td><td>Project documentation and/or interviews with the project leader and other actors involved.</td></tr>
<tr><td>Expected availability</td><td>As this will often go to the core of why a project is being executed, it is expected that this information will be available</td></tr>
<tr><td>Collection interval</td><td>At the end of the project, or ex-ante to evaluate plans</td></tr>
<tr><td>Expected reliability</td><td>The calculation can be performed reliably.</td></tr>
<tr><td>Expected accessibility</td><td>Restricted, part of the business case.</td></tr>
<tr><td colspan="2">References</td></tr>
<tr><td colspan="2">• Smart City Information System – Key Performance Indicator Guide
• Eurbanlab (2014). The Eurbanlab Selection of Indicators. Version 4.</td></tr>
</table>

Internal rate of return (IRR)	
Description incl. justification	The internal rate of return (IRR) is a widely used investment performance measure in commercial real estate. The IRR of an

<table>
<tr><td></td><td>investment is the discount rate at which the net present value of costs (negative cash flows) of the investment equals the net present value of the benefits (positive cash flows) of the investment (urbgrade.com). It is expressed as the net present value (NPV) equal to zero. Simply stated, the Internal rate of return (IRR) for an investment is the percentage rate earned on each euro invested for each period it is invested. IRR is also another term people use for interest. Ultimately, IRR gives an investor the means to compare alternative investments based on their yield.</td></tr>
<tr><td>Definition</td><td>The interest rate at which the net present value of the investment is zero.</td></tr>
<tr><td>Calculation</td><td>

Calculation

$$NPV \; = I_0 + \sum_{t=1}^{T} \frac{E_t - A_t}{(1+i)^t} = 0$$

Input parameters

I_0 = Initial investment in t_0 [€]

i = discount rate

E_t = Cash inflow in t [€]

A_t = Cash outflow in t [€]

T = Reference study period [years]

Nb The number of years evaluated could be the mean life time of the energy saving measure or the time expected to return the inversion by the politic authorities.

</td></tr>
<tr><td>Strengths and weaknesses</td><td>

Strenghts:

Weaknesses: the indicator seems most applicable to real estate innovations. The mathematical definition of NPV = 0 is quite abstract.

</td></tr>
<tr><td>Scoring</td><td>

An investment with an IRR that is lower than the discount rate used by public authorities, is considered unattractive and therefore awarded a 1.

<table>
<tr><td>IRR</td><td>Score</td></tr>
<tr><td>0-4</td><td>1</td></tr>
<tr><td>4-6</td><td>2</td></tr>
<tr><td>6-8</td><td>3</td></tr>
<tr><td>8-10</td><td>4</td></tr>
<tr><td>10-12</td><td>5</td></tr>
<tr><td>12-15</td><td>6</td></tr>
</table>

</td></tr>
</table>

15-18	7
18-21	8
21-25	9
>25%	10

Data requirements

Expected data source	Project documentation and/or interviews with the project leader or other actors involved.
Expected availability	As this will often go to the core of why a project is being executed, it is expected that this information will be available
Collection interval	At the end of the project, or ex-ante to evaluate plans
Expected reliability	The calculation can be performed reliably.
Expected accessibility	Restricted, part of the business case.

References

- https://urbgrade.files.wordpress.com/2014/12/urbgrade-kpis.pdf
- Smart City Information System – Key Performance Indicator Guide
- http://www.propertymetrics.com/blog/2014/06/09/what-is-irr/

Payback period

Description incl. justification	The Payback Period is another way to assess the financial performance of a smart city project, especially with regards to risks. The payback period is the time it takes to earn back the investment costs. It can be calculated from the number of years elapsed between the initial investment and the time at which cumulative savings offset the investment. Investments with a short payback period are considered safer than those with a longer payback period. As the invested capital flows back slower, the risk that the market changes and the invested capital can only be recovered later or not at all increases.
Definition	The number of years at which the net present value of costs (negative cash flows) of the investment equals the net present value of the benefits (positive cash flows) of the investment. (urbgrade.com)
Calculation	Payback Period = Amount to be Invested/Estimated Annual Net Cash Flow-1
Strengths and weaknesses	Strenghts: relatively easy to calculate Weaknesses: Payback period is usually considered as an additional criterion to assess the investment, especially to assess the risks. Also Payback in general ignores all costs and savings that occur after

	payback has been reached. Payback period doesn't take into consideration the time value of money and therefore may not present the true picture when it comes to evaluating cash flows of a project. This is why sometimes decisions that are based on payback periods are not optimal and it is recommended to also consult other indicators.
Scoring	At this moment we do not have a good appreciation of the distribution of values for the PP in built environment projects, where renovation projects may have very long payback periods. A preliminary normalisation formula:

Normalisation	
Payback period	Score
>30 yr	1
25-30 yr	2
21-25 yr	3
18-21 yr	4
15-18 yr	5
12-15 yr	6
9-12 yr	7
6-9 yr	8
3-6 yr	9
0-3 yr	10

Data requirements

Expected data source	Project documentation or interviews with project leader.
Expected availability	Usually not available as such, but the data to calculate it with usually are.
Collection interval	At the end of the project or ex-ante to evaluate plans.
Expected reliability	The calculation can be performed reliably.
Expected accessibility	Likely accessible, but maybe restricted.

References

- Smart City Information System – Key Performance Indicator Guide
- Eurbanlab (2014). The Eurbanlab Selection of Indicators. Version 4.
- https://urbgrade.files.wordpress.com/2014/12/urbgrade-kpis.pdf

Total cost vs. subsidies

Description incl. justification	Subsidies can support the development and implementation of smart city projects. However, too heavy a reliance on external funding might increase the perception of risk and create uncertainty in project development. It is usually perceived that smart city projects should, as much as possible, rely on a ‘sound business model’ and should be as independent as possible on subsidies. A high percentage of required subsidies in the total investment are therefore seen to be less desirable. The indicator ‘total costs versus subsidies’ aims to provide an indication of the project’s reliance on external funding mechanisms.
Definition	Percentage of subsidies as share of total investment of the project.
Calculation	(subsidies received/total investments or costs) * 100%
Strengths and weaknesses	Strenghts: The indicator provides an absolute value Weaknesses: Benchmarking can be done, but various project types might require different levels of funding. A more innovative project might need more subsidies to get started than a mature project.
Scoring	

Points	Percentage
10	0-10%
9	11-20%
8	21-30%
7	31-40%
6	41-50%
5	51-60%
4	61-70%
3	71-80%
2	81-90%
1	91-100%

Data requirements

Expected data source	Project documentation, grant agreement, interviews with project leader
Expected availability	Likely available
Collection interval	At the end of the project or ex-ante to evaluate plans
Expected reliability	The calculation can be performed reliably.

Expected accessibility	Since subsidies are public funds, this information should be open.
References	
• Eurbanlab (2014). The Eurbanlab Selection of Indicators. Version 4.	

Innovation

Involvement of extraordinary professionals	
Description incl. justification	Innovations are often based on bringing together multiple disciplines or creating unexpected combinations of knowledge and people that spark new ideas. Therefore, this indicator assesses the involvement in the smart city project of professionals that would normally not be contacted, e.g. representatives of the creative industry and professionals from other disciplines (such as environmental experts, facility managers or cost-estimators).
Definition	The extent to which the project involved professionals normally not encountered in these type of projects
Calculation	Likert scale Not at all – 1 – 2 – 3 – 4 – 5 – Very much 1. Not at all: Only the 'usual suspects' were involved in the smart the project. 2. Little: One or two extraordinary professionals were consulted in later stages of the project 3. Average: A small group pf extraordinary professionals were involved in various stages of the project. 4. Much: Extraordinary professionals from several fields were involved from the start of the project. 5. Very much: Extraordinary professionals from a wide variety of fields were closely involved from the start of the project.
Strengths and weaknesses	Strengths: This indicator is an extension of the indicator 'balanced project team' and highlights the added value for innovation of including a-typical members from the beginning. Weaknesses: Although it is tried to make scoring the indicator as objectively as possible, a certain amount of subjectivity is present. Overlap with professional stakeholder involvement
Scoring	Multiply Likert scale value by 2
Data requirements	
Expected data source	To be derived from project documentation and/or interviews with project leader
Expected availability	Just because it is not recorded, does not necessarily mean it did not

	happen.
Collection interval	After the project, but can also be used ex-ante to evaluate plans
Expected reliability	Because of the subjectivity that cannot be excluded, this indicator is not 100% reliable
Expected accessibility	If the information is available, it is expected that this information will be accessible (no sensitivities).
References	
- Eurbanlab (2014). The Eurbanlab Selection of Indicators. Version 4.	

Stimulating an innovative environment	💻 🏢
Description incl. justification	A project can stimulate an environment that enhances innovations, either by being part of it or by contributing to it. An important element of an innovative environment (or innovation ecosystem) is the coupling and close cooperation of business, government and knowledge institutes, the so called triple helix (stanford.edu).
Definition	The extent to which the project is part of or stimulates an innovative environment
Calculation	Likert scale: 1. Not at all: the project is not part of and does not stimulate an innovative environment. 2. Poor: the project is somewhat part of an innovative environment. 3. Somewhat: the project is part of and somewhat stimulates an innovative environment. 4. Good: the project is part of and stimulates an innovative environment. 5. Excellent: the project is an essential part of and stimulates an innovative environment.
Strengths and weaknesses	Strenghts: Weaknesses: Although it is tried to make scoring the indicator as objectively as possible, a certain amount of subjectivity is present.
Scoring	Multiply Likert scale value by 2
Data requirements	
Expected data source	To be derived from project documentation and/or interviews with project leader
Expected availability	Just because it is not recorded, does not necessarily mean it did not happen. The latter is more difficult to grasp.
Collection interval	After the project, but can also be used ex-ante to evaluate plans
Expected reliability	Because of the subjectivity that cannot be excluded, this

	indicator is not 100% reliable
Expected accessibility	No sensitivities expected

References

- http://erc-assoc.org/sites/default/files/topics/policy_studies/DJackson_Innovation%20Ecosystem_03-15-11.pdf
- http://triplehelix.stanford.edu/3helix_concept

Quality of open 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 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 project and whether they are kept up-to-date.
Definition	The extent to which the quality of the open data produced by the project was increased
Calculation	Likert scale, partly based on the average stars across all datasets generated by the project according to the 5 star deployment scheme for Open Data defined by Tim Berners Lee (5stardata.info): 1. Making data online available in whatever format under an open license 2. Making data available as structured data (e.g. Excel instead of image scan of a table) 3. Making data available in a non-proprietary open format (e.g. CSV) 4. Use URIs to denote things, so that people can point at your data

	5. Link your data to other data to provide context
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. Partly overlap with the indicator 'Interoperability'
Scoring	Multiply Likert scale value by 2
Data requirements	
Expected data source	To be derived from project documentation and/or interviews with project leader
Expected availability	Data is open
Collection interval	Ad hoc, after the project, but can also be used ex-ante to evaluate plans
Expected reliability	Because of the subjectivity that cannot be excluded, this indicator is not 100% reliable
Expected accessibility	Data is open
References • http://5stardata.info/en/ • http://opendatahandbook.org/guide/en/why-open-data/	

New startups	
Description incl. justification	A startup is a fledgling business enterprise, working to solve a problem where the solution is not obvious and success is not guaranteed (forbes.com).The key attribute of a startup is its ability to grow, a startup is a company designed to scale very quickly. It is this focus on growth unconstrained by geography which differentiates startups from small businesses. Somewhat ironically, if and when a startup becomes profitable it is likely moving away from startuphood. Because of their risk-taking nature and their search for solutions to problems, startups are considered beneficial to the innovative climate.
Definition	The number of startups resulting from the project
Calculation	
Strengths and weaknesses	Strenghts: the indicator is an absolute and objective value. Weaknesses: incomparable between projects

<table>
<tr><td></td><td>There exists no solid definition of a startup and interpretations may vary across cities.</td></tr>
<tr><td>Scoring</td><td><table><tr><td># of startups</td><td>Score</td></tr><tr><td>0</td><td>1</td></tr><tr><td>1</td><td>2</td></tr><tr><td>2</td><td>4</td></tr><tr><td>3</td><td>6</td></tr><tr><td>4</td><td>8</td></tr><tr><td>>5</td><td>10</td></tr></table></td></tr>
<tr><td colspan="2">Data requirements</td></tr>
<tr><td>Expected data source</td><td>Project documentation or interviews with the project leader.</td></tr>
<tr><td>Expected availability</td><td>If the project has an impact on this factor this information will likely be available.</td></tr>
<tr><td>Collection interval</td><td>After the project, but can also be used ex-ante to evaluate plans</td></tr>
<tr><td>Expected reliability</td><td>High.</td></tr>
<tr><td>Expected accessibility</td><td>As a component of a successful project and selling point in a marketing sense, it is expected that this information will be accessible if the project has an impact on this factor.</td></tr>
<tr><td colspan="2">References
• http://www.forbes.com/sites/natalierobehmed/2013/12/16/what-is-a-startup/</td></tr>
</table>

Improved interoperability	
Description incl. justification	Interoperability is the ability of a system (or product) to work with other systems (or products) by providing services to and accepting services from other systems and to use the services so exchanged to enable them to operate effectively together (ISO/TS 37151). An example of interoperability is ‘door-to-door’- travel information by public transport, where multiple systems or infrastructures (e.g. bus, train, tram, metro) exchange and combine information. While the term was initially defined for information technology or systems engineering services to allow for information exchange, a more broad definition takes into account social, political, and organizational factors that impact system to system performance. The challenge is to build coherent services for users when the individual components are technically different and managed by different organizations (Wikipedia). Different levels of interoperability can be distinguished. When two or more systems are able to communicate with each other, this is called syntactic interoperability. Semantic interoperability is when

	the systems are also capable of interpreting the information exchanged in order to produce useful results. Cross-domain interoperability exists when organizations or systems from different domains interact in information exchange, services, and/or goods to achieve their own or common goals (Wikipedia). As this indicator can be applied to a various types of projects, the indicator assesses the improvement in interoperability in a qualitative manner without going into details.
Definition	The extent to which the project has increased interoperability between systems
Calculation	Likert scale Not at all - 1 – 2 – 3 - 4- 5 – Excellent 1. Not at all: the project does not increase interoperability. 2. Poor: the project does little to increase interoperability. 3. Somewhat: the project somewhat increases interoperability. 4. Good: the project increases interoperability sufficiently. 5. Excellent: the project increases interoperability extensively.
Strengths and weaknesses	Strengths: the indicator allows the evaluation and comparability of a wide range of project types and (still to-be-developed) solutions. Weaknesses: although it is tried to make scoring the indicator as objectively as possible, a certain amount of subjectivity is present.
Scoring	Multiply Likert scale value by 2
Data requirements	
Expected data source	Project documentation or interviews with the project leader.
Expected availability	If the project has an impact on this factor this information will likely be available.
Collection interval	After the project, but can also be used ex-ante to evaluate plans
Expected reliability	Because of the subjectivity that cannot be excluded, this indicator is not 100% reliable
Expected accessibility	As a component of a successful project and selling point in a marketing sense, it is expected that this information will be accessible if the project has an impact on this factor.
References • ISO/TS 37151 (2014).Smart community infrastructures - Principles and requirements for performance metrics. ISO/TC 268/SC 1/WG 1-Infrastructure metrics.	

Competitiveness and attractiveness

Decreased travel time	

Description incl. justification	Cities and traffic have developed hand-in-hand since the earliest large human settlements. The same forces that draw inhabitants to congregate in large urban areas also lead to sometimes intolerable levels of traffic congestion on urban streets and thoroughfares, as well as increased amounts of time spent searching for a parking space. Effective urban governance requires a careful balancing between the benefits of agglomeration and the dis-benefits of excessive congestion. Also, the Strategic Implementation Plan on Smart Cities and Communities (EIP-SCC, 2013) defines more efficient urban transport as one goal of Smart City Development.
Definition	Percentage decrease in travel time due to the project
Calculation	This indicator can be calculated according to the congestion index of tomtom (tomtom.com): (travel times in peak hours after the project - travel times in peak hours before the project/ travel times in peak hours before the project)*100% Note: other options are also possible, e.g.: h/veh-km before the project – h/veh-km after the project (decrease in %).
Strengths and weaknesses	Strengths: The indicator is very often used in urban transport planning. Therefore, it will not be difficult to find the data. Weaknesses: The relevance of the indicator is disputed in transport research. Many academics argue, that traffic jams are unavoidable in urban areas and that traffic jams should be rather managed than avoided.
Scoring	It is expected that the effect of a project on decreased travel time is small, therefore a higher than 9% reduction is awarded a 10.

Normalisation	
Improvement	Score
<1%	1
1-2%	2
2-3%	3
3-4%	4
4-5%	5
5-6%	6
6-7%	7
7-8%	8
8-9%	9
>9%	10

Data requirements	
Expected data source	Project documentation or interviews with the project leader.
Expected availability	If the project has an impact on this factor this information will likely be available.
Collection interval	After the project, but can also be used ex-ante to evaluate plans
Expected reliability	Because of the subjectivity that cannot be excluded, this indicator is not 100% reliable
Expected accessibility	As a component of a successful project and selling point in a marketing sense, it is expected that this information will be accessible if the project has an impact on this factor.
References • EIP-SCC (2013). European Innovation Partnership on Smart Cities and Communities Strategic Implementation Plan • TomTom (2013).TomTom Australia & New Zealand Congestion Index. • www.tomtom.com/congestionindex.	

Governance

Organisation

Leadership	
Description incl. justification	Many of the current examples of smart projects in Europe appear to have required significant leadership from certain actors who have the determination and desire to create something new and challenging, and for such a project to succeed. Leadership at the individual or organizational level is critical in shaping sustainable urban development (UN-Habitat 2011, Romero-Lankao 2012). Aspects of leadership include framing, bridging, lobbying and persistency: • framing: explaining why this smart city project is better than the 'old' way of doing things • bridging: fostering collaboration, bringing people together, connecting different interests, and forming a supportive group of stakeholders • lobbying: creating the right connections to government officials (municipalities etc.) and creating support for the project' • persistency: persevering in his/her endeavour to realize the project plan (including its ambitions & targets), also in adverse conditions, to ensure the continuity of the project

	These aspects are, however, aggregated into one score for leadership in assessing this indicator. Also note that leadership can come from political, private, public and/or community actors, leadership does not necessarily come from the project owner or the official project leader.
Definition	The extent to which the leadership of the project is successful in creating support for the project.
Calculation	Likert scale: Not at all – 1 — 2 — 3 — 4 — 5 — Very much 1. Unsuccessful: the leader(s) failed to create support for the project; no effort has been made regarding framing, bridging, lobbying; and were unable to demonstrate perseverance in difficult circumstances. 2. Hardly successful: the leaders managed to create some support amongst a very small, yet critical group of stakeholders for the project; little effort has been made regarding framing, bridging, lobbying; and demonstrated little determination to keep the project going in difficult circumstances. 3. Somewhat successful: the leaders managed to create some support amongst a small, yet critical group of stakeholders for the project; some effort has been made regarding framing, bridging, lobbying; and demonstrated some determination to keep the project going in difficult circumstances. 4. Largely successful: the leader(s) managed to create support amongst a large group of stakeholders for the project; large effort has been made regarding framing, bridging, lobbying; and demonstrated large determination to keep the project going in difficult circumstances. 5. Very much: the leader(s) of the project is able to create support amongst the widest possible audience for the project; very large effort has been made regarding framing, bridging, lobbying; and demonstrated very large determination to keep the project going in difficult circumstances.
Strengths and weaknesses	Strengths: This indicator combines various aspects of leadership and allows for comparison across projects.Weaknesses: many people are responsible and may claim project success, while no-one will like to be associated with failure. Although it is tried to make scoring the indicator as objectively as possible, a certain amount of subjectivity is present.
Scoring	Multiply Likert scale value by 2
Data requirements	

Expected data source	To be derived from project documentation and/or interviews with the project leader or other actors involved in the project
Expected availability	The above sources should be able to provide insight, but it might require some effort and interview techniques to identify the actual leaders and their role in the project success or failure.
Collection interval	After the project, but can also be used ex-ante to evaluate plans
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 in a general sense, although it may become sensitive information when zooming in on specific persons, especially in case of failure.
References	
• 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. • 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. • Eurbanlab (2014). The Eurbanlab Selection of Indicators. Version 4.	

Balanced project team	
Description incl. justification	Smart city projects are inherently of an interdisciplinary nature, since every aspect of the built environment affects – and is affected by – other aspects, and they benefit from an integrated approach and design. The largest gains can be reached when all key members of the smart city project team (e.g. architects, designers, installers, construction company, sustainability consultant etc.)are brought together in the earliest stages of the project.
Definition	The extent to which the project team included all relevant experts and stakeholders from the start
Calculation	Likert scale Not at all – 1 — 2 — 3 — 4 — 5 — Excellent 1. Not at all: The project team did not include all relevant experts in the process; 2. Little: The project team included a basic selection of experts and expertise that was minimally necessary to design the project; 3. Some: The project team included experts and expertise from the fields that were relevant with regard to the main aims of the project; 4. Good: The project team included experts and expertise from a variety of relevant fields who joined in various stages;

	5. Excellent: The project team included, from the start, experts and expertise from all relevant fields.
Strengths and weaknesses	Strengths: This indicator allows benchmarking of the quality of project teams across many different project types. Weaknesses: although it is tried to make scoring the indicator as objectively as possible, a certain amount of subjectivity is present.
Scoring	Multiply Likert scale value by 2
Data requirements	
Expected data source	To be derived from project documentation and/or interviews with project leader
Expected availability	The above sources should easily be able to provide insight in the actors involved in the project and their role.
Collection interval	After the project, but can also be used ex-ante to evaluate plans
Expected reliability	Because of the subjectivity that cannot be excluded, this indicator is not 100% reliable.
Expected accessibility	It is not expected that information on the involvement of experts and stakeholders in the project is sensitive information
References	
• Eurbanlab (2014). The Eurbanlab Selection of Indicators. Version 4.	

Involvement of city administration	
Description incl. justification	Smart city projects are integrative projects. The extent to which the local authority is involved in the development of the project, gives an indication of the policy importance of the project. The number of departments that are involved, whether by contributing human or data resources, says something about the extent to which the city administration understands the integrated structure of smart city projects and its facilitation needs. NB contribution in the form of financial resources is covered in a separate indicator 'Municipal involvement – Financial support'.
Definition	The extent to which the local authority is involved in the development of the project, other than financial, and how many departments are contributing.
Calculation	Likert scale Not involved – 1 – 2 – 3 – 4 – 5 Very much involved 1. The local authority is not involved in the development of the project.

	2. The local authority is poorly involved in the development of the project, at maximum one department is involved. 3. The local authority is somewhat involved in the development of the project, with more than one department contributing. 4. The local authority is clearly involved in the development of the project, more than two departments are involved. 5. The local authority is very much involved in the development of the project. It is a policy priority and the integrative character of smart city projects is reflected in the large number of departments involved (i.e. through an interdepartmental steering committee).
Strengths and weaknesses	Strengths: Weaknesses: There are many reasons why the municipality is or is not involved and to what extent. It could be that the project can be implemented without the involvement of the municipality or that too much interference from the municipality is even hampering the development.
Scoring	Multiply Likert scale value by 2
Data requirements	
Expected data source	To be derived from project documentation and/or interviews with project leader and other team members
Expected availability	Most successful smart city projects will have paid specific attention to their relations with the city administration. If there is no documentation available, involved actors/stakeholders and the project leader itself should be able to provide insight upon which the assessor can base the score.
Collection interval	After the project, but can also be used ex-ante to evaluate plans
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 in a general sense.
References	
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Clear division of responsibility	
Description incl. justification	Without a clear responsibility for achieving the social and environmental components in the project plan, goals and targets might be downscaled, e.g. because of financial constraints.. This mainly concerns stating the actor(s) responsible for monitoring the progess towards these goals in written agreements during the early stages of the project. The institutions responsible for monitoring, should ideally be involved before the overall goals and targets are

	formulated to ensure their quantify-ability and achievability. By doing so, it is made sure that social and sustainability considerations are fully integrated into the smart city project.
Definition	Has the responsibility for achieving the social and sustainability targets been clearly assigned to (a) specific actor(s) in the project?
Calculation	Yes/no question: **Yes:** The responsibility was clearly assigned and known to all stakeholders in the project. **No:** The responsibility was not clearly assigned and was unclear to stakeholders in the project.
Strengths and weaknesses	Strengths: It is a straightforward indicatorWeaknesses: the indicator can be used as a checkbox at the onset of a project, but in hindsight this indicator doesn't have much added value, except for analyzing whether the projects success or failure could have been caused by a clear or unclear division of responsibility.
Scoring	No = 3; Yes = 7
Data requirements	
Expected data source	To be derived from project documentation and/or interviews with project leader and other team members
Expected availability	The above sources should easily be able to provide the necessary information.
Collection interval	After the project, but can also be used ex-ante to evaluate plans
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 in a general sense (although it may become sensitive when zooming in on specific persons especially in case of failure).
References	
• Eurbanlab (2014). The Eurbanlab Selection of Indicators. Version 4.	

Continued monitoring and reporting	
Description incl. justification	Continued monitoring of performance and compliance with the requirements is an essential stimulating factor for project success and allows the presentation of the actual progress made (Fortune and White 2006). Continued monitoring and reporting refers to the project control processes by which at each stage of the project development, key personnel is reported on how the project compares to the initial project goals, schedule and budget. Adequate monitoring and reporting mechanisms allow for an anticipation on problems, to

	oversee corrective measures, and warrants that no deficits are overlooked.
Definition	The extent to which the progress towards project goals and compliance with requirements is being monitored and reported
Calculation	Likert scale: No continued monitoring – 1 — 2 — 3 — 4 — 5 — Extensive monitoring 1. No monitoring & reporting: No monitoring and reporting at all was used to verify that the project was executed according to the sustainability ambitions, rules & regulations. 2. Little monitoring & reporting: there is a basic monitoring scheme in place: a basic set of indicators assessed at irregular time intervals. 3. Some monitoring & reporting: a monitoring scheme is in place with an elaborate set of indicators and measurement intervals, backed by well-defined (SMARTY) goals.The scope of the monitoring activities is limited, including only some facets of the project's development. 4. Very much monitoring & reporting: a monitoring scheme is in place with an elaborate set of indicators and measurement intervals, the findings of which are yearly reported upon. Most of the project's facets were monitored. 5. Extensive monitoring & reporting: monitoring and reporting to ensure that the project was executed according to the established sustainability ambitions, rules & regulations was a central and consistent concern during all stages of the project's development. Monitoring and reporting was frequent, and carried out at set intervals, the findings of which are yearly reported upon and published transparently online.. The scope of the monitoring activities were extensive, including all facets of the project's development.
Strengths and weaknesses	Strengths: Various aspects of the monitoring and evaluation are combined into one indicator and it allows for comparison among projects. Weaknesses: although it is tried to make scoring the indicator as objectively as possible, a certain amount of subjectivity is present.
Scoring	Multiply Likert scale value by 2
Data requirements	
Expected data source	To be derived from project documentation and/or interviews with project leader
Expected availability	It is expected that the project documents are easily available and

	that the project leader can be contacted easily. The availability of the monitoring reporting depends on the extent of monitoring and reporting.
Collection interval	After the project, but can also be used ex-ante to evaluate plans
Expected reliability	Because of the subjectivity that cannot be excluded, this indicator is not 100% reliable.
Expected accessibility	Information on monitoring and reporting is public information and no problems are expected with regards to the accessibility.
References	
• Eurbanlab (2014). The Eurbanlab Selection of Indicators. Version 4. • Fortune, J., and D. White. “Framing of project critical success factors by a systems model.” International Journal of Project Management, 2006: 53-65.	

Market orientation	🚗 💻 🏢
Description incl. justification	For a successful project, it is very important to define the result of the project in terms of what you want to achieve, for whom and how. What problem is solved by the project or what opportunity has become more attainable because of it? Who is the end-user or client that will reap the benefits of this? What inherent qualities does the project possess that will help to achieve this and what pitfalls need to be watched for? Examples of tools that can be used to provide answers are a SWOT-Analysis and a business model canvas. Although this seems like stating the obvious, many projects do not achieve their full potential because they have been started before having a good answer to these types of questions.
Definition	The extent to which the project was planned on the basis of a market analysis
Calculation	Likert Scale: No market orientation – 1 – 2 – 3 – 4 – 5 - Extensive feasibility study 1. No market orientation has taken place in whatever shape or form. 2. There was some discussion about market orientation, but this was never formalized. 3. Somewhat attention was given to market orientation in the form of a SWOT analysis or other business tools. 4. Significant attention was given to market orientation in the form of a SWOT analysis or other business tools, combined with a project team workshop. 5. A full-scale feasibility study was carried out.
Strengths and weaknesses	Strengths: The indicator leaves flexibility in the the way the market analysis was executed and allows benchmarking with other projects.

	Weaknesses: Although it is tried to make scoring the indicator as objectively as possible, a certain amount of subjectivity is present.
Scoring	Multiply Likert scale value by 2
Data requirements	
Expected data source	To be derived from project documentation and/or interviews with project leader and other project partners
Expected availability	Project documentation, involved actors/stakeholders and the project leader should easily be able to provide insight upon which the assessor can base the score.
Collection interval	After the project, but can also be used ex-ante to evaluate plans
Expected reliability	Because of the subjectivity that cannot be excluded, this indicator is not 100% reliable.
Expected accessibility	A market analysis of a smart city project could contain sensitive information and might be less accessible because of this.
References	
• Neubau Stadtquartiere, DGNB Handbuch für nachhaltiges Bauen , Version 2012	

Community involvement

Professional stakeholder involvement	🚗 💻 🏢
Description incl. justification	Next to the involvement of a wide-range of community stakeholders in the smart city project, the need to involve a wide-range of professional stakeholders is exemplified by the increasingly complex task of city management in recent years. Stakeholders in the urban environment are increasingly required to adopt sustainability principles, a process that requires integrated approaches across sectors and disciplines in order to be properly managed (Peris Blanes 2008, Corfee-Morlot, et al. 2009). For smart city projects to be successful in addressing the broad array of sustainability issues and interconnections, a large number of professionals must be engaged, each of whom will bring a different approach or concept of what is important (Suzuki, et al. 2010). In this context, relevant stakeholders may include: industry or business associations, local councils, government departments, politicians, environmental organisations, architects, project developers. Through systemic stakeholder collaboration, integrated planning and management can lead to significantly greater benefits (ibid).
Definition	The extent to which professional stakeholders outside the project team have been involved in planning and execution
Calculation	Likert scale No involvement — 1 — 2 — 3 — 4 — 5 — High involvement

	The Likert scale is based on the ladder of citizen participation , which can also be applied to professional stakeholders (Arnstein, 1969): 1. No involvement: apart from the project team no other professional stakeholders outside the project team are involved. 2. Inform: a select group of professional stakeholders is informed about the project plan. Consultation, however, is merely intended at seeking acceptance amongst these stakeholders. 3. Advise: the project plan is presented to professional stakeholders (representatives of industry, local councils, environmental organizations), who are invited to ask questions, provide feedback and give advice. Based on this input the planners may alter the project plan. 4. Partnership: in a number of sessions professional stakeholders are involved in developing the project plan. Stakeholders are able to effectively influence the planning process. 5. High involvement: a fully integrated planning process, whereby a wide range of professional stakeholders are actively involved on an almost day-to-day basis in developing the project plan and advising on its implementation.
Strengths and weaknesses	Strengths: this indicator determines the actual result in professional stakeholder participation efforts and allows benchmarking with other cities. Weaknesses: although it is tried to make scoring the indicator as objectively as possible, a certain amount of subjectivity is present. Partial overlap with indicator 'Involvement of extraordinary professionals'.
Scoring	Multiply Likert scale value by 2
Data requirements	
Expected data source	To be derived from project documentation and/or interviews with project leader and other stakeholders/actors
Expected availability	Project documentation, the project leader or others involved in the project should easily be able to provide insight upon which the assessor can base the score.
Collection interval	After the project, but can also be used ex-ante to evaluate plans
Expected reliability	Because of the subjectivity that cannot be excluded, this indicator is not 100% reliable.
Expected accessibility	It is expected that involvement of professional stakeholders in smart city projects is public information and should therefore be accessible.

References
• Eurbanlab (2014). The Eurbanlab Selection of Indicators. Version 4. • Peris Blanes, J. “Key governance principles underpinning urban sustainable development planning and management.” WIT Transactions on Ecology and the Environment 117 (2008): 55-65. • Corfee-Morlot, J, L Kamal-Chaoui, M.G Donovan, I Cochran, A Robert, and P.J Teasdale. Cities, Climate Change and Multilevel Governance. OECD Environmental Working Papers N° 14, OECD, Paris: OECD publishing, 2009. • Arnstein, S.R. “A Ladder of Citizen Participation.” JAIP 35, no. 4 (1969): 216-224. • 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.

Bottom-up or top-down initiative	
Description incl. justification	A growing body of literature is exemplifying the importance of civil society/community participation in sustainable urban planning and execution, for example by means of smart city projects, to bring together information, knowledge and skills from diverse backgrounds, to articulate the often ambiguous targets of smart cities and to create a sense of ownership over the outcomes (Healy 1999, Kasioumi 2011, Pollock and Sharp 2012). Moreover, public involvement is identified to have a positive effect on the agreement over solutions and acceptance of policy interventions through the creation of awareness (Driessen, Glasbergen and Verdaas 2001, Abdalla 2012). This indicator analyses to what extent the idea for the smart city project originated from the local community or whether it was top-down initiative.
Definition	Has the project idea originated from the local community?
Calculation	Yes/no question: ☐ **Yes:** It was a bottom-up initiative. ☐ **No:** It was a top-down initiative.
Strengths and weaknesses	Strengths: It is a straightforward indicator, all partners should know who was responsible for the original idea. Weaknesses: It has to be seen whether the (binary) question turns out to be useful in planning or analyzing projects.
Scoring	No = 3; yes = 7
Data requirements	
Expected data source	To be derived from project documentation and/or interviews with project leader and others involved in the project
Expected availability	The above sources should fairly easily be able to identify the origin

	of the idea.
Collection interval	After the project, but can also be used ex-ante to evaluate plans
Expected reliability	Because of the subjectivity that cannot be excluded, this indicator is not 100% reliable.
Expected accessibility	It is expected that information regarding the origin of the idea will be sensitive information, and , therefore, it will be accessible.

References

- Healy, P. “Institutional analysis, communicative planning and shaping places.” Journal of Planning Education and Research 19, no. 2 (1999): 111-121.
- Kasioumi, E. “Sustainable Urbanism: Vision and Planning Process Through an Examination of Two Model Neighborhood Developments.” Berkeley Planning Journal 24 (2011): 91-114.
- Pollock, V.L., and J. Sharp. “Real Participation or the Tyranny of Participatory Practice? Public Art and Community Involvement in the Regeneration of the Raploch, Scotland.” Urban Studies 49, no. 1 (2012): 3063-3079.
- Driessen, P.P.J., P. Glasbergen, and C. Verdaas. “Interactive policy-making: A model of management for public works.” European Journal of Operational Research (Elsevier), no. 128 (2001): 322-337.
- Abdalla, G. Sustainable Residential Districts: The residents' role in project success. Eindhoven: University of Technology, 2012.

Local community involvement in the planning phase	🚗 💻 🏢
Description incl. justification	A growing body of literature is exemplifying the importance of civil society/community participation in sustainable urban planning, for example by means of smart city projects, to bring together information, knowledge and skills from diverse backgrounds to articulate the often ambiguous targets of smart cities and to create a sense of ownership over the outcomes (Healy 1999, Kasioumi 2011, Pollock and Sharp 2012). Moreover, public involvement is identified to have a positive effect on the agreement over solutions and acceptance of policy interventions through the creation of awareness (Driessen, Glasbergen and Verdaas 2001, Abdalla 2012). The need for timely and effective public involvement has been identified for successful smart city projects as user behaviour is an essential component of the project’s performance in the use phase (Abdalla 2012, Williams 2012). As residents’ beliefs, needs, preferences and expectations towards sustainable living environments have a strong influence on project performance, public involvement during the development stage is essential to provide developers with input to ensure that the project will perform as intended (ibid). An active involvement of residents in the development process is therefore beneficial to the necessary awareness and long-term support for smart city projects.
Definition	The extent to which residents/users have been involved in the

	planning process.
Calculation	The Likert scale is based on the ladder of citizen participation of Arnstein (1969): No involvement – 1 — 2 — 3 — 4 — 5 — High involvement 1. Not at all: No community involvement. 2. Inform and consult: The more or less completed project plan is announced to the community either for information only, or for receiving community views. The consultation, however, is mainly seeking community acceptance of the plan. 3. Advise: the project plan is drafted by a project team and then presented to community actors, who are invited to ask questions, provide feedback and give advice. Based on this input the planners may alter the project plan. 4. Partnership: community actors are asked by the project planners to participate in the planning process by prioritizing issues and planning actions. The local community is able to influence the planning process. 5. Community self-development: the project planners have empowered community actors to outline their needs and to make action plans.
Strengths and weaknesses	Strengths: this indicator determines the actual result in citizen participation efforts and allows benchmarking with other cities. Weaknesses: although it is tried to make scoring the indicator as objectively as possible, a certain amount of subjectivity is present. Without guidance and supervision by experts and local authorities community self-development can lead to unwanted results.
Scoring	Multiply Likert scale value by 2
Data requirements	
Expected data source	To be derived from project documentation and/or interviews with project leader and others involved in the project
Expected availability	The above sources should easily be able to provide insight in the role of the local community in the planning process.
Collection interval	After the project, but can also be used ex-ante to evaluate plans
Expected reliability	Because of the subjectivity that cannot be excluded, this indicator is not 100% reliable.
Expected accessibility	The level of citizen participation is not regarded as sensitive information
References	
• Eurbanlab (2014). The Eurbanlab Selection of Indicators. Version 4. • Healy, P. “Institutional analysis, communicative planning and shaping places.”	

Journal of Planning Education and Research 19, no. 2 (1999): 111-121.
- Kasioumi, E. “Sustainable Urbanism: Vision and Planning Process Through an Examination of Two Model Neighborhood Developments.” Berkeley Planning Journal 24 (2011): 91-114.
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- Arnstein, S.R. “A Ladder of Citizen Participation.” JAIP 35, no. 4 (1969): 216-224.

Local community involvement in the implementation phase	🚗 💻 🏢
Description incl. justification	A growing body of literature is exemplifying the importance of civil society/community participation in sustainable urban planning and execution, for example by means of smart city projects, to bring together information, knowledge and skills from diverse backgrounds to articulate the often ambiguous targets of smart cities and to create a sense of ownership over the outcomes (Healy 1999, Kasioumi 2011, Pollock and Sharp 2012). Moreover, public involvement is identified to have a positive effect on the agreement over solutions and acceptance of policy interventions through the creation of awareness (Driessen, Glasbergen and Verdaas 2001, Abdalla 2012). As residents’ beliefs, needs, preferences and expectations towards sustainable living environments have a strong influence on project performance, public involvement during the implementation stage is essential to provide developers with input to ensure that the project will perform as intended (Abdallah 2012, Williams, 2012)).
Definition	The extent to which residents/users have been involved in the implementation process.
Calculation	The Likert scale is based on the ladder of citizen participation by Arnstein (1969): No involvement – 1 — 2 — 3 — 4 — 5 — High involvement 1. Not at all: No community involvement. 2. Inform and consult: The more or less completed project is announced to the community either for information only, or for receiving community views. The consultation,

	however, is mainly seeking community acceptance of the project. 3. Advise: the project implementation is done by a project team.Community actors are invited to ask questions, provide feedback and give advice. Based on this input the planners may alter the project. 4. Partnership: community actors are asked by the project planners to participate in the implementation process. The local community is able to influence the implementation process. 5. Community self-development: the project planners have empowered community actors to to manage the project implementation and evaluate the results.
Strengths and weaknesses	Strengths: this indicator determines the actual result in citizen participation efforts and allows benchmarking with other cities. Weaknesses: although it is tried to make scoring the indicator as objectively as possible, a certain amount of subjectivity is present. Without guidance and supervision by experts and local authorities community self-development can lead to unwanted results.
Scoring	Multiply Likert scale value by 2
Data requirements	
Expected data source	To be derived from project documentation and/or interviews with project leader and others involved in the project
Expected availability	The above sources should easily be able to provide insight in the role of the local community in the implementation process
Collection interval	After the project, but can also be used ex-ante to evaluate plans
Expected reliability	Because of the subjectivity that cannot be excluded, this indicator is not 100% reliable.
Expected accessibility	The level of citizen participation is not regarded as sensitive information
References	
• Eurbanlab (2014). The Eurbanlab Selection of Indicators. Version 4. • Healy, P. “Institutional analysis, communicative planning and shaping places.” Journal of Planning Education and Research 19, no. 2 (1999): 111-121. • Kasioumi, E. “Sustainable Urbanism: Vision and Planning Process Through an Examination of Two Model Neighborhood Developments.” Berkeley Planning Journal 24 (2011): 91-114. • Pollock, V.L., and J. Sharp. “Real Participation or the Tyranny of Participatory Practice? Public Art and Community Involvement in the Regeneration of the Raploch, Scotland.” Urban Studies 49, no. 1 (2012): 3063-3079. • Driessen, P.P.J., P. Glasbergen, and C. Verdaas. “Interactive policy-making: A model of management for public works.” European Journal of Operational Research (Elsevier), no. 128 (2001): 322-337.	

- Abdalla, G. Sustainable Residential Districts: The residents' role in project success. Eindhoven: University of Technology, 2012.
- Williams, J. “Regulative, facilitative and strategic contributions of planning to achieving low carbon development.” Planning theory & Practice (Routledge) 13, no. 1 (2012): 131-144.
- Arnstein, S.R. “A Ladder of Citizen Participation.” JAIP 35, no. 4 (1969): 216-224.

Participatory Governance	
Description incl. justification	Participatory governance focuses on deepening democratic engagement through the participation of citizens in the processes of governance with the state. The idea is that citizens should play a more direct role in public decision-making or at least engage more deeply with political issues (Gaventa 2006). A more active engagement of citizens into urban governance and decision making is one of the main aims of the European Innovation Parternship on Smart Cities and Communities (EIP SCC). In its Strategic Implementation Plan (SIP), the EIP SCC specifically highlights the potential of new online services for participatory governance: *“If smartly mobilized, the effect of citizen’s behaviour, choices, creativity and entrepreneurship could be enormous, offering huge untapped potential. ICTs play a vital role in this – particularly as the Internet, not least through smartphones, becomes all-pervasive – as well as the willingness to be open towards new citizen-driven initiatives that might not fit with the current administrative system.”(EIP SCC 2012. 12)* Several online platforms for a stronger engagement of citizens into decision making have been developed in recent years (e.g. ONTOPICA, GRANICUS, ACCELA, WE THINQ). This indicator looks at the degree of success of these platforms.
Definition	Share of population participating in online platforms
Calculation	The indicator is calculated as the sum of users actively engaged in relevant projects of the city during a year (numerator) divided by the total number of inhabitants of the city (denominator), multiplied by 100%
Strengths and weaknesses	Strengths: • Highly relevant for the European Smart City Debate • Easy to calculate Weaknesses: • The level of activity is not taken into account • Currently, only online participation is considered, which is limited. See OrganiCity for ideas on the participatory design approach and co-creation.
Scoring	Theoretically the sum of users could equal the total population, so the scale is evenly distributed in steps of 10%.

Normalisation	
Improvement	Score
0-10%	1
10-20%	2
20-30%	3
30-40%	4
40-50%	5
50-60%	6
60-70%	7
70-80%	8
80-90%	9
90-100%	10

Data requirements	
Expected data source	Software provider / platform host can provide the number of unique visitors
Expected availability	Depending on the contract between the municipality and the Software provider / platform host
Collection interval	Yearly
Expected reliability	High
Expected accessibility	Depending on the contract between the municipality and the Software provider / platform host

References

- European Innovation Partnership on Smart Cities and Communities (EIP SCC) 2013: Strategic Implementation Plan. Brussels: EIP SCC
- J. Gaventa (2006): Triumph, Deficit or Contestation? Deepening the 'Deepening Democracy' Debate. IDS Working Paper 264. Retrieved at http://www.ids.ac.uk/publication/triumph-deficit-or-contestation-deepening-the-deepening-democracy-debate
- http://www.ontopica.de
- http://www.wethinq.com
- http://www.granicus.com/
- https://www.accela.com/
- http://organicity.eu/

Multi-level governance

Smart City Policy	
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 smart city visions for a Smart City domain (i.e. smart mobility, smart people, smart government, etc.) or a comprehensive vision, alongside with a strong smart city strategy, provide ways in which smart city projects can connect to larger development aims within the city, as well as benefit from supporting measures. Unfortunately, present responses are often hampered by short term politics, rather than realistic long-term visions that support smart city development.
Definition	The extent to which the project has benefitted from a governmental smart city policy.
Calculation	Likert scale: Very much hampered – 1 — 2 — 3 — 4 — 5 — Very much benefitted 1. Very much hampered: Project development has been hampered by an absence of a long-term smart city vision (including and absence of long-term targets & goals) from the side of the government, or its vision hinders the smart city ambitions of the project. 2. Somewhat hampered: The long-term vision of the government has, to some extent, hampered the development of the project or the achievement of its ambitions. 3. Neutral: The long-term vision of the government on Smart City (domains) has had no significant, positive or negative, effect on the project's development or in achieving its ambitions. 4. Somewhat benefitted: The long-term vision of the government on Smart City (domains) has to some extent benefitted the project in the development of the project or in achieving its ambitions. 5. Very much benefitted: The comprehensive long-term vision on the future of the city has benefitted the project to a great extent in the development of the project or in achieving its ambitions.
Strengths and	Strengths:

weaknesses	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.
Scoring	Multiply Likert scale value by 2
Data requirements	
Expected data source	To be derived from project documentation, policy documents and/or interviews with project leader
Expected availability	Information on a supportive framework for the project will be easily available using the above sources.
Collection interval	After the project, but can also be used ex-ante to evaluate plans
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.	

Municipal involvement – financial support	
Description incl. justification	Smart city projects often rely to some extent on financial support, often in the form of subsidies. This indicator analyses whether the local authority provides financial support and in this way facilitates smart city developments. However, a strong reliance on financial support is not desirable and might increase the perception of risk and create uncertainty in project development.
Definition	The extent to which the local authority provides financial support to the project

Calculation	Likert scale: Not at all – 1 – 2 – 3 – 4 – 5 – Very much 1. The municipality does not provide financial support to the project 2. The municipality provides little financial support to the project, the administrative burden is high in relation to the amount of aid given 3. The municipality provides some financial support to the project, the administrative burden is reasonable in relation to the amount of aid given. 4. The municipality provides generous financial support to the project, the administrative burden is reasonable in relation to the amount of aid given. 5. The municipality provides very generous financial support to the project, with very low administrative burden in relation to the amount of aid given.
Strengths and weaknesses	Strengths: The indicator considers various aspects of financial support and allows comparison across different project types. Weaknesses: The indicator overlaps with total costs vs subsidies. Although the indicator says something about the fostering environment for smart city projects, it is debatable whether it is desirable or whether a project should be less dependent on subsidies. Although it is tried to make scoring the indicator as objectively as possible, a certain amount of subjectivity is present.
Scoring	Multiply Likert scale value by 2
Data requirements	
Expected data source	To be derived from project documentation and/or interviews with project leader and other team members
Expected availability	The required should be easily retrieved from the above sources.
Collection interval	After the project, but can also be used ex-ante to evaluate plans
Expected reliability	Because of the subjectivity that cannot be excluded, this indicator is not 100% reliable.
Expected accessibility	Information on municipal expenditures should be public and, therefore, accessible.
References	
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Propagation

Scalability & replicability

Social compatibility	
Description incl. justification	The indicator ‘social compatibility’ aims to provide an indication of the extent to which a solution fits with people’s current “frame of mind”, that is influenced by values and past experiences. If an innovation requires people to significantly think differently, and challenges assumptions or the ways how we normally are accustomed to do things, its implementation in society will be more difficult. Abdalla (2012) has shown that the gains from environmental measures in sustainable residential districts that go beyond the building codes, may be offset by residents’ behaviour if these measures do not match residents’ beliefs and expectations. For example, an innovation has a higher compatibility when it does not require an extremely different ‘frame of mind’ or ‘ways of doing things’. Moreover, social compatibility is affected by socio-cultural values and beliefs or past collective experiences that influence the general opinion about the innovation or similar innovations. The ‘frame of mind’, therefore, can differ between countries.
Definition	The extent to which the project’s solution fits with people’s ‘frame of mind’ and does not negatively challenge people’s values or the ways they are used to do things.
Calculation	Likert scale: Not at all – 1 — 2 — 3 — 4 — 5 — Very high 1. Not at all: the solution differs to such a degree from the usual way of doing things and/or from existing norms and values, that it is almost impossible for people to accept the solution. 2. Low: the solution requires considerable changes in the current way of doing things, and/or requires a change in norms and values. 3. Moderate: the solution has certain aspects that differ from the usual way of doing things which users (or others involved) will need to get accustomed to, but requires no major changes in norms or values. 4. High: the solution is largely compatible with the current way of doing things, or with existing norms and values. Only slight adjustments are needed. 5. Very high: the solution does not differ from the usual way of doing things in operational sense and is fully consistent with existing norms and values.

	Two examples and nuances between required changes to people's values or ways of doing things: - A car sharing system with membership and a per km payments requires a completely different mindset compared to a privately owned car and a change in travel habits, and thus would score a 1. - A public transport paying card requires some changes in habits (not buying paper tickets, ensuring that you always have the card with you when travelling, etc.), but not a major change in norms and values and thus gets a score of 3.
Strengths and weaknesses	Strengths: The indicator allows the evaluation and comparability of a wide range of project types and (still to-be-developed) solutions Weaknesses: A high social compatibility within a local or national context is not necessarily linked to social compatibility in other regions/countries. although it is tried to make scoring the indicator as objectively as possible, a certain amount of subjectivity is present.
Scoring	Multiply Likert scale value by 2
Data requirements	
Expected data source	To be derived from project documentation and/or interviews with the project leader and/or end-users and stakeholders.
Expected availability	Information on the social compatibility will be fairly easily retrieved from above sources and common sense.
Collection interval	After project completion or to be used ex-ante to evaluate plans
Expected reliability	Because of the subjectivity that cannot be excluded, this indicator is not 100% reliable.
Expected accessibility	The information on which to base the level of social compatibility is expected to open.
References	
• Eurbanlab (2014). The Eurbanlab Selection of Indicators. Version 4. • Abdalla, G. Sustainable Residential Districts: The residents' role in project success. Eindhoven: University of Technology, 2012.	

Technical compatibility	
Description incl. justification	This indicator aims to provide an indication of the technical compatibility of the smart city solution, meaning the extent to which the solution fits with current practices, administrative and existing technological standards/infrastructures. The large-scale implementation of micro-CHP in households, for example, is hampered by technical (and economic, regulatory and practical/organizational) barriers; problems "concerning voltage

	profiles, power quality and voltage displacement of the star point of the utility grid” (Six, Vekemans and Dexters 2009, 244) hamper the mass introduction of micro-CHP for domestic use. The culmination of such technical barriers hampers the technical compatibility of an innovation in society.
Definition	The extent to which the smart city solution fits with the current existing technological standards/infrastructures.
Calculation	The indicator provides a qualitative measure and is rated on a five-point Likert scale: No technical compatibility – 1 — 2 — 3 — 4 — 5 — Very high 1. No technical compatibility: the solution needs many and major adjustments to current (infra)structures and/or practices for its implementation. 2. Low compatibility: the solution requires some major adjustments to current (infra)structures and/or practices for its implementation. 3. Moderate: some adjustments to current (infra)structures and/or practices are necessary to implement the solution. 4. High: only minor adjustments (think of a different type of plug, a specific internet connection, etc.) are needed to implement the solution. 5. Very high: no adjustments to current (infra)structures and/or practices are needed, the solution can immediately be implemented.
Strengths and weaknesses	Strengths: the indicator allows the evaluation and comparability of a wide range of project types and (still to-be-developed) solutions Weaknesses: although it is tried to make scoring the indicator as objectively as possible, a certain amount of subjectivity is present.
Scoring	Multiply Likert scale value by 2
Data requirements	
Expected data source	To be derived from interviews with the project leader and/or stakeholders, and based on expert judgement
Expected availability	Information on the technical compatibility will be fairly easily retrieved from above sources and common sense.
Collection interval	After project completion or to be used ex-ante to evaluate plans
Expected reliability	Because of the subjectivity that cannot be excluded, this indicator is not 100% reliable.
Expected accessibility	Information about the technical compatibility is general information and problems with its accessibility are not expected
References	
• Eurbanlab (2014). The Eurbanlab Selection of Indicators. Version 4.	

- Six, D., G. Vekemans, and A. Dexters. “Market opportunities for micro-CHP in Flanders (Belgium).” 6th International Conference on the European Energy Market. IEEE, 2009. 1-6.

Ease of use for end users of the solution	
Description incl. justification	This indicator aims to provide an indication of the complexity of the solution for end-users. End-users are conceptualised as those individuals who will be using/working with the solution. Some solutions or innovations are perceived as relatively difficult to understand and use while others are clear and easy to the adopters. It is presumed that a smart city solution that is easy to use and understand will be more likely adopted than a difficult solution. In relation to sustainable HVAC-systems (Heating, Ventilation, Air-conditioning systems) for example, research has shown that the lack of knowledge and familiarity of residents with such systems, “will make it very complicated to understand the impact of their interaction on the output of these technologies in terms of environmental impact, energy costs or thermal comfort (Abdalla 2012, 68).” In other words, the HVAC-system was too complex for its intended users and relied heavily on ‘correct use’ to achieve the perceived outcomes. Resultantly, the system performed differently in different households (ibid).
Definition	The extent to which the solution is perceived as difficult to understand and use for potential end-users
Calculation	The indicator provides a qualitative measure and is rated on a five-point Likert scale: Very difficult – 1 — 2 — 3 — 4 — 5 — Very easy 1. Very diffcult: users need extensive and sustained instructions to understand the solution and without these the solution cannot be understood or used. 2. Fairly difficult: users need to be well instructed to be able to understand and use the solution properly. Considerable time is required to familiarize themselves with the solution. 3. Slightly difficult: users have to invest some time to understand the solution and get accustomed to working with it. Some time is needed before the solution has become fully familiar to end users. 4. Fairly easy: a small investment in time is required of the end users to understand the solution and get accustomed to it, but they are fairly quickly familiar to work with it. 5. Very easy: the solution is as easy to understand and use.
Strengths and weaknesses	Strengths: the indicator allows the evaluation and comparability of a wide range of project types and (still to-be-developed) solutions.

	Weaknesses: although it is tried to make scoring the indicator as objectively as possible, a certain amount of subjectivity is present.
Scoring	Multiply Likert scale value by 2
Data requirements	
Expected data source	To be derived from interviews with the project leader and end-users, and based on expert judgement.
Expected availability	Most information will already be available by using common sense, but can be checked with interviews.
Collection interval	After project completion or to be used ex-ante to evaluate plans
Expected reliability	Because of the subjectivity that cannot be excluded, this indicator is not 100% reliable.
Expected accessibility	Since complexity for end-users is no sensitive information, no problems are expected in accessing information.
References	
• Eurbanlab (2014). The Eurbanlab Selection of Indicators. Version 4. • Abdalla, G. Sustainable Residential Districts: The residents' role in project success. Eindhoven: University of Technology, 2012.	

Ease of use for professional stakeholders	
Description incl. justification	This indicator aims to provide an indication of the complexity of the smart city solution for professional stakeholders, those who are responsible for its supply, installation and/or maintenance. Professional stakeholders can be local politicians, project managers, construction companies, suppliers etc. As indicated by Six, et al., (2009), the diffusion and large-scale adoption of micro-CHP is hampered by the risk of incorrect implementation. Implementation of the innovation at the local level is complicated due to the fact that the current technology for domestic dwellings is not suitable for every dwelling, and is very much dependent on e.g. the correct sizing of the thermal storage (ibid). Measurement of the indicator can be based on a consideration of the difficulty to understand, maintain, implement or install the solution. The complexity of implementation increases when solutions take a long time to implement, are expensive, need adaptation of legislations, are difficult in maintenance etc.
Definition	The extent to which the innovation is perceived as difficult to understand, implement and use for professional users of the solution
Calculation	The indicator provides a qualitative measure and is rated on a five-point Likert scale:

	Very difficult – 1 — 2 — 3 — 4 — 5 — Very easy 1. Very difficult: The solution can only be installed/implemented/maintained by experts who have been explicitly trained to work with this solution. Training requires numerous workshops/lectures before the users are familiar enough the work with the solution. 2. Fairly difficult: Substantial extra effort is required from professional users to work with the solution, who need some additional training to understand the innovations before working with the solution. 3. Slighty difficult: A moderate level of additional expertise is required, which can be attained by reading/receiving a comprehensive instruction, and may require some trial and error before it can be used. 4. Fairly easy: The solution requires only a very low level of additional expertise, which can be easily attained by reading/receiving a very short instruction. 5. Very easy: The solution does not require any specific level of expertise and could, theoretically, be implemented/installed/maintained by non-professionals.
Strengths and weaknesses	Strengths: the indicator allows the evaluation and comparability of a wide range of project types and (still to-be-developed) solutions. Weaknesses: although it is tried to make scoring the indicator as objectively as possible, a certain amount of subjectivity is present.
Scoring	Multiply Likert scale value by 2
Data requirements	
Expected data source	To be derived from interviews with the project leader and stakeholders, and based on expert judgement.
Expected availability	Most information will already be available by using common sense, but can be checked with interviews.
Collection interval	After project completion or to be used ex-ante to evaluate plans
Expected reliability	Because of the subjectivity that cannot be excluded, this indicator is not 100% reliable.
Expected accessibility	The degree of complexity for stakeholders is not regarded as sensitive information.
References	
• Eurbanlab (2014). The Eurbanlab Selection of Indicators. Version 4. • Six, D., G. Vekemans, and A. Dexters. “Market opportunities for micro-CHP in Flanders (Belgium).” 6th International Conference on the European Energy Market. IEEE, 2009. 1-6.	

Trialability	

Description incl. justification	An innovative smart city solution that can be experimented with in the local context (e.g. ‘living lab’) before full implementation, will represent less uncertainty for the potential adopter. Moreover, testing at the local context allows for further fine-tuning of a solution itself, or of the local context to the solution, to increase its performance. The possibilities for such testing define, to some extent, the solution’s potential for diffusion and it is thus presumed that smart city solutions benefit from a higher level of trialability This indicator therefore assesses the extent to which the solution can be experimented with (Rogers, 1995) NB. It is not the question whether or not the project team has experimented with the innovation in the project in question. It is merely an indication whether or not the innovation’s characteristics allow for small-scale trials, before adopters might choose to implement it on a larger scale.
Definition	The extent to which the solution can be experimented with on a limited basis in the local context before full implementation
Calculation	The indicator provides a qualitative measure and is rated on a five-point Likert scale: No possibility for experimentation – 1 — 2 — 3 — 4 — 5 —Very high possibilities for experimentation. 1. No possibility: The solution cannot be experimented with on a limited basis in the local context. Implementation on a limited basis is either technically unfeasible or would require too much extra resources (time, money, expertise). 2. Limited possibilities: The solution has very low opportunities for experimentation at the local level, as it would be very difficult to implement the innovation on a limited basis only, or would require substantial extra resources (time, money, expertise). 3. Moderate possibilities: The solution has a moderate opportunity for experimentation at the local level. It would be difficult to implement the innovation on a limited basis only but would be possible with some extra resources (time, money, expertise). 4. High possibilities: The solution has a high opportunity as it can be quite easily implemented on a limited basis at the local context, with limited resources (time, money, expertise). 5. Very high possibilities: The solution can easily be experimented with on a limited basis at the local context, without requiring extra resources (time, money, expertise).
Strengths and weaknesses	Strengths: the indicator allows the evaluation and comparability of a wide range of project types and (still to-be-developed) solutions.

	Weaknesses: although it is tried to make scoring the indicator as objectively as possible, a certain amount of subjectivity is present.
Scoring	Multiply Likert scale value by 2
Data requirements	
Expected data source	To be derived from interviews with the project leader and/or stakeholders.
Expected availability	Information on the trialability of a solution will be fairly easy to retrieve from interviews.
Collection interval	After project completion or to be used ex-ante to evaluate plans
Expected reliability	Because of the subjectivity that cannot be excluded, this indicator is not 100% reliable.
Expected accessibility	It is expected that information about the trailability of a solution is not sensitive and, therefore, accessible.
References	
• Eurbanlab (2014). The Eurbanlab Selection of Indicators. Version 4. • Rogers, E.M. Diffusion of Innovations. 4th. New York: The Free Press, 1995.	

Advantages for end-users	
Description incl. justification	Smart city projects should preferably offer a clear advantage to end-users. End-users are conceptualised as those individuals who will be using/working with the solution. The advantage can take many forms, for instance cost savings, improved quality and increased comfort. It is presumed that solutions which have a higher level of advantages to end users will be more likely to be adopted than solutions which have negative or no advantages.
Definition	The extent to which the project offers clear advantages for end users
Calculation	The indicator provides a qualitative measure and is rated on a five-point Likert scale: No advantage– 1 — 2 — 3 — 4 — 5 — Very high 1. No advantage: The project does not offer clear advantages for end users. The technologies or principles applied in the project are not at all beneficial to end users. 2. Little advantage: The project offers very little advantage to end users. The vast majority of the technologies/principles offer an indirect and insignificant advantage to end users. 3. Some advantage: The project offers some advantage to end users who to a certain extent experience direct benefits from the technologies/principles applied in the project. 4. High advantage: The project offers a high advantage to end

	users who benefit mostly from the applied technologies or principles as the applied technologies/principles have a direct and high positive effect on end users. 5. Very high adavantage: The project offers a very high advantage to end users as the applied technologies/principles have a direct and an extremely positive effect on end users (e.g. cheaper housing costs, increased comfort, increased quality of the living environment etc.).
Strengths and weaknesses	Strengths: the indicator allows the evaluation and comparability of a wide range of project types and (still to-be-developed) solutions. Weaknesses: although it is tried to make scoring the indicator as objectively as possible, a certain amount of subjectivity is present. Overlap with the indicator 'financial benefit for the end-user'
Scoring	Multiply Likert scale value by 2
Data requirements	
Expected data source	To be derived from project documentation, and/or interviews with project leader or end-users, and based on expert judgement
Expected availability	The required information will be easily available with the above resources
Collection interval	After project completion or to be used ex-ante to evaluate plans
Expected reliability	Because of the subjectivity that cannot be excluded, this indicator is not 100% reliable.
Expected accessibility	Information on the advantages for end-users is open.
References	
• Eurbanlab (2014). The Eurbanlab Selection of Indicators. Version 4.	

Advantages for stakeholders	
Description incl. justification	While some smart city projects offer a clear advantage to those using or working with the smart city solution, some innovations offer a clear advantage to those investing in project. This advantage could, for example, be ease of management or reduced maintenance costs. It is presumed that solutions which have a higher level of advantages to stakeholders will be more likely to be adopted and invested in than solutions which have negative or no advantages to the investors themselves. The large-scale implementation of an electric public transport system, with public transportation running on 'green energy', for instance, generates no significant additional advantage to those using the solution. However, the city proliferates itself by

	introducing large-scale low-carbon transit options that will make the city more sustainable and known internationally.
Definition	The extent to which the project offers clear advantages for stakeholders
Calculation	The indicator provides a qualitative measure and is rated on a five-point Likert scale: No advantage– 1 — 2 — 3 — 4 — 5 — Very high 1. No advantage: The project does not offer clear advantages to any of the stakeholders. The technologies or principles applied in the project are not at all beneficial to stakeholders. 2. Little adavantage: The project offers very little advantage to stakeholders. The vast majority of the technologies/principles offer an indirect and insignificant advantage. 3. Some advantage: The project offers some advantage to stakeholders who, to a certain extent, experience direct benefits from the technologies/principles applied in the project. 4. High advantage: The project offers a high advantage to stakeholders who benefit mostly from the applied technologies or principles as the applied technologies/principles have a direct and high positive effect on stakeholders. 5. Very high advantage: The project offers a very high advantage to stakeholders as the applied technologies/principles have a direct and an extremely positive effect on stakeholders
Strengths and weaknesses	Strengths: the indicator allows the evaluation and comparability of a wide range of project types and (still to-be-developed) solutions. Weaknesses: although it is tried to make scoring the indicator as objectively as possible, a certain amount of subjectivity is present.
Scoring	Multiply Likert scale value by 2
Data requirements	
Expected data source	To be derived from project documentation, and/or interviews with project leader or stakeholders, and expert judgement
Expected availability	The required information will be easily available with the above sources.
Collection interval	After project completion or to be used ex-ante to evaluate plans
Expected reliability	Because of the subjectivity that cannot be excluded, this indicator is not 100% reliable.
Expected accessibility	It is expected that information on the advantages for stakeholders is largely open, but some elements might be sensitive,
References	
• Eurbanlab (2014). The Eurbanlab Selection of Indicators. Version 4.	

Visibility of results	
Description incl. justification	The indicator 'visibility of results' is derived from Rogers's observability of innovations (1995), which refers to "the degree to which the results of an innovation are visible to others" While some project's results are easily observed and communicated to other people, other results can be difficult to observe or describe. A high visibility of a solution's results will stimulate discussions and further considerations of adoption if the evaluation information is positive. It is, therefore, presumed that solutions with a higher level of visibility are more likely to be adopted than solutions which less observable results.
Definition	The extent to which the results of the project are visible to external actors
Calculation	The indicator provides a qualitative measure and is rated on a five-point Likert scale: No visibility – 1 — 2 — 3 — 4 — 5 — Very high visibility 1. No visibility: The results of the project are not visible to external actors 2. Low visibility: The results of the project are poorly visible to external actors 3. Moderate visibility: The results of the project are somewhat visible to external actors 4. High visibility: The results of the project are reasonably visible to external actors 5. Very high visibility: The results of the project are highly visible to external actors Some examples: • Electrical bicycles running on solar energy stand out in traffic because of their appearance, and therefore may score a 5. • A new type of insulation material used in the building structure will not be visible, and therefore may score a 1.
Strengths and weaknesses	Strengths: the indicator allows the evaluation and comparability of a wide range of project types and (still to-be-developed) solutions. Weaknesses: although it is tried to make scoring the indicator as objectively as possible, a certain amount of subjectivity is present.
Scoring	Multiply Likert scale value by 2
Data requirements	
Expected data source	Asessor's common sense and/or project documentation or an interview with project leader.

Expected availability	Readily available
Collection interval	After project completion or to be used ex-ante to evaluate plans
Expected reliability	Because of the subjectivity that cannot be excluded, this indicator is not 100% reliable.
Expected accessibility	Readily accessible
References	
• Eurbanlab (2014). The Eurbanlab Selection of Indicators. Version 4. • Rogers, E.M.. Diffusion of Innovations. 4th. New York: The Free Press, 1995.	

Solution(s) to development needs	
Description incl. justification	If the smart city project connects to and/or offers a solution to problems that are common to European cities, the innovation is expected to possess a greater potential for propagation across cities.
Definition	The extent to which the project offers a solution to problems which are common to European cities
Calculation	The indicator provides a qualitative measure and is rated on a five-point Likert scale: Not a solution – 1 — 2 — 3 — 4 — 5 — Very much a solution 1. The project does not offer a solution to a problem/problems common to European cities, it is only applicable to the local context. 2. The project offers a solution for a problem/problems common to few European cities with similar circumstances. 3. The project offers a solution for a problem/problems common to some European cities. 4. The project offers a solution for a problem/problems common to many European cities. 5. The project offers a solution for a problem/problems common to most European cities.
Strengths and weaknesses	Strengths: the indicator allows the evaluation and comparability of a wide range of project types and (still to-be-developed) solutions Weaknesses: although it is tried to make scoring the indicator as objectively as possible, a certain amount of subjectivity is present.
Scoring	Multiply Likert scale value by 2
Data requirements	
Expected data source	To be derived from project documentation and/or interviews with the project leader and stakeholders.

Expected availability	Most successful smart city projects will have paid specific attention to their contribution to development issues in their city, as it is part of their business case. If there is no documentation available, the project leader should be able to provide insight upon which the assessor can base the score.
Collection interval	After project completion or to be used ex-ante to evaluate plans
Expected reliability	Because of the subjectivity that cannot be excluded, this indicator is not 100% reliable.
Expected accessibility	As a component of a successful project and selling point in a marketing sense, it is expected that this information will be accessible.
References	
• Eurbanlab (2014). The Eurbanlab Selection of Indicators. Version 4.	

Market demand	
Description incl. justification	An important characteristic for the rate of adoption of smart city solutions is the extent to which the innovation meets the needs of its potential adopters. It is expected that innovation can have a distinctive connection to generic problems in European cities, but that the current demand for a solution is relatively low. The potential for diffusion is expected to be greater for solutions with a high level of market demand.
Definition	The extent to which there is a general market demand for the solution
Calculation	The indicator provides a qualitative measure and is rated on a five-point Likert scale: No demand – 1 — 2 — 3 — 4 — 5 — Very high demand 1. No demand: There is no discernible market demand for the offered solution. 2. Little demand: There is little market demand for the offered solution. 3. Some demand: There is some market demand for the offered solution. 4. High demand: There is a large market demand for the offered solution. 5. Very high demand: There is a widespread market demand for the offered solution.
Strengths and weaknesses	Strengths: the indicator allows the evaluation and comparability of a wide range of project types and (still to-be-developed) solutions. Weaknesses: although it is tried to make scoring the indicator as objectively as possible, a certain amount of subjectivity is present.

	Partly overlap with 'Advantages for end-users/stakeholders' Market-oriented projects not necessarily make a city smarter.
Scoring	Multiply Likert scale value by 2
Data requirements	
Expected data source	To be derived from interviews with the project leader and/or stakeholders, and based on expert judgement.
Expected availability	Information on market demand will not be readily available and an estimate will need to be extracted from interviews.
Collection interval	After project completion or to be used ex-ante to evaluate plans
Expected reliability	Because of the subjectivity that cannot be excluded, this indicator is not 100% reliable.
Expected accessibility	Market information can be sensitive. Possibly, not all information will be accessible for a complete picture of the market demand
References	
• Eurbanlab (2014). The Eurbanlab Selection of Indicators. Version 4.	

Factors of success

Changing professional norms	🚗 💻 🏢
Description incl. justification	'Professional' norms can refer to the industry norm, i.e. what the companies and industry consider the 'state of the art' for urban development. Take as an example the car industry: now cars can function well on very low fuel consumption, cars that consume a lot of fuel per kilometer have become 'old-fashioned'. Designing a new fuel inefficient car is not a serious option anymore for a car manufacturer, with the only exception perhaps if the car would be designed for a small niche (e.g. a race car). In other words, a new development can de-legitimize an old solution, and thereby set a new norm for performance (DiMaggio and Powell, 1983). It is presumed that projects which have already started the diffusion process by changing the professional norms in the field and thereby inspiring a new or improved norm of what a good urban development should look like, are expected to have a greater potential for diffusion.
Definition	The extent to which the project changes the professional 'state of the art'
Calculation	The indicator provides a qualitative measure and is rated on a five-point Likert scale: No impact– 1 — 2 — 3 — 4 — 5 — Extensive impact NB. The measurement can be based on the number of publications in professional magazines in the last 3 years, presentations at

	conferences / trade fairs, input of project knowledge in expert groups. 1. No distinct positive impact: The project is not positively featured in professional magazines/conferences/trade fairs, and had no role in inspiring a new or improved norm. 2. Little positive impact: The project has been positively featured in one or two professional magazines/conferences/trade fairs and had a minor role in inspiring a new or improved norm. 3. Some impact: The project has been positively featured in several professional magazines/conferences/trade fairs, and somewhat inspired a new or improved norm. 4. Broad impact: The project has been featured in numerous professional magazines/conferences/trade fairs, and had an important role in inspiring a new or improved norm. 5. Extensive impact: The project has been featured extensively in professional magazines/conferences/trade fairs and was a very important inspiration for the agreement on a new or improved norm in the market. Example of changing professional norms: The goal for Hammarby Sjöstad in Stockholmwas to halve the environmental impact compared with contemporary urban development. Even though the goal was not fully attained, Hammarby Sjöstad is an often cited example of what sustainable urban development should look like. Not only has the residential development become a Mecca for many professionals wanting to learn about European eco-districts, the district served as a benchmark when the National Board of Housing, Building and Planning set its targets for heating supply in new residential areas.
Strengths and weaknesses	Strengths: the indicator allows the evaluation and comparability of a wide range of project types and (still to-be-developed) solutions. Weaknesses: although it is tried to make scoring the indicator as objectively as possible, a certain amount of subjectivity is present.
Scoring	Multiply Likert scale value by 2
Data requirements	
Expected data source	To be derived from interviews with the project leader and experts in this field and from consultation of professional magazines of the last 3 years and of conference agendas (online search with keywords).
Expected availability	As professional norms are difficult to define, to agree upon between stakeholders and are changing constantly, it will be hard pinpoint a change in norms due to a smart city project.
Collection interval	Some time after project completion
Expected reliability	Because of the subjectivity that cannot be excluded, this indicator is not 100% reliable.

Expected accessibility	Since a professional norm is a norm shared by various stakeholders, problems to access information are not expected.
References	
• Eurbanlab (2014). The Eurbanlab Selection of Indicators. Version 4. • Dimaggio, P. J. 1988. Interest and agency in institutional theory. Cambridge: M.A: Ballinger.	

Changing societal norms	
Description incl. justification	A new urban development can set a new norm for the public, i.e. a level of performance that a customer, end-user, or 'the society' sees as acceptable. If we take the car industry as an example: whereas fuel inefficient cars can be considered old-fashioned from a technological and professional point of view, they might be considered anti-social by the public (DiMaggio and Powell, 1983). As better solutions are available, old solutions are not accepted anymore which might result in protest against the old, and support and demand for the new solution. It is presumed that projects which have already started the diffusion process by changing the societal norms and thereby inspiring a new or improved norm of what a good urban development should look like, are expected to have a greater potential for diffusion.
Definition	The extent to which the project changes the norms and values of the society.
Calculation	The indicator provides a qualitative measure and is rated on a five-point Likert scale: No impact on societal norms – 1 — 2 — 3 — 4 — 5 — Extensive impact on societal norms NB. The measurement can be based on the number of publications in the popular media in the last 3 years (e.g. magazines, television, newspaper, social media), visits to the site in the last 3 years etc. 1. No impact: The project has not sparked the attention of those directly or indirectly involved. The project was not positively featured in the public media/magazines, and did not raise debate about what good urban development should look like. 2. Little effect: The project sparked the attention of a few who were directly involved. The project, however, was not positively featured in magazines/the public media, and did not raise a general debate about what good urban development should look like. 3. Some effect: The project sparked the attention of some who were directly and indirectly involved, and was positively featured in one or two magazines/the public media. The

	project did not raise a general debate about what good urban development should look like. 4. Broad effect: The project sparked the attention of numerous people who were directly and indirectly involved, and was positively featured in numerous magazines/the public media. The project raised some debate about what good urban development should look like. 5. Extensive effect: The project sparked the attention of the general public, and was extensively featured in magazines/the public media. The project raised a public debate about what good urban development should look like.
Strengths and weaknesses	Strengths: the indicator allows the evaluation and comparability of a wide range of project types and (still to-be-developed) solutions. Weaknesses: although it is tried to make scoring the indicator as objectively as possible, a certain amount of subjectivity is present.
Scoring	Multiply Likert scale value by 2
Data requirements	
Expected data source	To be derived from interviews with the project leader (including insights in site-visits) and /or end-users, and from consultation of popular media (online search for keywords).
Expected availability	As societal norms are difficult to define and are changing constantly, it will be hard to pinpoint a change in norms to a smart city project.
Collection interval	Some time after project completion
Expected reliability	Because of the subjectivity that cannot be excluded, this indicator is not 100% reliable.
Expected accessibility	Societal norms are by definition public, so no problems are expected with accessibility to information
References	
• Eurbanlab (2014). The Eurbanlab Selection of Indicators. Version 4. • Dimaggio, P. J. 1988. Interest and agency in institutional theory. Cambridge: M.A: Ballinger.	

Diffusion to other locations	
Description incl. justification	A smart city concept can be copied by other cities or regions. This can entail both the solutions within the project (e.g. technology, new product) as the institutional aspects of the project. The latter can for instance be the copying the procurement process, mimicking the way civil servants' support for a new development, creating a culture conducive of change, or changing regulations in another location to free the way for a new development. An example of active copying of low carbon strategies is the 'Replication Cluster' in the European

	SINFONIA project by ‘early adopter cities’. It is presumed that smart city projects have a higher potential for diffusion, when other locations have already copied the solutions or institutional aspects.
Definition	The extent to which the project is copied in other cities and regions
Calculation	The indicator provides a qualitative measure and is rated on a five-point Likert scale: Not copied in other locations – 1 — 2 — 3 — 4 — 5 — Very much copied in other locations 1. The innovation is not copied in other locations. 2. The innovation has been copied once in another location within the same city/region. 3. The innovation has been copied several times within the same city/region. 4. The innovation has been copied in projects within the same city/region, as well as projects outside the original city/region. 5. The innovation has been copied in its country of origin, as well as internationally.
Strengths and weaknesses	Strengths: the indicator allows the evaluation and comparability of a wide range of project types and (still to-be-developed) solutions. Weaknesses: although it is tried to make scoring the indicator as objectively as possible, a certain amount of subjectivity is present. To which extent the innovation will be copied might not be known when assessing the indicator.
Scoring	Multiply Likert scale value by 2
Data requirements	
Expected data source	To be derived from interviews with the project leader and/or stakeholders and an online search with keywords.
Expected availability	Information on the diffusion of smart city solutions will not be readily available and will require interviews and desktop research.
Collection interval	After project completion
Expected reliability	Because of the subjectivity that cannot be excluded, this indicator is not 100% reliable.
Expected accessibility	If a commercial company is involved, knowledge in its early stages about repeating a solution could be sensitive information and therefore difficult to get access to.
References	
• Eurbanlab (2014). The Eurbanlab Selection of Indicators. Version 4. • http://www.sinfonia-smartcities.eu/en/replication	

Diffusion to other actors	🚗 💻 🏢
Description incl. justification	The solutions within the project, e.g. new technologies, principles and/ or practices, can be copied by other parties, commercial or non-commercial. Innovative projects might inspire others to include aspects of this project in their products or processes. Being copied by others implies success.
Definition	The extent to which the project is copied by other parties
Calculation	The indicator provides a qualitative measure and is rated on a five-point Likert scale: Not copied– 1 — 2 — 3 — 4 — 5 — Very much copied 1. The solution is not at all copied/adopted by other parties. The newly applied technologies, principles and/or practices remain exclusive to the initial parties involved. 2. The solution has been copied/adopted by one other party who aims to apply, or has applied, the new technologies, principles and/or practices in other projects. 3. The solution is copied by several other parties. 4. The solution is copied by many other parties. 5. The solution has become the new guideline for parties, most have copied 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. Weaknesses: although it is tried to make scoring the indicator as objectively as possible, a certain amount of subjectivity is present. To which extent the solution will be copied might not be known when assessing the indicator.
Scoring	Multiply Likert scale value by 2
Data requirements	
Expected data source	To be derived from interviews with the project leader and/or stakeholders and an online search with keywords.
Expected availability	Information on diffusion of the solution will not be readily available and will require some interviews and desk research
Collection interval	After project completion
Expected reliability	Because of the subjectivity that cannot be excluded, this indicator is not 100% reliable.
Expected accessibility	If a commercial company is involved, knowledge about copying or adopting a solution in its early stages could be sensitive information and therefore difficult to get access to.

References
• Eurbanlab (2014). The Eurbanlab Selection of Indicators. Version 4.

Change in rules and regulations	
Description incl. justification	The implementation of urban innovations is often hampered by existing regulatory frameworks and systems. Because such existing rules and regulations are based upon old systems (centralised energy networks, traditional building processes), true innovations often break the rules (TNO, 2012). If projects are able to change the context in which they were applied, by providing a different interpretation of existing rules and regulations (at local -city planning, zoning- or national-, -spatial law, energy laws- level), the potential for propagation is improved. The change in local rules has an important signaling function which can inspire a new interpretation of the rules in other locations, paving the way for repetition of the urban innovation or for similar innovations.
Definition	The extent to which the project has contributed to, or inspired, changes in rules and regulations
Calculation	The indicator provides a qualitative measure and is rated on a five-point Likert scale: No impact– 1 — 2 — 3 — 4 — 5 — High impact 1. No impact: the project has not, at any level, inspired changes in rules and regulations. 2. Little impact: the project has led to a localised discussion about the suitability of the current rules and regulations. 3. Some impact: the project has led to a public discussion, leading to a change in rules and regulations. 4. Notable impact: the project has led to a public discussion, leading to a change in rules and regulations. This in its turn has sparked a discussion amongst other administrations about the suitability of the current rules and regulations. 5. High impact: the project has led to a public discussion, leading to a change in rules and regulations. This in turn has inspired other administrations to reconsider their rules and regulations Example interpretation of rules & regulation: The 'Solids' case in the Netherlands is a good example of changing rules and regulations at the local level and it contributed to a different interpretation of building for a sustainable future :

	Solids is a new sustainable concept which allows tenants themselves to decide on how to use spaces in the building. The concept builds on the idea to construct sustainable buildings, with a life expectancy of a 100 years, without predefined zoning plans to increase flexibility of the buildings. To allow this concept to be implemented in Amsterdam, the project had to be exempted from many existing regulations. For example, because the functions of and within the building – residential or for work – are not predefined, the land lease could not be determined. The corporation and the municipality decided that the average occupancy, over a period of five years, had to be the determining factor for the amount of the land lease. Next to this, the corporation had to achieve numerous other exceptions and exemptions to implement the concept and to achieve the desired flexibility in the building.
Strengths and weaknesses	Strengths: the indicator allows the evaluation and comparability of a wide range of project types and (still to-be-developed) solutions. Weaknesses: although it is tried to make scoring the indicator as objectively as possible, a certain amount of subjectivity is present.
Scoring	Multiply Likert scale value by 2
Data requirements	
Expected data source	To be derived from desk research and interviews with the project leader and with the legislative department within local administration
Expected availability	There will be no records available listing the cause and background of changed rules and regulations, so interviews and some desk research are required to retrieve information.
Collection interval	Some time after project completion
Expected reliability	Because of the subjectivity that cannot be excluded, this indicator is not 100% reliable.
Expected accessibility	Since information on rules and regulations is not sensitive, no problems are expected with accessing the information
References	
• Eurbanlab (2014). The Eurbanlab Selection of Indicators. Version 4. • TNO. 2012. Samenwerking en duurzame innovatie in de bouw. Delft.	

Change in public procurement	
Description incl. justification	Public procurement can be an important driver for innovation. As procurement procedures are often very precise in detailing all requirements of a project, e.g. the construction of a building, specifying building materials and installations ex ante, it rules out

	innovations. A new public procurement procedure, e.g. giving freedom to market parties to come up with new solutions, could be more effective for getting the optimal solution. An example of such a process is Tampere and Bomenbuurt Ulft in The Netherlands. In this project, a different procurement method was used, based only on a very limited amount of performance related criteria (TNO 2012, VTT 2013): • Maximum price for building the houses • Energy bill zero • LCA approach • Set and guaranteed maintenance costs over a 15-20 year period • Possibilities of users to participate Because of the complete freedom in 'how' to achieve this, the builders set up innovative coalitions to make it happen and built at lower costs than expected and met all performance criteria without much effort. Projects like described above, can form an inspiration for altering procurement methods, thereby opening the way for other projects to be realized. In the Tampere and Bomenbuurt Ulft case, the success of the project has inspired various other projects to be realized like this.
Definition	The extent to which the project has contributed to, or inspired, new forms of public procurement procedures
Calculation	The indicator provides a qualitative measure and is rated on a five-point Likert scale: No impact– 1 — 2 — 3 — 4 — 5 — High impact 1. No impact: the project used a new procurement procedure but this is not known to the outside world. 2. Little impact: the project used a new procurement procedure but is hardly known for this. 3. Some impact: the project developed and used a new procurement procedure and has received some professional attention because of this. 4. Notable impact: the project developed and used a new procurement procedure and has attracted a lot of professional attention because of this which has led to a few further experiments with the new public procurement procedure. 5. High impact: the project developed and used a new procurement procedure and has attracted a lot of public and professional attention because of this which has led to several further experiments with the new public procurement procedure.

Strengths and weaknesses	Strengths: the indicator allows the evaluation and comparability of a wide range of project types and (still to-be-developed) solutions. Weaknesses: although it is tried to make scoring the indicator as objectively as possible, a certain amount of subjectivity is present. Whether the new public procurement procedure will be used later or not might not be known when assessing the indicator.
Scoring	Multiply Likert scale value by 2
Data requirements	
Expected data source	To be derived from interviews with the project leader and the department for public procurement within local administration
Expected availability	There will be no readily available records listing the cause and background of changes in public procurement procedures, so interviews and some desk research are required.
Collection interval	Some time after project completion
Expected reliability	Because of the subjectivity that cannot be excluded, this indicator is not 100% reliable.
Expected accessibility	Since information on public procurement procedures is not sensitive, no problems are expected with accessing the information
References	
• Eurbanlab (2014). The Eurbanlab Selection of Indicators. Version 4. • TNO (2012). Samenwerking en duurzame innovatie in de bouw. Delft. • VTT (2013). Innovative public procurement of 'soft services' - Analysis of impacts and challenges in the procurement of innovation in social services Pelkonen, Antti; Valovirta, Ville XVII IRSPM Conference, Public sector responses to global crisis: New challenges for politics and public management?, 10 - 12 April 2013, Prague, Czech Republic. International Research Society for Public Management (IRSPM)	

New forms of financing	
Description incl. justification	New financial arrangements refer to the importance of new contractual forms, property rights and financial arrangements that help in realizing new ventures (Pacheco 2010). Urban developments are often very traditional as they are inspired by vested interests and executed with taken for granted ownership arrangements. By negotiating new formal institutional arrangements, incentive schemes can be altered and, for instance, problems of split incentives can be solved. Examples of such new arrangements are ESCO's (Energy Service Companies) and cooperatives. In the urban context, contracts are negotiable between government, developers, real estate owners, and tenants or buyers. New business models can emerge when, for instance, buildings are transformed to produce energy and both owners and tenants share in realized production or profits. Banks, possibly in collaboration with the government, can

	also offer new financial products such as 'green mortgages' or revolving funds for sustainable investments.
Definition	The extent to which the project has contributed to, or inspired, the development of new forms of financing
Calculation	The indicator provides a qualitative measure and is rated on a five-point Likert scale: No impact on new forms of financing– 1 — 2 — 3 — 4 — 5 — High impact on new forms of financing 1. No impact: the project used a new form of financing but this is not known to the outside world. 2. Little impact: the project used a new form of financing but is hardly known for this 3. Some impact: the project used a new form of financing and received some professional attention because of this. 4. Notable impact: the project is (one of the first) to develop and use a new form of financing and has attracted a lot of professional attention because of this, which has led to a few further experiments with the new way of financing. 5. High impact: the project developed and used a new form of financing and has attracted a lot of public and professional attention because of this, which has led to several further experiments with the new way of financing.
Strengths and weaknesses	Strengths: the indicator allows the evaluation and comparability of a wide range of project types and (still to-be-developed) solutions Weaknesses: although it is tried to make scoring the indicator as objectively as possible, a certain amount of subjectivity is present. Whether the new for of financing will be used later or not might not be known when assessing the indicator.
Scoring	Multiply Likert scale value by 2
Data requirements	
Expected data source	To be derived from project documentation and interviews with the project leader and/or stakeholders
Expected availability	Part of the information will be available in project documentation complemented with insights from interviews.
Collection interval	After project completion
Expected reliability	Because of the subjectivity that cannot be excluded, this indicator is not 100% reliable.
Expected accessibility	Information on whether a project has applied a new form of financing will be accessible, but the details may not be.
References	
• Eurbanlab (2014). The Eurbanlab Selection of Indicators. Version 4.	

- Pacheco, D. F., York, J. G., Dean, T. J., & Sarasvathy, S. D. 2010. The Coevolution of Institutional Entrepreneurship: A Tale of Two Theories. Journal of Management, 36(4): 974-1010.

Smart City project visitors

Description incl. justification	Successful smart city projects will attract visitors to explore the site for inspiration, insights, networking, etc. The amount of tourists and the distance they travelled can be seen as an indicator for the level of success of the project. The energy neutral town of Güssing in Austria, for example, attracted 600-1000 eco-tourists per week (mea.org.uk). Some projects, however, may not have a physical area to visit. For these projects, the unique visitors of the projects' website can be measured.
Definition	The number of visitors to the physical project site or to the website hosting the smart city project
Calculation	The number of visitors to the project site is leading. Only if there is no physical area to visit, can one count the number of unique visitors of the projects'website.
Strengths and weaknesses	Strengths: It is an absolute indicator leaving no room for subjective interpretation. Weaknesses: It suggest there is an area to be visited, which might not be the case, for instance when it concerns an ICT project.
Scoring	Incomparable between projects, no scoring suggested for the moment.

Data requirements

Expected data source	The project leader or current manager, visitor's logs and the project's website (visitors number)
Expected availability	Readily available from.above sources.
Collection interval	Some time after project completion
Expected reliability	Very reliable
Expected accessibility	As a component of a successful project and selling point in a marketing sense, it is expected that this information will be accessible.

References

- http://www.mea.org.uk/news/mea-visits-impressive-eco-town-gussing-austria

APPENDIX 2: DESCRIPTION OF THE CITY INDICATORS

People

Health

Access to basic health care services	
Description incl. justification	Since good health is the foundation for all other aspects of life, an good access to health is essential for the general well-being and functioning of the society. Health care access — as measured by the ease and timeliness with which people obtain medical services — is a key indicator of quality of care. Basic health care service consists of a minimum degree of health care considered to be necessary to maintain adequate health and protection from disease and includes: - General practicioners - Hospitals, including emergency and chronic treatments - Baby/youth clinics - Pharmacies Accessibility includes e.g. to physical distance (<500m), 24hrs availability, e-health services, overcoming literacy and language barriers.
Definition	Share of population with access to basic health care services within 500m
Calculation	(population with access to basic health care services <500m/total population)*100
Strengths and weaknesses	Strengths: The indicator provides an absolute measure for the ease of access of public transportation Weaknesses: In order to truthfully measure the accessibility of basic health care facilities, measuring only the physical dimension of accessibility is not sufficient. The social (affordability of such services) and cultural barriers would have to be measured as well, if the 'full picture' is to be shown.
Data requirements	
Expected data source	It might be possible to use city software and perform the exercise with the help of a computer. One could also obtain a map of the area, point the health care facilities, draw circles around them and use city resident information (available in city administrative documents) to analyse which buildings outside this area are houses and how many people are registered to them.

Expected availability	The required information should be easily available with the above sources
Collection interval	Yearly
Expected reliability	Depending on the methods of data collection and required resolution
Expected accessibility	Information on the location of health crae facilities is open information.

References

- http://medical-dictionary.thefreedictionary.com/basic+health+services
- https://www.wien.gv.at/gesundheit/einrichtungen/planung/pdf/sozialbericht-2015.pdf
- https://www.wien.gv.at/gesundheit/einrichtungen/planung/soziales/gesundheitsberichterstattung.htm
- Gulliford M1, Figueroa-Munoz J, Morgan M, Hughes D, Gibson B, Beech R, Hudson M. Health Serv Res Policy. 2002 Jul;7(3):186-8. What does 'access to health care' mean?http://www.ncbi.nlm.nih.gov/pubmed/12171751

Encouraging a healthy lifestyle	
Description incl. justification	Simply telling people to change unhealthy behaviors doesn’t work. We often rely on automatic behaviors to get us through the day. People change if unhealthy behaviors become too inconvenient: making bad choices harder is actually the best way to help people get healthier. For example programming elevator doors to close really slowly actually motivates more people to climb stairs. Little changes like these reach everyone—not just the people targeted with a health message. And they get us healthier just by letting us stay on autopilot. Encouraging a healthy lifestyle includes measures like: - 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: Weaknesses: It is a complex topic, which may be difficult to measure in a holistic manner
Data requirements	
Expected data source	Policy and other documents at the municipal health department.
Expected availability	
Collection interval	Yearly
Expected reliability	Depends on the local context
Expected accessibility	Information on policy measures is public information
References • http://heapro.oxfordjournals.org/content/current • http://www.healthpromotionresource.ir/attachment/912.pdf	

Safety

Traffic accidents	
Description incl. justification	Traffic accident rates and, specifically, fatality rates, can serve as indicators for the overall safety of the transportation system, the complexity and congestion of the roadway and transport network, the amount and effectiveness of traffic law enforcement, the quality of the transportation fleet (public and private), and the condition of the roads themselves (ISO/DIS 37120, 2013). Traffic deaths represent the most severe type of traffic safety failure, allowing cities to focus on their most urgent traffic safety needs. This indicator includes deaths due to any transportation-related proximate causes in any mode of travel (automobile, public transport, walking, bicycling, etc.): any death directly related to a transportation incident, even if death does not occur at the site of the incident, but is directly attributable to the accident. This indicator is particularly urgent in Central-Eastern European countries, where improvements in traffic infrastructures have not kept up with the rapidly growing traffic density. Transportation fatalities are used here as a proxy for all transportation

	injuries. Whereas many minor injuries are never reported—and thus cannot be measured— deaths are almost always reported. It is also worth noting that differences in the quality of the roadway, the quality of motorized vehicles, and the nature of law enforcement can change the relationship between injury and fatality. Cities and countries may have different definitions of causality, specifically related to the amount of time that can elapse between a traffic incident and a death.
Definition	Number of transportation fatalities per 100 000 population
Calculation	This indicator shall be calculated as the number of fatalities related to transportation of any kind (numerator), divided by one 100 000th of the city's total population (denominator). The result shall be expressed as the number of transportation fatalities per 100 000 population. The city shall include in this indicator deaths due to any transportation-related proximate causes in any mode of travel (automobile, public transport, walking, bicycling, etc.). The city shall count any death directly related to a transportation incident within city limits, even if death does not occur at the site of the incident, but is directly attributable to the accident.
Strengths and weaknesses	Strengths: This indicator is expressed as an absolute and objective value. Weaknesses: Traffic accidents with minor injuries or only material damage are not taken into account.
Data requirements	
Expected data source	City statistics bureau, municipal traffic department and police office. The urban audit database als contains information on the number of deaths in road accidents.
Expected availability	It is expected that this information is readily available in the above sources.
Collection interval	Yearly
Expected reliability	The indicator is common and clearly defined and the data should be reliable.
Expected accessibility	No sensitivities expected
References	

- ISO/DIS 37120 (2013). Sustainable development and resilience of communities — Indicators for city services and quality of life. ICS 13.020.20
- http://ec.europa.eu/transport/road_safety/index_en.htm

Crime rate	
Description incl. justification	The number of violence, annoyances and crimes is a lead indicator of feelings of personal safety (ISO/DIS 37120, 2013). Violence is the intentional use of physical force or power, threatened or actual, against oneself, another person or against a group or community, that either

	results in or has a high likelihood of resulting in injury, death, psychological harm, maldevelopment or deprivation (e.g. murder). Crime refers to illegal acts in general (e.g. car radio theft). Annoyances are not necessarily illegal, but do cause hinder (e.g. littering).
Definition	Number of violence, annoyances and crimes per 100.000 population
Calculation	This indicator shall be calculated as the total number of all crimes reported (numerator) divided by one 100 000th of the city's total population (denominator). The result shall be expressed as the number of crimes per 100 000 population.
Strengths and weaknesses	Strengths: Weaknesses: Not all crime is reported.
Data requirements	
Expected data source	To be derived by city police departments. The urban audit database also contains information on the number of murders and violent deaths.
Expected availability	The information is readily available at the above source.
Collection interval	Yearly
Expected reliability	The indicator is common and clearly defined and the data should be reliable.
Expected accessibility	Crime rates are public information
References • ISO/DIS 37120 (2013). Sustainable development and resilience of communities — Indicators for city services and quality of life. ICS 13.020.20	

Cybersecurity	
Description incl. justification	Cybersecurity is defined as "the discipline of ensuring that ICT systems are protected from attacks and incidents, whether malicious or accidental, threatening the integrity of data, their availability or confidentiality, including attempts to illegally 'exfiltrate' sensitive data or information out of the boundaries of an organization" (ITU, 2015). Cybersecurity will certainly gain importance in the near future because of increased digitalisation and the development of the Internet of Things (IoT) and highly increasing number of cyberattacks (Symantec, 2014). Cybersecurity is important for smart cities because smart cities with ICT as key enabler mean increasing generation of data, ICT complexity and hyper-connectivity which will also mean increasing vulnerability, both to malicious attacks and unintentional incidents. By conceiving interconnected urban systems with cybersecurity and data protection in mind, city administrators

	will be able to ensure service continuity, safety and well-being for citizens and businesses alike. (ITU, 2015) This indicator analyses the city’s preparedness to risks of cybersecurity (use of proper security procedures) and its ability to manage and mitigate possible disturbances (e.g. cyberattacks). In addition to this indicator, cities are recommended to adopt more detailed cybersecurity indicators adapted to their risks. Such have been developed by ITU, see ITU Recommendation ITU-T X.1208 (2014) ”A cybersecurity indicator of risk to enhance confidence and security in the use of telecommunication/information and communication technologies”.
Definition	The level of cybersecurity of the cities’ systems.
Calculation	Likert scale Low level of cybersecurity –– 1 — 2 — 3 — 4 — 5 — High level of cybersecurity 1. Maximum one of the following conditions is met. 2. Two of the following conditions are met 3. Three of the following conditions are met. 4. Four of the following conditions are met. 5. All the five following conditions are met. 1. There has been no serious information leakage or cyberattack with significant negative impact on the organisation, its employees or citizens during the past two years. Serious means that it results in disclosure of information (e.g. confidential or sensitive personally identifiable information) or financial lost, due to illegal system access, unauthorized data storage or transmission, unauthorized hardware and software modifications or personnel’s lack of compliance with security procedures. 2. The city makes annually a risk assessment on risks of cybersecurity and has a contingency plan against the identified risks. 3. All city personnel receive basic security training when they are employed to conduct adequately to security incidents. 4. The city has recruited personnel dedicated to cybersecurity and they have signed a security pledge. 5. Employees’ devices deploy an antivirus program for mitigating malware including viruses residing in them and remote access protected, i.e. controlled with security function for intrusion prevention or intrusion detection.
Strengths and weaknesses	Strengths: This indicator combines various cybersecurity indicators of risk proposed by ITU (2014).

	Weaknesses:
Data requirements	
Expected data source	City's IT or security department
Expected availability	The required information is expected to be readily available with the above sources.
Collection interval	Yearly
Expected reliability	Good
Expected accessibility	Good (open information)
References	
• ITU, 2015. "Cybersecurity, data protection and cyber resilience in smart sustainable cities". ITU-T FG-SSC Technical report. • Symantec, 2014. Internet security threat report 2014 – Volume 19. Available at: http://www.symantec.com/content/en/us/enterprise/other_resources/b-istr_main_report_v19_21291018.en-us.pdf • ITU, 2014. "A cybersecurity indicator of risk to enhance confidence and security in the use of telecommunication/information and communication technologies". Recommendation ITU-T X.1208 of SERIES X: Data networks, open system communications and security. Cyberspace security – Cybersecurity.	

Data privacy	
Description incl. justification	Data privacy, or information privacy, is the privacy of personal information and usually relates to personal data stored on computer systems (Technopedia). Privacy concerns exist wherever personally identifiable information or other sensitive information is collected and stored – in digital form or otherwise. If personal data is being collected, the purpose of data collection should be known and the collected data shouldn't be used for any other purpose. The owner of the data i.e. the administrator of the register should also be defined. If the city collects private data from the citizens (e.g. on energy consumption), authorisations from the end-users need to be acquired. It is recommended that such authorisations are made in form of a written agreement that clearly specifies the data to be collected, collection interval, use purpose and that the data won't be used for other purposes, and who will have access to the data. It is to be noted that information based on personal or private data can often be anonymised e.g. through aggregation. This indicator analyses the extent to which regulations on data protection are followed and to which proper procedures to protect personal or private data are implemented. Data protection refers to the tools and processes used to store data relevant to a certain ICT system or environment, as well as recover lost data in case of an

	incident – be it fraudulent, accidental or caused by a natural disaster. One critical element about data is the concept of data ownership, which refers to who is in charge of data, who can authorize or deny access to certain data, and is responsible for its accuracy and integrity, in particular personally identifiable information (PII) . (ITU, 2015)
Definition	The level of data protection by the city.
Calculation	Likert scale Not at all — 1 — 2 — 3 — 4 — 5 — Very high 1. City doesn't follow national regulations/laws on protection of personal data. 2. City follows national regulations/laws on protection of personal data. 3. City follows relevant national regulations on protection of personal data and the EU Directive on the Protection of Personal Data (95/46/EG). 4. City follows all the relevant national and European regulations/laws related to data privacy and protection. If personal/private data is collected from citizens, proper authorisations with written agreements are made. 5. Relevant national and European regulations on data protection and privacy are followed and written agreements are made for use of citizens' private/personal data. All the collected personal/private data, especially sensitive personal data, is accessed only by agreed persons and is heavily protected from others (e.g. locked or database on internal server with firewalls and restricted access).
Strengths and weaknesses	Strengths: 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's security or IT department
Expected availability	The required information is expected to be readily available with the above sources
Collection interval	Yearly
Expected reliability	Good
Expected accessibility	Good (open information)
References	
• ITU, 2015. "Cybersecurity, data protection and cyber resilience in smart sustainable	

cities". ITU-T FG-SSC Technical report. • Technopedia. https://www.techopedia.com/definition/10380/information-privacy

Access to (other) services

Access to public transport	
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). 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 describes the percentage of population with nearby access to a public transport stop or connection, including all modes of public transport; train, tram, subway, bus, etc. (adapted to: City Protocol, 2015).
Definition	Share of population with access to a public transport stop within 500m
Calculation	(Number of inhabitants with a transportation stop <500m/total population)*100% NB. It can be calculated as the sum of buildings with a point of access within 500m, multiplied by its inhabitants. 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:** Considering purely the geographical catchment areas as absolute measure, may exclude other important information with regards to (the quality of) mobility (e.g. attractive frequencies, comfort, reliability of services, and intermodal integration are the main characteristics of service quality (EC, 2011)). 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 (1). By looking singularly at the residential location of inhabitants as the source for % calculation, only the source location of movement is being taken into account, but not the main destinations. Thus the outcome may contain distortions in regards to the true situation concerning the accessibility of public transport.
Data requirements	
Expected data source	It might be possible to use city software and perform the exercise with the help of a computer. One could also obtain a map of the area, point the

	transportation stops (available at the public transport utilities), draw circles around them and use city resident information (available in city administrative documents) to analyse which buildings outside this area are houses and how many people are registered to them.
Expected availability	The information on location of transportation stops and dwellings should be easily available with the above sources.
Collection interval	Yearly
Expected reliability	Depending on the methods of data collection and required resolution
Expected accessibility	The information on location of transportation stops and dwellings is public information

References

- (1) http://www.highdensityliveability.org.au/community_sustainable_transport.php (as seen in March, 2013)
- 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.

Access to vehicle sharing solutions for city travel	
Description incl. justification	Providing opportunities for sharing vehicles like (e-)bicycles, (e-)cars and (e-)scoorters, can decrease the need for and use of private cars, thereby contributing to an accessible, green and healthy neighbourhood. Cycling is a healthy, flexible, cheap and sustainable way to get from a to b over a short distance. Many European cities therefore would like to stimulate cycling, but in countries without a cycling culture there is limited private ownership of bikes. Car-sharing is about not owning a car, but renting it from a car-sharing company or sharing the car with friends, family, neighbours or co-workers (1,2). Car-sharing is an attractive option for people who drive less than 10.000 km a year. Car-sharers are more likely to travel by bike, saving on car use and improving their health. Car-sharing also decreases the need for parking space, less vehicles are on the road and less pollution is emitted. Car sharing may furthermore improve social cohesion in the neighborhood.
Definition	Number of vehicles available for sharing per 100.000 inhabitants
Calculation	Number of vehicles per 100.000
Strengths and weaknesses	Strengths: Solid indicator on the vehicle sharing situation in a city, capturing the quantitative aspect of the facilities.

	Weaknesses: The indicator does not consider the qualitative aspects of vehicle sharing (e.g. costs, quality of the vehicle, etc.).
Data requirements	
Expected data source	Consult vehicle sharing companies in the city for the total number of vehicles available. Some companies might be run by the government and information might be available on the city website.
Expected availability	To be gathered from different service providers and/or open government data
Collection interval	Yearly
Expected reliability	The number is expected to be reasonably accurate, since the companies will need to have updated information on their fleet to properly run their business.
Expected accessibility	It is not expected that the vehicle sharing companies will consider the number of vehicles as secret information.
References - (1) http://utrechtdeelt.nl/daarom-autodelen/wat-is-autodelen/ - (2) http://utrechtdeelt.nl/daarom-autodelen/de-voordelen/ - https://www.wien.gv.at/verkehr/kfz/carsharing/ - https://www.wien.gv.at/verkehr/kfz/carsharing/wissenswertes.html	

Length of bike route network	
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. 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	% of bicycle paths and lanes in relation to the length of streets (excluding motorways)
Calculation	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 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, e.g for Vienna (1). The urban audit database also has information on the length of bicycle network (dedicated cycle paths and lanes).
Expected availability	The information is expected to be readily available with the above sources
Collection interval	Yearly
Expected reliability	Good
Expected accessibility	If the information is available, there is no reason to believe that it will not be accessible (not sensitive information)

References

- (1) https://www.wien.gv.at/english/transportation-urbanplanning/cycling/cycling-map.html
- 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.

Access to public amenities	
Description incl. justification	It is presumed that nearby availability of amenities leads to a lively neighbourhood and less car use. Amenities in the urban environment make an area more enjoyable and contribute to its desirability. Public amenities are services/facilities which are provided by the government or town/city councils for the general public to use, with or without charge. Examples of the types of public amenities considered here are social welfare points, social meeting centers, theatres and libraries. (note: other public amenities such as green spaces, public recreation and healthcare facilities are already covered in separate indicators).

	Access to public amenities is an indicator which partially exposes the mix and distribution of different uses in an urban area, indicating the availability of public services in a close proximity of residential location of inhabitants.
Definition	Share of population with access to at least one type of public amenity within 500m
Calculation	(Number of inhabitants with a public amenity <500m/total population)*100% NB. It can be calculated as the sum of buildings with a public amenity within 500m, multiplied by its inhabitants.
Strengths and weaknesses	**Strengths:** Indicator is focused on an even distribution of public amenities **Weaknesses:** The indicator does not address the quality of the amenities. Lack of density of different public amenities in centered urban locations encourages urban sprawl and loss of urban identity. The attempt to distribute such amenities 'evenly' throughout space may cause down turning effects on different modes of transportation, increasing the use of private motorized vehicles.
Data requirements	
Expected data source	It might be possible to use GIS software. One could also obtain a map of the area , point the public amenities (available at the city planning office), draw circles of 500m around them and use city resident information (available in city administrative documents) to analyse which buildings fall outside this area are houses and how many people are registered to them.
Expected availability	The information on location of public amenities and dwellings should be publicly available.
Collection interval	Yearly
Expected reliability	Depending on the methods of data collection and required resolution
Expected accessibility	It is expected that this information is not sensitive
References • Towards an Urban Rennaissance. Final Report of the Urban Task Force, Chaired by Lord Rogers of Riverside, 1999, London, pp. 61 • http://webapps.stoke.gov.uk/uploadedfiles/Urban%20Design%20Compendium%201.pdf • Eurbanlab (2014). The Eurbanlab Selection of Indicators. Version 4.	

Access to commercial amenities	
Description	It is presumed that availability of amenities leads to a lively neighbourhood

incl. justification	and less car use. Amenities in the urban environment make an area more enjoyable and contribute to its desirability. Commercial amenities are services/goods for daily use provided by private actors. Typical commercial amenities include shops for bread, fish, meat, fruits and vegetables, general food shops (i.e. supermarkets), press, and pharmaceutical products (City Protocol (2015)). Access to commercial amenities is an indicator which partially exposes the mix and distribution of different uses in an urban area, indicating the availability of commercial amenities in a close proximity of residential location of inhabitants.
Definition	Share of population with access to at least six types of commercial amenities providing goods for daily use within 500m.
Calculation	
Strengths and weaknesses	**Strengths:** Indicator is focused on an even distribution of commercial amenities **Weaknesses:** Diversity and quality are not considered
Data requirements	
Expected data source	Open government data and city maps. To measure this, the city can be analyzed with a package of spatial statistics (City Protocol (2015).
Expected availability	The information on location of commercial amenities and dwellings should be available at the city planning office.
Collection interval	Yearly
Expected reliability	The underlying information is considered very reliable. The analysis with regards to the accessibility is more difficult and can render is little less reliable.
Expected accessibility	It is expected that this information is not sensitive.
References • Towards an Urban Rennaissance. Final Report of the Urban Task Force, Chaired by Lord Rogers of Riverside, 1999, London, pp. 61 • http://webapps.stoke.gov.uk/uploadedfiles/Urban%20Design%20Compendium%201.pdf • City Protocol (2015). CPWD - [-] 002 Anatomy Indicators- City Indicators. City Protocol Agreement (CPWD-[-]002) • Eurbanlab (2014). The Eurbanlab Selection of Indicators. Version 4.	

Access to high speed internet	
Description incl.	The internet has proven to be an important enabler. First mainly for sharing information, but more and more for online services such as

justification	shopping, but also municipal services such as making an appointment for a new passport or report something stolen to the police. In 2010, ADL and Chalmers found, based on a survey conducted by Ericsson Consumer Labs, that broadband speed is an important factor for driving economic growth, both on micro and macro level (Chalmers, 2013). This indicator aims to ensure good city connectivity and the provision of efficient digital infrastructures and focuses on the fixed (wired)-broadband subscriptions. Fixed (wired)-broadband subscriptions refers to the number of subscriptions for high-speed access to the public Internet (a TCP/IP connection) (ITU, 2014). High-speed access is defined as downstream speeds equal to, or greater than, 256 Kbits/s. Fixed (wired) broadband includes cable modem, DSL, fiber and other fixed (wired)-broadband technologies (such as Ethernet LAN, and broadband-over-power line (BPL) communications). Subscriptions with access to data communications (including the Internet) via mobile-cellular networks are excluded.
Definition	Fixed (wired)-broadband subscriptions per 100 inhabitants .
Calculation	
Strengths and weaknesses	**Strengths:** It is a solid indicator showing the 'physical' availability of high speed internet **Weaknesses:** Other aspects such as affordability, availability of devices, blackouts, etc. are not taken into account What is considered 'high-speed' internet changes constantly. The current ITU indicator based on 256Kbits/s seems already outdated (wikipedia). A better reference value is needed for Europe.
Data requirements	
Expected data source	Internet access records are kept by internet service and telecommunications providers in the form of subscriber locations and accounts. Other sources include government censuses, telecommunications records and official estimates (ISO/DIS 37120, 2013).
Expected availability	The number of subscriptions is known to the providers.
Collection interval	Yearly
Expected reliability	Very good
Expected accessibility	May be difficult to receive data form network providers
References • INTERNATIONAL TELECOMMUNICATION UNION (2014). Key performance indicators (KPIs) definitions for Smart Sustainable Cities. SSC-0162-rev3 • Chalmers (2013). Need for speed. A descriptive analysis of socio-economic and	

usage factors characterizing users with different levels of broadband speed. Bachelor Thesis TEKX04-13-04.
- http://www.broadbandcommission.org/
- ISO/DIS 37120 (2013). Sustainable development and resilience of communities — Indicators for city services and quality of life. ICS 13.020.20
- https://en.wikipedia.org/wiki/List_of_countries_by_Internet_connection_speeds

Access to public free Wi-Fi access	
Description incl. justification	Wi-Fi* is defined as local area networks compliant with the 802.11 standards (City protocol 2015). Wi-Fi coverage is defined as the urban surface within 200m of a Wi-Fi node, be it available to the general public or restricted to city officials. Public Wi-Fi coverage has proven instrumental in improving the image of public spaces, as well as the reputation of the city itself (City protocol 2015). It also improves the city's attractiveness to potential visitors, and facilitates basic internet access to those not wealthy enough to afford their own connection, reducing the technology gap, and improving quality of life and equity of opportunities, thus strengthening social tissue. In addition, Wi-Fi coverage connects the variety of sensors, actuators, and other devices that make the smart city to the fiber optics network running through the city, providing capillarity to it. Lastly, city officials themselves can connect to this Wi-Fi area, allowing the city administration's data intake and output to reach even further. This strengthening of the communications network provides the city with increased resilience and reaction capabilities. This indicator measures the percentage of a city's public space which is covered by a public Wi-Fi network. NB. Security of Wi-fi hotspots is covered in the indicator 'Cybersecurity'. * What constitutes a wifi network is defined by the ieee and can be found at: http://standards.ieee.org/getieee802/download/802.11af-2013.pdf
Definition	Public space Wi-Fi coverage
Calculation	$(Sum\ of\ wifi\ node's\ coverage/Total\ city\ urban\ surface)$*100% (City protocol 2015)
Strengths and weaknesses	Strengths: It is an absolute and objective indicator that can easily be compared with other cities. Weaknesses:
Data requirements	
Expected data source	A map of publicly owned Wi-Fi nodes is often held by the city government, and the surface covered can be obtained from that.

Expected availability	Good
Collection interval	Yearly
Expected reliability	Good
Expected accessibility	As this concerns public Wi-fi hotspots, this information is expected to be open and public.
References	
- ITU, 2015. "Cybersecurity, data protection and cyber resilience in smart sustainable cities". ITU-T FG-SSC Technical report. - City protocol (2015). City Anatomy - City Indicators. CPWD-PR_002_Anatomy_Indicators	

Flexibility in delivery services	
Description incl. justification	The internet has proven to be an important enabler. Not only for sharing information, but more and more for online services such as shopping. It provides the flexibility of shopping when it is convenient for the consumer, since web stores never close. However, all these online orders need to be delivered as well. This indicator analyses the improvement in providing flexibility in delivery services. Examples of improved delivery options: • Possibility to reschedule the delivery appointment to a more convenient time; • Possibility to have the package accepted by a neighbor; • Possibility to pick up the package at a distribution point near the home (such as a post office or a super market);
Definition	The extent to which there is flexibility in delivery services.
Calculation	Likert scale: None – 1 — 2 — 3 — 4 — 5 — Very much. 1. Not at all: there is no flexibility in delivery services at all. Receiving a package requires the consumer to be home during regular business hours (the default). 2. Poor: there is little flexibility in delivery services, providing one additional option to the default. 3. Somewhat: there is some flexibility in delivery services, providing two additional options to the default. 4. Good: there is sufficient flexibility in delivery services, providing three additional options to the default. 5. Excellent: there is extensive flexibility in delivery services, providing more than three additional options to the default.
Strengths and weaknesses	Strengths: the indicator is relevant to access to services. Weaknesses: although it is tried to make scoring the indicator as

	objectively as possible, a certain amount of subjectivity is present. It might be difficult to collect the necessary data at city level.
Data requirements	
Expected data source	Interviews with residents; expert opinion of city administrators.
Expected availability	Might be difficult to gather data.
Collection interval	Yearly
Expected reliability	Because of the subjectivity that cannot be excluded, this indicator is not 100% reliable.
Expected accessibility	No sensitivities expected.
References	
•	

Education

Access to educational resources	
Description incl. justification	Education and training is critical to enhance human creativity and social quality and to prevent social exclusion (ITU, 2014). Next to traditional education, i.e. primary, secondary and tertiary educational facilities, this indicator also emphasizes the importance of life-long learning. 'Lifelong learning' is the "ongoing, voluntary, and self-motivated" pursuit of knowledge for either personal or professional reasons. Therefore, it not only enhances social inclusion, active citizenship, and personal development, but also self-sustainability, rather than competitiveness and employability (EC, 2006). In addition, the number of years of education is strongly associated with the health of populations in both developed and developing countries (ITU, 2014). This indicator analyses the effort made by the city to provide access for all to adequate and affordable educational services. This access includes: physical access to educational institutions, e.g. schools, universities, libraries (number and distance), and digital access (e-learning) to education resources (e.g. open, well-documented and well-indexed).
Definition	The extent to which the city provides easy access (either physically or digitally) to a wide coverage of educational resources
Calculation	Likert scale: Not at all – 1 – 2 – 3 – 4 – 5 – very much 1. Not at all: There are not enough basic educational amenities (schools, universities) in the city to provide easy access to or decent quality of education for the citizens

	2. Poor: The citizens have decent access to basic education (schools, universities) but the provision of additional educational resources (e.g. libraries) for (life-long) learning is poor 3. Somewhat: The access to basic education is good and additional free educational resources are available for all through libraries and online services 4. Good: Easy access to basic education and good coverage free educational resources for all enabling life long learning 5. Excellent: Wide variety of educational resources available with easy access offline (schools, libraries, universities, museums) and online (e.g. Massive Open Online Courses) ; most of them provided freely to all with special attention to possibilities for life long learning.
Strengths and weaknesses	Strengths: Weaknesses: although it is tried to make scoring the indicator as objectively as possible, a certain amount of subjectivity is present. ‘Educational resources’is a broad concept and can be interpreted differently.
Data requirements	
Expected data source	City administration, department on education. Many cities have open data on schools, universities and/or libraries.
Expected availability	Although some basic information such as the number of schools/100.000 inhabitants will probably be available, it remains to be seen whether the level of detail needed to fill out a score on this indicator is available.
Collection interval	Yearly
Expected reliability	Because of the subjectivity that cannot be excluded, this indicator is not 100% reliable.
Expected accessibility	No sensitivities expected
References	
• ITU (2014). Key performance indicators (KPIs) definitions for Smart Sustainable Cities. SSC-0162-rev3 • Commission of the European Communities (2006). "Adult learning: It is never too late to learn". COM(2006) 614 final. Brussels, 23.10.2006.	

Environmental education	
Description incl. justification	Awareness of environmental problems is important for creating support for environmental projects and programs. Special attention should be given to children at school, as they are the next generation. This indicator, therefore, assesses the extent to which education programs about the environment and sustainability have

	been implemented at schools.
Definition	The percentage of schools with environmental education programs
Calculation	Calculation;(Number of schools with environmental education programs/total number of schools)*100%
Strengths and weaknesses	Strengths: Weaknesses: ‘environmental education’ is a broad concept and can be interpreted differently.
Data requirements	
Expected data source	To be derived from city administration documentation, interviews/questionnaires and school reports (online?).
Expected availability	It is expected that this information requires some work, but will be available.
Collection interval	Yearly
Expected reliability	The number can be calculated reliably in some cities, in some cities only estimations might be available
Expected accessibility	It is expected that information on educational programs is open information.
References	
●	

Digital literacy	
Description incl. justification	The European Commission has acknowledged digital competence as a key skill for lifelong learning and essential for participating in our increasingly digitalized society (EC, 2013). The ECDL foundation states that digital literacy is now a critical factor in supporting the overall growth of an economy and development of society (ECDL, 2009). Digital competence can be broadly defined as the confident, critical and creative use of ICT to achieve certain goals. Digital competence is a transversal key competence which, as such, enables us to acquire other key competences (e.g. language, mathematics, learning to learn, cultural awareness). However, in practice many people currently lack digital capabilities. The four main components of the digital divide are access, affordability, relevancy of content and skills (ECDL, 2009). Many national and international policies and investments focus on addressing the first 3 components, often to the detriment of a structured focus on skills. It appears very difficult to measure the actual increase in digital literacy (ECDL, 2009). Therefore, the assessment will focus on the percentage of the target group (e.g. elderly, less-

	educated, immigrants) reached by activities (e.g. courses) to increase digital literacy, taking into account the 5 main competence areas information, communication, content-creation, safety and problem-solving (EC, 2013).
Definition	Percentage of target group reached
Calculation(suggestion if available)	(Number of people reached/number of people in target group)*100%
Strengths and weaknesses	Strengths: Weaknesses: The actual increase in digital literacy is not evaluated.
Data requirements	
Expected data source	To be derived from documents on activities that have taken place in the city, e.g. at the city administration and/or the organization providing trainings and schools.
Expected availability	The number of participants in events or courses will often be registered, but it might more difficult to get information on which activities took place, who organized them and where documentation can be found.
Collection interval	Yearly
Expected reliability	Data found on the registered number of students will be fairly reliable.
Expected accessibility	Students participating in trainings by private organisations might be considered sensitive information, but no big problems are expected with regards to accessibility.
Expected data models	
References	
- European Commission (2013). DIGCOMP: A Framework for Developing and Understanding Digital Competence in Europe. JRC Scientific and Policy Reports, JRC83167. EUR 26035 EN, ISBN 978-92-79-31465-0 (pdf), ISSN 1831-9424 (online), doi:10.2788/52966 - http://www.go-on.co.uk/get-involved/go-uk-heatmap/about-heatmap/ - http://www.theguardian.com/news/datablog/2015/oct/19/map-shows-parts-of-uk-most-excluded-from-digital-world	

Diversity & Social cohesion

No indicators identified at city level

Quality of Housing and the built environment

Diversity of housing	

Description incl. justification	It is presumed that a mix of housing types (houses of different sizes, different forms of ownership) is beneficial for the diversity in the city and its neighbourhoods. Jane Jacobs, for example, strongly emphasized the importance of diversity and a mixture of uses as a prerequisite for urban success. She wrote the book 'The death and life of great American cities'(1961), arguing that policies, such as urban renewal and separation of uses (i.e., residential, industrial, commercial) destroy communities and innovative economies by creating isolated, unnatural urban spaces. Jacobs identified four 'generators of diversity' that "create effective economic pools of use": 1. The district must serve more than one primary use, and preferably more than two, activating streets at different times of the day 2. Most blocks must be short, allowing high pedestrian permeability 3. Buildings must be mingled in their age, condition, and required economic yield. 4. A dense concentration of people. Though her theories were very influential, they have not been verified. However, they have recently been applied to the City of Seoul, who found that they "provided important theoretical viewpoints and implications for promoting a vital urban life in contemporary Seoul" (Sung et al., 2015). This case study also translated the theories into indicators which, after further investigation, might be relevant for uptake in CITYkeys indicators at a later stage. At the moment, this indicator focuses on diversity of housing (targeting mainly Jacob's third generator). Below, two calculation methodologies are noted that focus on one aspect of diversity in buildings; housing types (Simpson Diversity Index) and ownership variety (Social housing). Nb. The indicators 'access to public and commercial amenities' partly contribute to Jacob's first generator.
Definition	**Simpson Diversity Index** Simpson Diversity Index of total housing stock in the city **Social Housing** Percentage of social dwellings as share of total housing stock in the city
Calculation	Below, two options to calculate the diversity in housing types are listed and explained. Because of the direct and coherent calculation, the Simpson Diversity Index is the preferred method. However, this Index is perceived as difficult to calculate. As an alternative, this diversity in housing can be approached by assessing the variety in ownership. **Simpson Diversity Index** The Simpson Diversity Index calculates the probability that any two randomly selected dwelling units in a city will be of a different type. An index score greater than 0,5 is considered preferable (LEED, 2014).

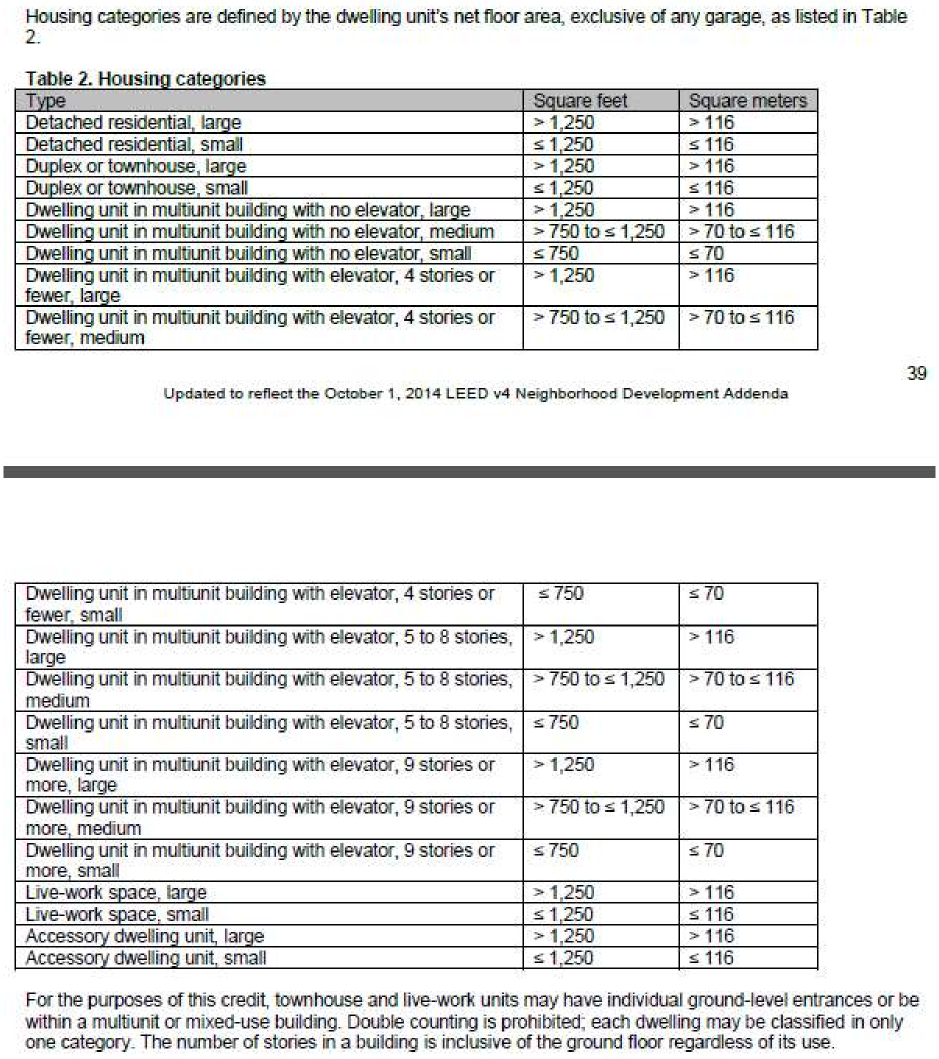
$$Score = 1- \sum (n/N)\square^{2]}$$

Where

n = the total number of dwelling units in a single category, and

N = the total number of dwelling units in all categories.

The housing categories are defined in the table below (LEED, 2014).



Housing categories are defined by the dwelling unit's net floor area, exclusive of any garage, as listed in Table 2.

Table 2. Housing categories

Type	Square feet	Square meters
Detached residential, large	> 1,250	> 116
Detached residential, small	≤ 1,250	≤ 116
Duplex or townhouse, large	> 1,250	> 116
Duplex or townhouse, small	≤ 1,250	≤ 116
Dwelling unit in multiunit building with no elevator, large	> 1,250	> 116
Dwelling unit in multiunit building with no elevator, medium	> 750 to ≤ 1,250	> 70 to ≤ 116
Dwelling unit in multiunit building with no elevator, small	≤ 750	≤ 70
Dwelling unit in multiunit building with elevator, 4 stories or fewer, large	> 1,250	> 116
Dwelling unit in multiunit building with elevator, 4 stories or fewer, medium	> 750 to ≤ 1,250	> 70 to ≤ 116
Dwelling unit in multiunit building with elevator, 4 stories or fewer, small	≤ 750	≤ 70
Dwelling unit in multiunit building with elevator, 5 to 8 stories, large	> 1,250	> 116
Dwelling unit in multiunit building with elevator, 5 to 8 stories, medium	> 750 to ≤ 1,250	> 70 to ≤ 116
Dwelling unit in multiunit building with elevator, 5 to 8 stories, small	≤ 750	≤ 70
Dwelling unit in multiunit building with elevator, 9 stories or more, large	> 1,250	> 116
Dwelling unit in multiunit building with elevator, 9 stories or more, medium	> 750 to ≤ 1,250	> 70 to ≤ 116
Dwelling unit in multiunit building with elevator, 9 stories or more, small	≤ 750	≤ 70
Live-work space, large	> 1,250	> 116
Live-work space, small	≤ 1,250	≤ 116
Accessory dwelling unit, large	> 1,250	> 116
Accessory dwelling unit, small	≤ 1,250	≤ 116

39

Updated to reflect the October 1, 2014 LEED v4 Neighborhood Development Addenda

For the purposes of this credit, townhouse and live-work units may have individual ground-level entrances or be within a multiunit or mixed-use building. Double counting is prohibited; each dwelling may be classified in only one category. The number of stories in a building is inclusive of the ground floor regardless of its use.

Social housing

The indicator 'social housing' focuses on variety in ownership, rather than housing types. There is, however, no single formal definition of social housing amongst the different European countries (Whitehead and Scanlon 2007). In some countries, social housing is related to ownership – as for example in the Netherlands where social housing often refers to housing in ownership of local authorities. In others, social housing relates to the actor who constructs the dwellings (e.g. Austria and France), or whether or not

	the rents are below market levels (e.g. England). In most countries, however, social housing is a supportive measure which is directed at those who cannot serve their own housing needs (ibid). Moreover, sometimes this entails social rented dwellings (e.g. the Netherlands), and sometimes the concept entails social housing that is privately owned (e.g. Spain). This variety in definitions and interpretations of social housing means that it is virtually impossible to provide strictly comparable figures on the supply of social housing in urban innovations. The indicator is therefore to be used in the context of the country specific interpretation of social housing, as well as its importance in the national housing stock. Following Dutch social housing policy, for example, 10-90% social housing as share of the total is considered acceptable. In other countries margins are very different. In the UK, more than 75% of social housing is considered too much. Note: when the country in question has a social housing share of less than 10% in the total housing stock, the assessor can opt to qualify this indicator as “not applicable”.
Strengths and weaknesses	**Simpson Diversity Index** Strengths: The indicator can easily be compared between cities and countries. Weaknesses: This indicator requires detailed calculation. **Social housing** Strengths: Data are easily available Weaknesses: It is not easy to determine a reference value on what a good share of social housing is. The definition of ‘social housing’ can be different in various countries. The share considered ‘correct’ can vary between countries
Data requirements	
Expected data source	Housing categories for existing neighbourhoods can be derived from city administration/planning documents,
Expected availability	Uncertain
Collection interval	Yearly
Expected reliability	Good
Expected accessibility	No sensitivities expected
References	

- Eurbanlab (2014). The Eurbanlab Selection of Indicators. Version 4.
- Whitehead, C., and K. Scanlon. Social Housing in Europe. London: LSE London, 2007.
- City Protocol, 2015. City anatomy indicators.
- LEED (2014). LEED v4 for Neighbourhood Development.
- http://www.newgeography.com/content/002711-on-jane-jacobs-generating-and-preserving-diversity
- CECODHAS Housing Europe (European Federation of Public, Cooperative & Social Housing), 2007.
- Hyungun Sung, Sugie Lee, and SangHyun Cheon (2015). Operationalizing Jane Jacobs's Urban Design Theory: Empirical Verification from the Great City of Seoul, Korea. Journal of Planning Education and Research 1 –14.

Preservation of cultural heritage	
Description incl. justification	An important aspect in promoting the feeling of community/home is 'place-making'; the creation of place and identity.This identity can be created by building on local and regional history, culture and character. This entails integrating urban design and heritage conservation so that it enhances or connects to the existing character of the place, e.g. preservation, restoration and/or adaptive re-use of historic buildings and cultural landscapes. Keeping these locations' special identity could also bring economic as well as other benefits to the area.
Definition	The extent to which preservation of cultural heritage of the city is considered in urban planning.
Calculation	The indicator provides a qualitative measure and is rated on a five-point Likert scale: Not at all – 1 — 2 — 3 — 4 — 5 — Very much 1. Not at all: no attention has been paid to existing cultural heritage in urban planning. 2. Fair: heritage places have received some attention in urban planning, but not as an important element. 3. Moderate: some attention has been given to the conservation of heritage places. 4. Much: heritage places are reflected in urban planning 5. Very much: preservation of cultural heritage and connections to existing heritage places are a key element of urban planning.
Strengths and weaknesses	Strengths: the indicator allows the evaluation and comparability of a wide range of forms of cultural heritage.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	To be derived from interviews with the department for urban planning of the local government and their documentation.

Expected availability	It will be fairly easy to retrieve information on cultural heritage from interviews
Collection interval	Yearly
Expected reliability	Because of the subjectivity that cannot be excluded, this indicator is not 100% reliable.
Expected accessibility	Cultural heritage is public information, no problems are expected with regards to access
References	
• Eurbanlab (2014). The Eurbanlab Selection of Indicators. Version 4.	

Ground floor usage	
Description incl. justification	Making use of ground floors for commercial and public purposes can increase the liveability and atmosphere of a neighbourhood. Also, an interesting public realm will enhance the consumer's experience and support the endeavors of small businesses and retailers thereby adding to successful retail and commerce (Arlington, 2014). One can think of a variety of uses suitable for the ground floor, dependent on the location, including retail, personal and business services, retail equivalents such as educational and conferencing facilities, and arts and cultural resources (Arlington, 2014). The potential for increasing the use for ground floor space lies mostly within residential and office buildings.
Definition	Percentage of ground floor surface of buildings that is used for commercial or public purposes as percentage of total ground floor surface.
Calculation	(ground floor space used commercially/publically (in m2)/total ground floor space (in m2) *100%. Depending on the city, this indicator maybe limited to certain (central) parts of the urban area.
Strengths and weaknesses	Strengths: Absolute and objective value for ground floor usage. Weaknesses: Data are scattered. Definitions of public and commercial spaces can vary between cities.
Data requirements	
Expected data source	To be derived from administrative documents and/or from interviews with the department for urban planning within the local government.
Expected availability	It will be fairly easy to retrieve information on commercial and public activities from interviews and documents, though it might be more challenging to determine the ground floor space used by them.
Collection interval	Yearly

Expected reliability	Documentation on registered commercial or public activities is highly reliable.
Expected accessibility	Information on ground floor usage is specified in development plans, so no problems are expected with regards to access
Expected data models	
References	
• Arlington County - Arlington Economic Development (2014). Ground Floor Retail & Commerce: Policy Guidelines and Action Plan for Arlington's Urban Villages.	

Public outdoor recreation space	
Description incl. justification	Recreation is an important aspect of city life, contributing to the health of citizens, the vitality of the city and community participation. Recreation is a service that many cities provide through a parks and recreation department or related office (ISO/DIS 37120, 2013). Public recreation space is defined broadly to mean land and open space available to the public for recreation. Recreation space shall include only space that primarily serves a recreation purpose. Outdoor recreation space should include: a) city-owned or maintained land; b) other-recreation lands within the city not owned or operated by the city, provided they are open to the public. This category may include state or provincially owned lands, school and college grounds, as well as non-profit. If cities report only city-owned recreation space, this shall be noted. For multi-use facilities, only the portion of the land devoted to recreation shall be counted (the play areas at a school or college, for example, not the entire school site). Double counting shall be avoided. For example, do not include indoor facilities on parkland. The area of the entire outdoor recreation site shall be included (including, for example woodedareas of parks, building maintenance and utility areas) but shall exclude parking areas.
Definition	Square meters of public outdoor recreation space per capita
Calculation	Square meters of public outdoor recreation space per capita shall be calculated as square meters of outdoor public recreation space (numerator) divided by the population of the city (denominator), and shall be expressed as the number of square meters of outdoor recreation space per capita (ISO/DIS 37120, 2013).
Strengths and weaknesses	Strengths: This is a solid and objective indicator Weaknesses: the quality of the space is not taken into account.

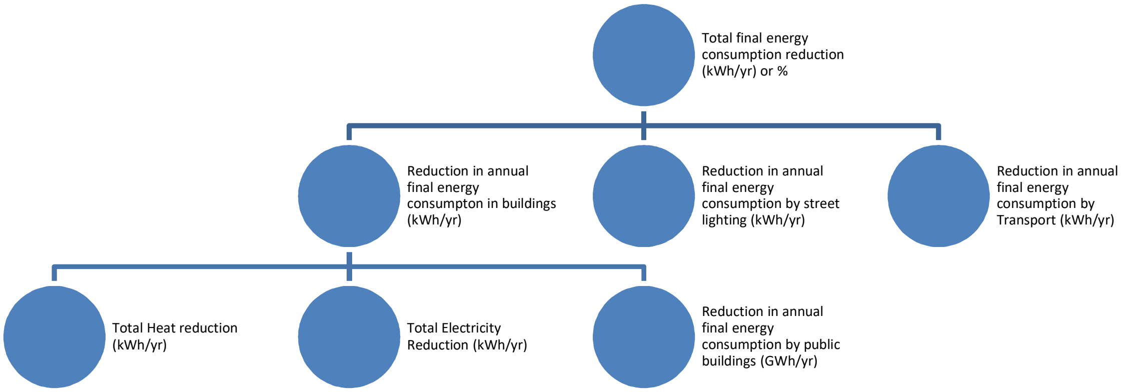
Data requirements	
Expected data source	This information should be obtained from a City Planning Department together with departments knowledgeable about the city. Outdoor recreation spaces may also be delineated using aerial photography and/or land use maps. Once the areas have been identified on a map, the area in square meters may be calculated using low cost Geographic Information Systems (GIS) or, if not available, through use of hand-held measuring devices. Area may be calculated in hectares or acres and converted to square meters.
Expected availability	The information should be easily available with the above sources
Collection interval	Yearly
Expected reliability	High
Expected accessibility	Information on public outdoor recreation space is specified in development plans which are publicly available.
References	
• ISO/DIS 37120 (2013). Sustainable development and resilience of communities — Indicators for city services and quality of life. ICS 13.020.20	

Green space	
Description incl. justification	The amount of green area, natural and semi-natural, parks and other open space is an indicator of how much green space a city has. Green areas perform important environmental functions in an urban setting (ISO/DIS 37120, 2013). They improve the urban climate, capture atmospheric pollutants and improve quality of life by providing recreation for urban inhabitants. Research has shown that green neighbourhoods improve the health of their inhabitants (Van den Berg & Van den Berg, 2015). Urban vegetation can also reduce heat in the built environment by providing shade and evaporative cooling (Steeneveld et al., 2011; Heusinkveld et al., 2014; Van Hove et al., 2015). In addition, green elements have a significant positive influence on the human perception of temperature (Klemm et al., 2013). This indicator reflects green area, publicly or privately owned, that is "publicly accessible" as opposed to whether or not the green area is protected. Note: Green area is broader than recreation space (clause 13 ISO/DIS 37120, 2013).
Definition	Green area (hectares) per 100 000 population
Calculation	Green space shall be calculated as the total area (in hectares) of green in the city (numerator) divided by one 100 000th of the city's total population (denominator). The result shall be expressed in hectares of green area per 100 000 population.

Strengths and weaknesses	Strengths: This is an absolute and objective indicator and comparable to other cities. Weaknesses: Definitions of green and recreational spaces might be interpreted differently.
Data requirements	
Expected data source	Information on green area should be obtained from municipal recreation and parks departments, planning departments, forestry departments and census. In addition, the Urban Audit database contains information on the indicator ' Green space to which the public has access'.
Expected availability	The information should be easily available with the above sources
Collection interval	Yearly
Expected reliability	High
Expected accessibility	Information on green space is specified in development plans which are publicly available.
References	

- Van den Berg, A. E., & van den Berg, M. M. H. E. (2015). Health benefits of plants and green space: establishing the evidence base. Acta Horticulturae 1093,19-30.
- ISO/TS 37151 (2014).Smart community infrastructures - Principles and requirements for performance metrics. ISO/TC 268/SC 1/WG 1-Infrastructure metrics.Steeneveld, G.J., Koopmans,S., Heusinkveld, B.G., van Hove, L.W.A., Holtslag, A.A.M. (2011). Quantifying urban heat island effects and human comfort for cities of variable size and urban morphology in the Netherlands. J. Geophys. Res.116, D20129, 14pp., doi: 10.1029/2011 JDO15988.
- Van Hove, L.W.A., Jacobs, C.M.J., Heusinkveld B.G., Elbers, J.A., van Driel, B.L., and Holtslag, A.A.M. (2015). Temporal and spatial variability of urban heat island and thermal comfort within the Rotterdam agglomeration. Building and Environment . DOI: 10.1016/j.buildenv.2014.08.029
- Heusinkveld, B. G., G. J. Steeneveld, et al. (2014). "Spatial variability of the Rotterdam urban heat island as influenced by urban land use." Journal of Geophysical Research: Atmospheres: 2012JD019399.
- Klemm, W., Lenzholzer, S., Heusinkveld, B., Hove, B. van (2013). Towards green design guidelines for thermally comfortable streets. In PLEA 2013.

Planet



Energy & mitigation

Annual final energy consumption	
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/DIS 37120, 2013) This indicator shall assess the final energy consumption of the city taking into account all forms of energy (e.g. electricity, gas, fuels) and for all functions (transport, buildings, 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
Calculation	Energy consumption shall be calculated per year as the total use of final energy (MWh) within a city (numerator) divided by the amount of residents in city (denominator). The result indicates the total energy consumption per year in megawatt hours per capita. 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, ICT, 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, m3), 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 city. Relevant unit conversions are 1 W = 1 kg m2 s–3; 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) Note: All calculations need to be thoroughly recorded for transparency.
Strengths and weaknesses	Strengths: - High relevance with regard to policy aims. Weaknesses: - Data is scattered and has to be translated into one value - The reliability of data for the different kinds of energy consumption varies. While in some cases the data is higly 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. Thus calculation after the first year of operation does not provide objective data.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). - For some uses (e.g. transport) there are only indirect ways to collect data for indicator calculation. Thus the data acquired and calculated are only estimations.
Data requirements	
Expected data source	Data has to be collected from many different sources: - Buildings (public, residential, commercial) - Transport (public, private)

	- Industry - ICT
Expected availability	Depending on the local situation and the type of energy consumed
Collection interval	Yearly
Expected reliability	The reliability varies depending on the kind of energy consumed.
Expected accessibility	Depends on the sources from which the information has to be gathered.
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)	

Renewable energy generated within the city	
Description incl. justification	The promotion of renewable energy sources is a high priority for sustainable development, for reasons such as the security and diversification of energy supply and for environmental protection (ISO/DIS 37120, 2013). This indicator is the percentage of total energy derived from the renewable systems installed in the city as a share of the city's total energy consumption (ISO/DIS 37120, 2013). Renewable energy shall include both combustible and non-combustible renewables (ISO/DIS 37120, 2013). Noncombustible renewables include geothermal, solar, wind, hydro, tide and wave energy. For geothermal energy, the energy quantity is the enthalpy of the geothermal heat entering the process. For solar, wind, hydro, tide and wave energy, the quantities entering electricity generation are equal to the electrical energy generated. The combustible renewables include biomass (fuelwood, vegetal waste, ethanol) and animal products (animal materials/waste and sulphite lyes). Municipal waste (waste produced by the residential, commercial and public service sectors that are collected by local authorities for disposal in a central location for the production of heat and/or power) and industrial waste are not considered a renewable source for energy production.
Definition	The percentage of total energy derived from renewable sources, as a share of the city's total energy consumption
Calculation	The share of renewable energy produced within the city is calculated as the total consumption of electricity generated from renewable sources (numerator) divided by total energy consumption (denominator). The result shall then be multiplied by 100 and

	expressed as a percentage. Consumption of renewable sources includes geothermal, solar, wind, hydro, tide and wave energy, and combustibles, such as biomass. (ISO/DIS 37120, 2013).
Strengths and weaknesses	Strengths: This indicator is very relevant for assessing the realization of city's renewable energy targets. Weaknesses: The real share of renewables consumed can be higher than indicated by this indicator when energy is imported..
Data requirements	
Expected data source	Data available from local utility provider, city energy or environment office, and from various international sources, such as the International Energy Agency (IEA), and the World Bank. (ISO/DIS 37120, 2013)
Expected availability	Energy generation by private households might be more difficult to measure.
Collection interval	Annual
Expected reliability	The data reliability depends on the source of the data.
Expected accessibility	There should be no major issues with accesibility, in case high quality data is not available, other sources could be used instead.
References	
• ISO/DIS 37120 (2013). Sustainable development and resilience of communities — Indicators for city services and quality of life. ICS 13.020.20	

CO_2 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 (CO2), methane (CH4), nitrous oxide (N2O), 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 Green House Gas emissions in urban areas. The main sources for CO2 emissions are combustion processes related to energy generation and transport. Tons of CO2 emissions per capita can therefore considered a useful indicator to assess the contribution of urban development on climate change.
Definition	CO2 emissions in tonnes per capita per year
Calculation	The CO_2 emissions measured in tonnes per capita shall be measured as the total amount of direct CO_2 emisissions in tonnes (equivalent carbon dioxide units) generated over a calendar year by all activities within the city, including indirect emissions outside city boundaries (numerator) divided by the current city population (denominator). The result shall be expressed as the total direct CO2 emissions per capita in tonnes.The Global Protocol for Community-Scale GHG Emissions (GPC), (2012 Accounting and Reporting Standard) refers to a multi-stakeholder consensus-based protocol for developing international

	recognized and accepted community-scale greenhouse gas accounting and reporting. This protocol defines the basic emissions sources and categories within sectors for a community-scale GHG inventory, in order to standardize GHG inventories between communities and within a community over time. The protocol provides accounting methodologies and step-by-step guidance on data collection, quantification, and reporting recommendations for each source of emissions. Both emissions sources and sector categorizations reflect the unique nature of cities and their primary emissions sources. These include emissions from: 1) Stationary Units, 2) Mobile Units, 3) Waste, and 4) Industrial Process and Product Use sectors. For further specifications, refer to the full GPC methodology. Local governments shall be expected to provide information (i.e., quantified emissions) for each of these emission sources. In order to address the issue of inter-city sources of emissions that transcend more than one jurisdictional body, the GPC integrates the GHG Protocol Scope definitions, as follows: 1. Scope 1 emissions: All direct emission sources from activities taking place within the community's geopolitical boundary. 2. Scope 2 emissions: Energy-related indirect emissions that result as a consequence of consumption of grid-supplied electricity, heating and/or cooling, within the community's geopolitical boundary. 3. Scope 3 emissions: All other indirect emissions that occur as a result of activities within the community's geopolitical boundary. For step-by-step guidance on data and accounting collection, see Section 3 of the GPC. http://www.ghgprotocol.org/files/ghgp/GPC%20v9%2020120320.pdf
Strengths and weaknesses	Strengths: This indicator summarizes the adverse contribution the city is making to climate change. (ISO/DIS 37120, 2013) Weaknesses: Other sources of GHG emissions are not taken into account
Data requirements	
Expected data source	The CO2-emissions can be calculated from the energy consumption figures of indicator 'annual final energy consumption', using conversion factors for various forms of energy. Other sources for information on CO2 emissions can be Sustainable Energy Action Plans (SEAPs), Local Greenhouse Gast Inventories, The municipal statistical department
Expected availability	The availability is expected to be sufficient depending on the quality of the data source.
Collection interval	Annual
Expected reliability	Depends on the quality of input data

Expected accessibility	Good
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 Mayors 2010: How to develop a Sustainable Energy Action Plan (SEAP) – Guide Book. Brusses: Covenant of Mayors	

Local freight transport fuel mix	
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 vehicle types, however this can be supporting information.
Definition	The ratio of renewable fuels in the local freight transport fuel mix.
Calculation	(ton kilometres transported by renewable fuel in the city/total ton kilometers in the city)*100% Please indicate which fuels/energy carriers have been considered. Renewable fuels include: bio-fuels, hydrogen and electricity. Other fuels include: petrol, diesel, liquefied petroleum gas, compressed natural gas, alcohol mixtures.
Strengths and weaknesses	Strengths: The indicator can easily be compared between neighbourhoods, cities and countries. Weaknesses: This indicator requires detailed calculation. It might be difficult to collect the necessary data.
Data requirements	
Expected	Fuel consumption by each type of vehicle and the corresponding vehicle-km

data source	can be collected from service operators, by recording fuel used and vehicle-km completed during the given periods, complemented by city transport statistics.
Expected availability	Might be difficult to gather data. If the city has paid attention to this, some figures will be available with the above sources.
Collection interval	Annually
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	

Materials, water and land

Domestic material consumption	
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: reduce materials consumption, use recycled materials (and make sure the materials used are recyclable again) and use renewable materials. This indicator targets the first step in this logic. The indicator 'domestic material consumption' (DMC) considers the domestic material extraction (i.e. the amount of raw material extracted from the natural environment, except for water and air), including both imports (added) and exports (deducted) through their simple product weight when crossing the city limits. This makes cross-city comparisons 'asymmetric'. A city with almost no domestic extraction and importing all necessary resources indirectly in the form of mainly finished products will have a much lower DMC compared to a resource rich city (Eurostat 2013, modified).
Definition	The total amount of material directly used in the city per capita (t/cap/year)
Calculation	Domestic Material Consumption (DMC) equals Direct Material Input (DMI) minus exports. DMI measures the direct input of materials for the use in the economy. DMI equals Domestic Extraction (DE) plus imports
Strengths and weaknesses	Strengths: Improvement in resource consumption has also indirect effect by

	saving environmental and economic impacts. Saving the amount of natural raw-materials needed for the project implementations, saves also consequent material manufacturing processes with used energy resources and consequent emissions. Weaknesses: The meaning of the weight of materials, however, can be debated, since it doesn't say anything about the required quality for the function. Materials for different functions require different characteristics (density, elasticity, etc.). Also, renewable materials are, in general, lighter than non-renewable materials. However, efforts to decrease the use of materials are beneficial from all perspectives. Data availability (see below)
Data requirements	
Expected data source	This indicator requires a detailed material flow analysis on the city level, as the required data is usually not immediately available on the city level.
Expected availability	Very low
Collection interval	Ad hoc
Expected reliability	Depends
Expected accessibility	Depends
References	
•	

Water consumption	
Description incl. justification	Water consumption must be in harmony with water resources to be sustainable (ISO/DIS 37120, 2013). This harmony may be achieved through improvements in water supply systems and changes in water consumption patterns. The main driver for water consumption indicator is the increased concern of water scarcity and decreased water quality. Water management and supply of safe drinking water have become a global issue. Due to changes in the climate, there has been an increase of either extreme dry and warm seasons in some countries or rainy seasons connected with floods in other areas. Water scarcity varies greatly between countries, even between regions inside the country. This indicator will need to be measured in terms of changes from year to year within a city within a range of rates due to the variability among cities.
Definition	Total water consumption per capita per day

Calculation	The indicator shall be calculated as the total amount of the city's water consumption in litres per day (numerator) divided by the total city population (denominator). The result shall be expressed as the total water consumption per capita in litres/days.
Strengths and weaknesses	Strengths: Good availability of information and accuracy of information. Indicates the progress in the increased use of water saving equipment and changes in user behavior. Weaknesses: The difference between the total use of surface and groundwater in the municipality and the volume of water released into the distribution network is caused by use of water by households and other actors not linked to the municipal water supply system.
Data requirements	
Expected data source	This information should be obtained from the main water supply companies, which maintain record on water supplied, delivered, consumed and ultimately paid by the end-users. The urban audit database also contains information on the 'Total use of water'.
Expected availability	Good
Reporting interval	Yearly
Expected reliability	High
Expected accessibility	Dependent on local supply companies
References	
• ISO/DIS 37120 (2013). Sustainable development and resilience of communities — Indicators for city services and quality of life. ICS 13.020.20 • European Commission 2012: Methodological Manual on City Statistics. Retrieved at http://ec.europa.eu/eurostat/cache/metadata/en/urb_esms.htm • http://ec.europa.eu/eurostat/web/cities/data/database	

Grey and rain water use	
Description incl. justification	Water consumption must be in harmony with water resources to be sustainable (ISO/DIS 37120, 2013). Re-using grey water and rain water lowers the demand for tap water and improves the balance of the water system. Greywater is wastewater generated in households or office buildings from sources such as water basins, showers, baths, clothes washing machines or dish washers (streams except for the wastewater from toilets). Grey water and rain water use may be an important aid to significantly decrease the domestic water consumption. The published literatures indicate that the typical volume of grey water varies from 90 to 120 l/p/d depending on lifestyles, living standards and other issues.

Definition	Percentage of houses equipped to reuse grey and rain water
Calculation	
Strengths and weaknesses	Strengths: Weaknesses: Limited availability of information. The indicator is overlapping with domestic water consumption indicator. While grey water from baths, showers and basins is usually clean enough for flushing toilets, there are concerns about the increase of bacteria levels when nutrient rich waste water is left untreated for a period of time.
Data requirements	
Expected data source	Records of building permission authorities or surveys among households
Expected availability	Limited. Collection of information may be time consuming
Collection interval	Annual
Expected reliability	The coverage of information may be limited if greywater systems are installed also without building permission.
Expected accessibility	No sensitivities expected
References	
• National water footprint accounts: The green, blue and grey water footprint of production and consumption. Vol. 1 Main report. Authors Mekonnen, N.M. and Hoekstra A.Y. Value of water research report series No 50. 2011. Published by UNESCO-IHE. http://doc.utwente.nl/76913/1/Report50-NationalWaterFootprints-Vol1.pdf • EPA Water recycling and reuse http://www3.epa.gov/region9/water/recycling/ • Review of the technological approaches for grey water treatment and reuses. Authors Fangyue Li, Knut Wichmann, Ralf Otterpohl. Science of the Total Environment 407 (2009) 3439–3449	

Water exploitation index	
Description incl. justification	Water consumption must be in harmony with water resources to be sustainable (ISO/DIS 37120, 2013). The earth's freshwater resources are subject to increasing pressure in the form of consumptive water use and pollution. The Water Exploitation Index (WEI) compares the volumes of water consumption to available resources.
Definition	Annual total water abstraction as a percentage of available long-term freshwater resources in the geographically relevant area (basin) from which the city gets its water.

Calculation	(volume of water abstraction in the geographically relevant area/volume of long term freshwater resources in the geographically relevant area)*100% (EEA)
Strengths and weaknesses	Strengths: The indicator takes into account the sustainability aspect by considering not only the consumption but also the water resources. Weaknesses: Of limited relevance for cities, as the indicator considers a wider geographical area. Although local focus is important, it also limits the understanding about the comprehensive impact on water footprint. The 'geographically relevant area' is a vague concept and can be applied differently.
Data requirements	
Expected data source	Water abstraction: Records of water supply companies on water abstraction (groundwater, surface water) and city documents on water abstraction permits, Water resources: Local water boards and the municipal environment department.
Expected availability	Probably good, but dependent on local situation
Collection interval	Yearly
Expected reliability	High
Expected accessibility	The city or region probably has to grant permission to abstract water, making abstraction volumes known and accessible.
References	
• EEA. Indicator Fact Sheet - (WQ01c) Water exploitation index. Version 01.10.03 • ISO/DIS 37120 (2013). Sustainable development and resilience of communities — Indicators for city services and quality of life. ICS 13.020.20	

Water loss	
Description incl. justification	Water consumption must be in harmony with water resources to be sustainable. Before reaching the users, a part of the water supplied might be lost through leakage or illegal tapping (ISO/DIS 37120, 2013). In cities with old and deteriorating water reticulation systems, a substantial proportion of piped water may be lost through cracks and flaws in pipes – for example up to 30 per cent of water is lost in this way in some countries in Eastern Europe. The percentage of water loss (unaccounted for water) represents the percentage of water that is lost from treated water entering distribution system and that is accounted for and billed by the water provider. This includes actual water losses, e.g. leaking pipes, and

	billing losses, e.g. delivered through informal or illegal connection.
Definition	Percentage of water loss of the total water consumption
Calculation	This indicator shall be calculated as the volume of water supplied minus the volume of customer billed water (numerator) divided by the total volume of water supplied (denominator). The result shall then be multiplied by 100 and expressed as a percentage.
Strengths and weaknesses	Strengths: High relevance with regards to policy aims Weaknesses: There are different kinds of losses. Apparent losses are produced by metering, human and management errors, and lead to consumption of water without charging. On the other hand, real losses include wasted water and can be categorized to pipe system leakage (reported and unreported bursts, and background.
Data requirements	
Expected data source	Data should be obtained from water utilities servicing the city.
Expected availability	Good
Collection interval	Yearly
Expected reliability	
Expected accessibility	Good, no sensitivities expected
References	
• ISO/DIS 37120 (2013). Sustainable development and resilience of communities — Indicators for city services and quality of life. ICS 13.020.20	

Population density	
Description incl. justification	Population density is an indicator usually associated with several aspects of sustainable urban development, such as the efficient operation of urban infrastructures, the share of green transport modes, street life, and soil sealing: • Efficient urban infrastructures: The higher the population density is, the easier it is to operate the public transport, but also water, communication and energy infrastructures at low cost. • There is strong statistical evidence for a positive correlation between population density and the share of green transport modes public transport, walking and biking (Newman & Kenworthy 1999, 2006) • Also, a higher urban population is sometimes associated with lively urban streets. • Also, a high population density reduces the footprint of urban development and prevents the development of farm

	land and natural areas
Definition	Number of people per km2
Calculation	Population density is calculated as the ratio of number of inhabitants (numerator) divided by the overall area of the city (km²) (denominator).
Strengths and weaknesses	Strengths: Absolute and objective indicator. Easy to calculate Weaknesses: Limited comparability among European cities due to different traditions for metropolitan governance. No direct link with smartness or sustainability
Data requirements	
Expected data source	City statistics
Expected availability	Good
Collection interval	Every year (city records)
Expected reliability	High
Expected accessibility	Good
References:	
- http://ec.europa.eu/eurostat/statistics-explained/index.php/European_cities_%E2%80%93_the_EU-OECD_functional_urban_area_definition#Main_tables - http://ec.europa.eu/eurostat/web/cities/data/database - Newman, P. & Kenworthy, J. (1999) Sustainability in Cities. Overcoming the automobile dependence. Washington D.C: Island Press - Newman, P. & Kenworthy, J. (2006) Urban Design to Reduce Automobile Dependence. In: Opolis Vol. 2, No. 1, 2006. pp. 35-5. Retried at http://www.naturaledgeproject.net/documents/newmankenworthyurbandesign.pdf - European Commission 2012: Methodological Manual on City Statistics. Retrieved at http://ec.europa.eu/eurostat/cache/metadata/en/urb_esms.htm - http://ec.europa.eu/eurostat/web/cities/data/database	

Local food production	
Description incl. justification	Local food production increases self-reliant and resilient food networks, enhances local economies by connecting food producers and food consumers in the same geographic region. It can reduce the carbon footprint of the urban areas by reducing energy demand of transport, stimualte the local economy, and improve citizen participation and social cohesion in the city, and stimulate the local economy

Definition	Share of food consumption produced within a radius of 100 km.
Calculation	(Food produced in 100 km radius (tons) / Total food demand within city (tons)) * 100
Strengths and weaknesses	Strenghts: Indicator is a good measure for density/quantity of local producing entities and gives therefore a good overview about regions with possible self-sufficiency options. Weaknesses: Comparable data on the agricultural yield is only available at the NUTS2 level. The indicator teherefore requires significant disaggregation of data.
Data requirements	
Expected data source	Food consumption: The yearly intake in Europe was 770 kg per person in 2000 (EEA, 2005). The food demand can then be calculated by multiplying the number of citizens with 770 kg. Food production: Crop statistics and animal populations at NUTS2 level (Eurostat, 2015)
Expected availability	Comparable data on the agricultural yield is only available at the NUTS2 – level.
Collection interval	Yearly
Expected reliability	Low, as NUTS2 data has to be disaggregated
Expected accessibility	Good
References:	
	• EEA (2005). Household consumption and the environment. EEA Report No 11/2005. • EUROSTAT (2015) Crop statistics by NUTS 2 regions (from 2000 onwards). Retrieved at http://ec.europa.eu/eurostat/web/agriculture/data/database • EUROSTAT (2015) Animal populations (December) by NUTS 2 regions (from 2000 onwards). Retrieved at http://ec.europa.eu/eurostat/web/agriculture/data/database • Morrison KT et al. (2011) Methods for mapping local food production capacity from agricultural statistics. In: Agricultural Systems 104 (2011), 491–499 • Smith, A & MacKinnon, JB (2007) The 100-mile diet. A year of local eating. New Yort City: Random House. ISBN 0-679-31482-2

Brownfield redevelopment	
Description incl. justification	Brownfield is a term used in urban planning to describe “land which is or was occupied by a permanent structure, including the curtilage of the developed land and any associated fixed surface infrastructure.” (Department for Communities and Local Government 2012). Many brownfields are contaminated as a result of previous industrial or commercial uses. The European Environment Agency (EEA) has estimated that there are as many as three million brownfield sites across Europe, often located and well connected within urban boundaries and as such offering a competitive alternative to greenfield investments. Brownfield remediation and regeneration represents a valuable opportunity, not only to prevent the loss of pristine countryside and reduce ground sealing, but also to enhance urban spaces and remediate the sometimes contaminated soils (DG Environment 2013).
Definition	Share of brownfield area that has been redeveloped in the past period as percentage of total brownfield area
Calculation	The indicator “brownfield redevelopment” is calculated as the brownfield area redeveloped in the last year [km²] (numerator] divided by the total brownfield area in the city [km²] (denominator). The result shall then be multiplied by 100 and expressed as a percentage. Nb. Database entries, SHP files can be used
Strengths and weaknesses	Strenghts: High relevance with regard to policy aims. Easy to calculate Weaknesses: Limited comparability of data across European cities, as the understanding of the term “brownfield” may differ. Not all cities might have brownfield space to redevelop.
Data requirements	
Expected data source	City statistics
Expected availability	Highly different: Not all cities collect this data in a systematic way.
Collection interval	Highly different: Not all cities collect this data in a systematic way.
Expected reliability	Depending on the quality of the collected data
Expected accessibility	Access is very often restricted to employees of the city administration / urban planning department
References	
	• Department for Communities and Local Government (2012): National Planning Policy Framework. London: Department for Communities and Local Government

• DG Environment (2013) Brownfield Regeneration. Science for Envrionment Policy, 39

Climate resilience

Climate resilience strategy	
Description incl. justification	Urban areas in Europe and worldwide are increasingly experiencing the pressures arising from climate change and are projected to face aggravated climate-related impacts in the future. Cities and towns play a significant role in the adaptation to climate change in the EU, which has been recognised by the EU Strategy on adaptation to climate change. Several cities and towns across Europe are already pioneering adaptation action and many others are taking first steps to ensure that European cities remain safe, liveable and attractive centres for innovation, economic activities, culture and social life (climate-adapt.org). This indicator assesses to what extent the city has a resilience strategy and action plan.
Definition	The extent to which the city has developed and implemented a climate resilience strategy.
Calculation	The indicator provides a qualitative measure and is rated on a seven -point Likert scale. This Likert scale is based on the steps suggested by the “Mayors adapt” initiative for climate change adaptation in urban areas (Mayors Adapt 2015a,b) No action taken – 1 — 2 — 3 — 4 — 5 — 6 – 7 – implementation, monitoring and evaluation on the way 1. No action has been taken yet 2. The ground for adaptation has been prepared (the basis for a successful adaptation process) 3. Risks and vulnerabilities have been assessed 4. Adaptation options have been identified 5. Adaptation options have been selected 6. Adaptation options are being implemented 7. Monitoring and evaluation is being carried out.
Strengths and weaknesses	Strengths: Weaknesses: The number of cities involved in the Mayors Adapt Initiative is rather limited. Therefore, the steps described in the documents of the initiative may not be familiar for many city stakeholders.
Data requirements	
Expected data source	Environmental/sustainability/climate department/service.
Expected availability	Good

Collection interval	Yearly
Expected reliability	Moderate, as the rating will be subjetctive
Expected accessibility	Good

References:

- Mayors adapt 2015a: About the Urban Adaptation Support Tool. Powerpoint presentation Retrieved at http://mayors-adapt.eu/wp-content/uploads/2015/04/UrbanAST_forWEB.pdf
- Mayors Adapt 2015b: Urban Adaptation Support Tool. Retrieved at http://climate-adapt.eea.europa.eu/tools/urban-ast/step-1-0
- http://climate-adapt.eea.europa.eu/

Urban heat island	
Description incl. justification	Urban areas in Europe and worldwide are increasingly experiencing the pressures arising from climate change and are projected to face aggravated climate-related impacts in the future. Cities and towns play a significant role in the adaptation to climate change in the EU, which has been recognised by the EU Strategy on adaptation to climate change. This indicator focuses on the urban heat island (UHI) effect, the difference in air temperature between the city and its surroundings. The UHI effect is caused by the absorption of sunlight by (stony) materials, the lack of evaporation and the emission of heat caused by human activities. The effect is at its highest point after sunset and can reach up to 9 ˚C in e.g. Rotterdam (Van Hove et al., 2014). Due to the UHI effect, urban areas experience more heat stress than the countryside.
Definition	Maximum difference in air temperature within the city compared to the countryside during the summer months
Calculation	Whether there is one or several measurement stations in the built environment, compare the air temperature measurements of these stations with a station outside the city which functions as a reference station, and look for the largest temperature difference (hourly average) during the summer months.
Strengths and weaknesses	Strengths: This indicator provides an absolute measure of the problem a city has with regards to heat stress. Weaknesses: Data/measurements may not be available
Data requirements	
Expected data source	Operators of weather stations within the city and outside (e.g meteorological institute, research organisations, weather amateurs)
Expected availability	Dependent on situation, not all cities will have air temperature

	measurements.
Collection interval	Yearly
Expected reliability	If measurement stations are available the information will be highly reliable (little less with regards to weather amateurs).
Expected accessibility	No sensitivities expected
References:	
- Van Hove, L.W.A., Jacobs, C.M.J., Heusinkveld B.G., Elbers, J.A., van Driel, B.L., and Holtslag, A.A.M. (2014). Temporal and spatial variability of urban heat island and thermal comfort within the Rotterdam agglomeration. Building and Environment.	

Pollution and waste

Nitrogen oxide emissions (NO_x)	
Description incl. justification	Improving the air quality in urban areas has been identified by the European Innovation Partnership on Smart Cities anc Communities (EIP SCC) as one of the main challenges in the vertical priority area of Sustainable Urban Mobility (EIP SCC 2013, 8) Nitrogen oxides (NO and NO_2) are major air pollutants, which can have significant impacts on human health and the environment (ISO/DIS 37120, 2013). NO contributes to ozone layer depletion and, when exposed to oxygen, can transform into NO_2. NO_2 contributes to the formation of photochemical smog and at raised levels can increase the likelihood of respiratory problems. Nitrogen dioxide inflames the lining of the lungs, and it can reduce immunity to lung infections. This can cause problems such as wheezing, coughing, colds, flu and bronchitis. Increased levels of nitrogen dioxide can have significant impacts on people with asthma because it can cause more frequent and more intense attacks. NO_2 chemically transforms into nitric acid and contributes to acid rain. Nitric acid can corrode metals, fade fabrics, and degrade rubber. When deposited, it can also contribute to lake acidification and can damage trees and crops, resulting in substantial losses. Nitrogen dioxide is part of the exhaust gases of motor vehicles, but also emanates from other combustion processes, related e.g to domestic heating and industrial processes.
Definition	Annual nitrogen oxide emissions (NO and NO_2) per capita
Calculation	$$\left(\frac{\textbf{NOx emissions (g)}}{\textbf{population}}\right) = \frac{\textbf{g}}{\textbf{cap}} \boldsymbol{of\ NOx}$$
Strengths and weaknesses	Strengths: Important indicator related to transport. Weaknesses: NO_x emissions are directly related to energy use,

	especially in the transport sector. Double counting with the energy indicators occurs.
Data requirements	
Expected data source	Environmental department/service; City emission registration. Hourly average concentrations are measured by monitoring equipment and reported to Air Quality monitoring authority (i.e., City Environment Office, National Environment Office, etc.). NO_x emissions can be derived from energy use if not directly available. The level of NO_x emissions are varying depending mainly on the energy generation technology and type of fuel. The urban audit database also contains information on the 'number of hours nitrogen dioxide NO2 concentrations exceed 200 µg/m3' and the 'annual average concentration of NO2 (µg/m3)'.
Expected availability	Good. Many cities maintain an emission register; however the information might require further processing of data or database.
Collection interval	Annually
Expected reliability	Emission factors may change from country to country. If results can be based on actual energy/NOx performance and not ex-ante estimations of how the energy balance is expected change, then the results are very reliable. If based on expectations, the results are somewhat reliable.
Expected accessibility	No sensitivities expected
References • ISO/DIS 37120 (2013). Sustainable development and resilience of communities — Indicators for city services and quality of life. ICS 13.020.20 • European Innovation Partnership on Smart Cities and Communities (EIP SCC) 2013: Strategic Implementation Plan. Brussels: EIP SCC	

Fine particulate matter emissions (PM 2,5)	
Description incl. justification	Improving the air quality in urban areas has been identified by the European Innovation Partnership on Smart Cities and Communities (EIP SCC) as one of the main challenges in the vertical priority area of Sustainable Urban Mobility (EIP SCC 2013, 8). Fine particulate matter can cause major health problems in cities. According to the WHO, any concentration of particulate matter (PM) is harmful to human health. PM is carcinogenic and harms the circulatory system as well as the respiratory system. As with many other air pollutants, there is a connection with questions of environmental justice, since often underprivileged citizens may suffer from stronger exposure. The evidence on PM and its public health impact is consistent in showing adverse health effects at

	exposures that are currently experienced by urban populations in both developed and developing countries. The range of health effects is broad, but are predominantly to the respiratory and cardiovascular systems (ISO/DIS 37120, 2013).
Definition	Annual particulate matter emissions (PM 2,5) per capita
Calculation	The unit for this indicator should for the city level be grams per capita: $\left(\frac{\mathbf{PM2.5\ emissions\ (g)}}{\mathbf{population}}\right) = \frac{\mathbf{g}}{\mathbf{cap}} \boldsymbol{of\ PM2.5}$
Strengths and weaknesses	Strengths: Weaknesses:
Data requirements	
Expected data source	Concentrations are measured by monitoring equipment and reported to Air Quality monitoring authority (i.e., City Environment Office, National Environment Office, etc.). The urban audit database contains information on the'number of days particulate matter PM10 and PM2,5 concentrations exceed 50 µg/m3' and the 'annual average concentration of PM10 (µg/m3)'.
Expected availability	Since a standard is to be met amongst there is most likely data from either measurements or modelling calculations. Many cities maintain an emission register; however the information might require further processing of data or database.
Collection interval	Annually
Expected reliability	Emission factors may change from country to country. If results can be based on actual performance and not ex-ante estimations of how the energy balance is expected change, then the results are very reliable. If based on expectations, the results are somewhat reliable.
Expected accessibility	No sensitivities expected
References • European Innovation Partnership on Smart Cities and Communities (EIP SCC) 2013: Strategic Implementation Plan. Brussels: EIP SCC • ISO/DIS 37120 (2013). Sustainable development and resilience of communities — Indicators for city services and quality of life. ICS 13.020.20	

Air quality index	
Description incl. justification	Improving the air quality in urban areas has been identified by the European Innovation Partnership on Smart Cities and Communities (EIP SCC) as one of the main challenges in the vertical priority area of

<table>
<tr><td></td><td>
<p>Sustainable Urban Mobility (EIP SCC 2013, 8).</p>
<p>Air quality is expressed in the concentration of major air pollutants. At this moment from a human health perspective most important are particulates (PM10, PM2,5), NO2 (as indicator of traffic related air pollution) and ozone (important for summersmog). The concentration levels of these pollutants together define the air quality.</p>
<p>For the EU, the CiteAir project has defined hourly, daily and yearly indices to express in one figure air quality. (http://www.airqualitynow.eu/index.php)</p>
<p>For this indicator we use the year average air quality index. It is a distance to target indicator that provides a relative measure of the annual average air quality in relation to the European limit values (annual air quality standards and objectives from EU directives). If the index is higher than 1: for one or more pollutants the limit values are not met. If the index is below 1: on average the limit values are met.</p>
</td></tr>
<tr><td>Definition</td><td>Annual concentration of relevant air pollutants</td></tr>
<tr><td>Calculation</td><td>
<p>For each pollutant a subindex is calculated according to the scheme below:</p>
<table>
<tr><th>Pollutant</th><th>Target value / limit value</th><th>Subindex calculation</th></tr>
<tr><td>NO_2</td><td>Year average is 40 µg/m3</td><td>Year average / 40</td></tr>
<tr><td>PM10</td><td>Year average is 40 µg/m3</td><td>Year average / 40</td></tr>
<tr><td>PM10daily</td><td>Max. number of daily averages above 50 µg/m3 is 35 days</td><td>Log(number of days+1) / Log(36)</td></tr>
<tr><td>Ozone</td><td>25 days with an 8-hour average value >= 120 µg/m3</td><td># days with 8-hour average >=120 / 25</td></tr>
<tr><td>SO2</td><td>Year average is 20 µg/m3</td><td>Year average / 20</td></tr>
<tr><td>Benzene</td><td>Year average is 5 µg/m3</td><td>Year average / 5</td></tr>
</table>
<p>Note: CO is not calculated</p>
<p>The overall city index is the average of the sub-indices for NO2, PM10 (both year average and the number of days >=50 µg/m3 sub-index) and ozone for the city background index. For the traffic year average index the averages of the sub-indices for NO2 and PM10 (both) are being used. The other pollutants (including PM2.5) are used in the presentation of the city index if data are available, but do not enter the calculation of the city average index. They are treated as additional pollutants like in the hourly and daily indices. The main reason is that not every city is monitoring this full range of pollutants.</p>
<p>NOTE: Potential users of the CAQI must notify the CITEAIR partners (at caqi@airqualitynow.eu) and establish a user agreement (www.airqualitynow.eu/about_copyright.php#legal_agreement). This way, users can be kept informed in case of further developments concerning the index. The use of the CAQI is free of charge for non-commercial purposes.</p>
<p>Note: data models are described in Van den Elshout et al, 2012.</p>
</td></tr>
</table>

Strengths and weaknesses	Strengths: See for an extensive discussion Van den Elshout et al, 2012. Dusseldorp et al. 2014. Weaknesses: -
Data requirements	
Expected data source	Concentrations are measured by monitoring equipment and reported to Air Quality monitoring authority (i.e., City Environment Office, National Environment Office, etc.). Many cities use a local or national variant of an air quality index, which can replace this indicator (but loosing EU comparability).
Expected availability	Good. Most pollutants are measured continuously in EU member states. See http://www.airqualitynow.eu/comparing_home.php
Collection interval	Annually
Expected reliability	If the data is based on measurements the results are very reliable.
Expected accessibility	Access may be restricted to employees of the city administration
References	
	• Van den Elshout, Stef; Hans Bartelds, Hermann Heich, Karine Léger (2012). Comparing Urban Air Quality across Borders. Citeair II. http://www.airqualitynow.eu/download/CITEAIR-Comparing_Urban_Air_Quality_across_Borders.pdf • Dusseldorp, A., P.H. Fischer, M.B.A. Dijkema, M.M. Strak (2014). Luchtkwaliteitsindex. Aanbevelingen voor de samenstelling en duiding. RIVM rapport 2014-0050. Bilthoven. [includes an overview of national and european indices]. http://www.rivm.nl/Documenten_en_publicaties/Wetenschappelijk/Rapporten/2015/mei/Luchtkwaliteitsindex_Aanbevelingen_voor_de_samenstelling_en_duiding • European Innovation Partnership on Smart Cities and Communities (EIP SCC) 2013: Strategic Implementation Plan. Brussels: EIP SCC • European Environment Agency: http://www.eea.europa.eu/themes/air

Noise pollution	
Description incl. justification	Prolonged exposure to noise can lead to significant health effects, both physical and mental (ISO/DIS 37120, 2013). This indicator assesses the number of inhabitants exposed to noise >55 dB(A) at night time.
Definition	Share of the population affected by noise >55 dB(a) at night time
Calculation	$\left(\frac{\#\ \textbf{inhabitants exposed to noise} > \textbf{55 dB(A)}}{\textbf{total number of inhabitants}} \times \textbf{100}\%\right) = \textbf{share of population affetcted by noise}\ [\%]$

	Noise pollution shall be calculated by mapping the noise level at night (Ln) likely to cause annoyance as given in ISO 1996-2:1987, identifying the areas of the city where Ln is greater than 55 dB(A) and estimating the population of those areas as a percentage of the total city population. The result shall be expressed as the percentage of the population affected by noise pollution. (ISO/DIS 37120, 2013)
Strengths and weaknesses	Strengths: Weaknesses: Difficult to represent spatial variation in one indicator

Data requirements	
Expected data source	Member countries of the European Union are committed to the reduction of noise pollution to those levels recommended by the WHO by the year of 2020. Member countries might therefore have measurements of noise pollution for at least official areas. Average concentrations are measured by monitoring equipment and reported to Air Quality monitoring authority (i.e., City Environment Office, National Environment Office, etc.)The urban audit database contains information on the 'number of inhabitants exposed to road/rail/air traffic noise >65 dB(A) at day time/>55 dB(A) at night time'.
Expected availability	Good
Collection interval	Yearly
Expected reliability	If the data is based on measurements the results are very reliable. If based on expectations/calculations, the results are somewhat reliable.
Expected accessibility	Data about noise pollution are to be public amongst member states.

References

- European directive 2002/49/EC article 10.1
- ISO/DIS 37120 (2013). Sustainable development and resilience of communities — Indicators for city services and quality of life. ICS 13.020.20

Municipal solid waste	
Description incl. justification	The proper discharge, transportation and treatment of solid waste is one of the most important components of life in a city and one of the first areas in which governments and institutions should focus. Solid waste systems contribute in many ways to public health, the local economy, the environment, and the social understanding and education about the latter. A proper solid waste system can foster recycling practices that maximize the life cycle of landfills and create recycling micro-economies; and it provides alternative sources of

	energy that help reduce the consumption of electricity and/or petroleum based fuels. This indicator provides a measure of how much waste a city is producing and the level of service a city is providing for its collection (ISO/DIS 37120, 2013). Municipal waste shall refer to waste collected by or on behalf of municipalities.The data shall only refer to the waste flows managed under the responsibility of the local administration including waste collected on behalf of the local authority by private companies or regional associations founded for that purpose. Municipal waste should include waste originating from: — households; — commerce and trade, small businesses, office buildings and institutions (e.g. schools, hospitals, government buildings). The definition should also include: — bulky waste (e.g. white goods, old furniture, mattresses); — garden waste, leaves, grass clippings, street sweepings, the content of litter containers, and market cleansing waste, if managed as waste; — waste from selected municipal services, i.e. waste from park and garden maintenance, waste from street cleaning services (e.g. street sweepings, the content of litter containers, market cleansing waste), if managed as waste. The definition shall exclude: — waste from municipal sewage network and treatment; — municipal construction and demolition waste.
Definition	The amount of municipal solid waste generated per capita annually
Calculation	$\left(\frac{\mathbf{Annual\ amount\ of\ generated\ municipal\ solid\ waste\ (t/yr)}}{\mathbf{capita}}\right) = \frac{\frac{\mathbf{t}}{\mathbf{cap}}}{\mathbf{yr}}\ \boldsymbol{of\ generated\ municipal\ solid\ waste}$ The total collected municipal solid waste per capita shall be expressed as the total municipal solid waste produced in the municipality per person. This indicator shall be calculated as the total amount of solid waste (household and commercial) generated in tonnes (numerator) divided by the total city population (denominator). The result shall be expressed as total municipal solid waste collected per capita in tonnes (ISO/DIS 37120, 2013).
Strengths and weaknesses	Strengths: Clear unit that is easily understandable and measurable Weaknesses: -
Data requirements	

Expected data source	EU member countries are estimating their recycling rates and levels of municipal solid waste through measuring and model calculation methods. Environmental department, department resonsoble for waste collection. The urban audit database contains information on 'municipal waste generated (domestic and commercial)'.
Expected availability	Good
Collection interval	Annually
Expected reliability	The data might range from highly reliable to somewhat reliable.
Expected accessibility	Good

References

- ISO/DIS 37120 (2013). Sustainable development and resilience of communities — Indicators for city services and quality of life. ICS 13.020.20
- http://www.eea.europa.eu/publications/managing-municipal-solid-wast

Recycling rate	
Description incl. justification	Many cities generate more solid waste than they can dispose of (ISO/DIS 37120, 2013). Even when municipal budgets are adequate for collection, the safe disposal of collected waste often remains a problem. Diverting recyclable materials from the waste stream is one strategy for addressing this municipal issue. Higher levels of municipal waste contribute to greater environmental problems and therefore levels of collection, and also methods of disposal, of municipal solid waste are an important component of municipal environmental management. Solid waste systems contribute in many ways to public health, the local economy, the environment, and the social understanding and education about the latter. A proper solid waste system can foster recycling practices that maximize the life cycle of landfills and create recycling micro-economies; and it provides alternative sources of energy that help reduce the consumption of electricity and/or petroleum based fuels.
Definition	Percentage of city's solid waste that is recycled
Calculation	The percentage of city's solid waste that is recycled shall be calculated as the total amount of the city's solid waste that is recycled in tonnes (numerator) divided by the total amount of solid waste produced in the city in tonnes (denominator). The result shall then be multiplied by 100 and expressed as a percentage (ISO/DIS 37120, 2013). Recycled materials shall denote those materials diverted from the waste stream, recovered, and processed into new products following local government permits and regulations (International Solid Waste Association, ISWA).

	Hazardous waste that is produced in the city and is recycled shall be reported separately.
Strengths and weaknesses	Strengths: Clear unit that is easily understandable and measurable Weaknesses: -
Data requirement	
Expected data source	This information should be obtained from municipal bodies, public services and major private contractors dealing with solid waste collection and disposal. Data may be obtained from specific studies carried out on solid waste for specific projects. Information on selected disposal methods should be gathered from municipal facilities and operators, parastatal and private companies dealing with solid waste treatment. Solid waste experts, as well as NGOs working in this area, may be consulted
Expected availability	Good
Collection interval	Annually
Expected reliability	The data might range from highly reliable to somewhat reliable.
Expected accessibility	Good

References

- ISO/DIS 37120 (2013). Sustainable development and resilience of communities — Indicators for city services and quality of life. ICS 13.020.20
- http://ec.europa.eu/eurostat/statistics-explained/index.php/Municipal_waste_statistics

Ecosystem

Share of green and blue spaces	
Description incl. justification	Green and water spaces are regarded as an index representing the degree of the nature conservation and improving the public health and quality of life as they are directly related to the natural water circulation, environmental purification and the green network. More green and blue also reduces vulnerability to extreme weather events like urban heat islands and flooding by heavy rainfall. This indicator reflects the ratio of green and water space area from total city land area. Green areas are forest and park areas that are partly or completely covered with grass, trees, shrubs, or other vegetation. Water areas here meaning lakes, ponds, rivers.
Definition	Share of green and water surface area as percentage of total land area

Calculation	$\left(\frac{\textbf{Water area}\,[\mathbf{km^2}] + \textbf{Green space area}\,[\mathbf{km^2}]}{\textbf{Total land area}\,[\mathbf{km^2}]}\,\mathbf{x\ 100}\right)$ $= \textbf{Share of Green and blue spaces}\,[\%]$
Strengths and weaknesses	Strengths: Weaknesses:
Data requirements	
Expected data source	Data can be retrieved from the urban planning and environment department of the city. The urban audit database contains information on ’water and wetland’, ‘green space area (km2)’ and‘total land area according to cadastral register)’. The surface area can also bes estimated using a map of the city.
Expected availability	Good
Collection interval	Yearly
Expected reliability	Good
Expected accessibility	Public information
References:	
• European Commission (2012): Methodological Manual on City Statistics. Retrieved at http://ec.europa.eu/eurostat/cache/metadata/en/urb_esms.htm • http://www.eea.europa.eu/data-and-maps/data/urban-atlas	

Change in number of native species	
Description incl. justification	Urbanization affects biodiversity through urban sprawl/habitat fragmentation, loss of fertile agricultural lands, and spread of invasive alien species (ISO/DS 37120, 2013). A loss in biodiversity threatens food supplies, lessens opportunities for recreation and tourism, and impacts a diverse range of medicinal and practial uses, varieties of wood, and energy. It also interferes with essential ecological function, such as carbon sequestration and air filtering. The net change in the number of species in a municipality is an indication of biological diversity loss or gain. Three key taxonomic groups that are most surveyed worldwide, i.e., plants, birds and butterflies, have been selected as “core indicators”. To ensure fairness and objectivity in the index, cities can select 2 other taxonomic groups that would reflect their best biodiversity, e.g. mammals, insects, bryophytes, fungi, amphibians, reptiles, freshwater fish, molluscs, dragonflies, carabid beetles, spiders, hard corals, marine fish, seagrasses, sponges, etc. A full list can be found in the User’s Manual for the City Biodiversity Index. To ensure that this indicator is unbiased against any city based on its

	geographical location, ecological history, size, land-use, etc., a city is requested to list the number of native species* of a) vascular plants, b) birds, and c) butterflies, d) at least 2 other taxonomic groups, and e) any other taxonomic groups that it has data on. **Native species are considered to be native only if they occur naturally in an area, without the involvement of human activity or intervention. There are two types of native species: indigenous and endemic. Indigenous species are native species that are found in multiple locations, whereas endemic species are only found in a specific, unique location.*
Definition	Net change in number of species
Calculation	The net change in native species shall be calculated as the number of new native species within the city from the three core taxonomic groups and the city's selection of an additional two taxonomic groups (as a result of re-introduction, rediscovery, new species found, etc.) subtracted by the number of native species that have become extirpated or locally extinct within the city.
Strengths and weaknesses	Strengths: Weaknesses: the indicator does not address the state of health of the species, only their presence.
Data requirements	
Expected data source	Possible sources of data include government agencies in charge of biodiversity, city municipalities, urban planning agencies, city forestry departments, biodiversity centers, nature groups, universities, etc.
Expected availability	Since data collection is elaborate, availability may be limited
Collection interval	Ideally every 3 years
Expected reliability	If the research is good, so is the indicator
Expected accessibility	No sensitivities expected
References:	
- ISO/DIS 37120 (2013). Sustainable development and resilience of communities — Indicators for city services and quality of life. ICS 13.020.20 - https://www.cbd.int/authorities/doc/User's%20Manual-for-the-City-Biodiversity-Index18April2012.pdf	

Prosperity

Employment

Unemployment rate	

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 labout 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 labour force (denominator). The result shall be multiplied by 100 and expressed as a percentage (ISO/DIS 37120, 2013).
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 labour bureau, city statistical office
Expected availability	Statistics are usually frequently (at least yearly) updated by the

	labour bureaus
Collection interval	Yearly
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/statistics-explained/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	

Youth unemployment rate	
Description incl. justification	The youth unemployment rate is a key indicator for quantifying and analyzing the current labour market trends for young people (ISO/DIS 37120, 2013). Unemployed or underemployed youth are less able to contribute effectively to community and national development and have fewer opportunities to exercise their rights as citizens. They have less to spend as consumers, less to invest as savers and often have no “voice” to bring about change in their lives and communities. Widespread youth unemployment and underemployment also prevents companies and countries from innovating and developing competitive advantages based on human capital investment, thus undermining future prospects. Knowing the costs of non-action, many governments around the world do prioritize the issue of youth employment and attempt to develop pro-active policies and programmes. Unemployed youth shall refer to individuals above the legal working age and under 24 years of age who are without work, actively seeking work in a recent past period (past four weeks), and currently available for work. Youth 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 not be 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). Youth labour force shall refer to all persons above the legal working age and under 24 years of age, who are either employed or unemployed over a specified reference period.(ISO/DIS 37120, 2013).
Definition	Percentage of youth labour force unemployed

Calculation	Youth unemployment rate shall be calculated as the total number of unemployed youth (numerator) divided by the youth labour force (denominator). The result shall be multiplied by 100 and expressed as a percentage.
Strengths and weaknesses	Strengths: City's youth 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. A large share of people between these ages are outside the labour market (since many youths are studying full time and thus are not available for work),
Data requirements	
Expected data source	Statistics from local labour bureau or city statistical office
Expected availability	Statistics are usually frequently (monthly or at least yearly) updated by the labour bureaus
Collection interval	Yearly
Expected reliability	Various calculation rules and definition of the lower age group within each country/city are to be expected and taken into account regarding comparison between cities.
Expected accessibility	High

References

- youth unemployment rate definition, Eurostat http://ec.europa.eu/eurostat/statistics-explained/index.php/Glossary:Youth_unemployment_rate
- ISO/DIS 37120 (2013). Sustainable development and resilience of communities — Indicators for city services and quality of life. ICS 13.020.20

Equity

Fuel poverty	
Description incl. justification	Fuel poverty occurs when a household is unable to afford the most basic levels of energy for adequate heating, cooking, lighting and use of appliances in the home. In absolute sense, when more than 10% of the income is spent on energy bills this is considered too much (DECC, 2013).

	As a large share of the European housing stock consists of buildings in desperate need of refurbishment, particularly in lower income low-energy-efficiency buildings with residents living in fuel poverty, the key to alleviate fuel poverty is to renovate the stock into more energy efficient buildings. Avoiding energy poverty has therefore become an important policy aim in many European countries, for example in the UK, in Austria and in Germany. It should be noted that there are various definitions and calculation procedures for calculating fuel poverty. Fuel poverty lines are arbitrary in some aspects. Proposed definitions differ strongly in terms of robustness to changes in energy prices, incomes and with regard to data requirements (DIW, 2014). The CITYkeys city indicator is derived from the UK definition, according to which households are considered as energy poor if their energy bill consumes 10% or more of the household income (DECC, 2013).
Definition	The percentage of households unable to afford the most basic levels of energy
Calculation	For simplicity the 10% variant and not the more complicated Low Income High Costs (LIHC) variant is proposed here. The fuel poverty ratio of a single household under this method is defined as: $Fuel\ Poverty\ Ratio = Modelled\ fuel\ costs\ (i.e. modelled\ consumption \times price)/Income$ Where this ratio has a value greater than 0.1, the household is considered to be fuel poor. In the next calculation step the number of households living in fuel poverty is compared with the total number of households in the city. Note: The energy costs include all building related energy, i.e. for heating/cooling, warm water and electricity.
Strengths and weaknesses	Strengths: Connects policy area energy reduction with poverty alleviation. Weaknesses: Due to the high variance in calculation rules the comparability between cities may be poor. Requires census data and quite some calculations.
Data requirements	
Expected data source	The data needed for the calculation are: Household income; Energy consumption (dependent on dwelling characteristics and the lifestyle of householders) and Prices of energy. The cost of energy is modelled rather than based on actual spending. It is calculated by combining the fuel requirements of the household with corresponding fuel prices. Household income data may be available from the city statistical office. Energy prices should be metered prices and should be available from the local energy providers. Energy consumption data per household is usually modelled based on statistics on dwellings, household size, etc. For further details see DECC (2013), DIW (2014), p16 ff.

Expected availability	The information sources needed should be available through the city statistical office and energy service providers.
Collection interval	Annual
Expected reliability	Depending on the quality of the data needed fitting the calculation rules, the indicator will produce more or less reliable results.
Expected accessibility	Depending on information categories, it is expected that the minimum set of indicator data should be accessible. As the indicator calculation requires individual data, data processing might need to be done by the statistical office or an entity with sufficient protection of private data.
Expected data models	Documented in DECC, 2013.

References

- DECC, 2013. The fuel poverty statistics methodology and user manual. UK department of Energy and Climate change. https://www.gov.uk/government/publications/fuel-poverty-methodology-handbook-2013
- Measuring Fuel Poverty: General Considerations and Application to German Household Data, [DIW2014], http://www.diw.de/documents/publikationen/73/diw_01.c.438766.de/diw_sp0632.pdf
- EU fuel poverty network http://fuelpoverty.eu/

Affordability of housing	
Description incl. justification	Many Europen cities face spatial segregation of social groups. Gentrification combined with an increase in housing costs, make it more difficult for low-income residents to find affordable housing. Smart cities aim to maintain or increase the diversity within neighbourhoods to ensure that also inhabitants with low incomes can remain in developing neighbourhoods and not being pushed into suburbs or outside the city. As a rule of thumb, no more than 25-40 % of income should be spend on housing in order to be considered affordable. For developed countries the upper limit is between 33-40 %. For this indicator affordable housing is defined as: less than 40% of the household income is spend on housing expenditures. This includes rents, hereditary tenure, mortgage payments, but excludes expenditures for services or utilities.
Definition	% of population living in affordable housing
Calculation	The indicator shall be calculated as the number of people living in affordable housing (numerator) divided by the city population (denominator). The result shall then be multiplied by 100 and

	expressed as a percentage.
Strengths and weaknesses	Strengths: reflecting important processes in cities, such as gentrification; connects with policy goal of poverty reduction. Weaknesses: Because of the variability of the definition, a certain amount of subjectivity and uncertainty is given.
Data requirements	
Expected data source	The indicator combines per household data on fixed housing costs, with the gross household income. City statistical department. City social or housing department.
Expected availability	The basic individual data are census data, of which availability depends on the regularity of these censuses in the city/country. Alternatively combining registers might be considered.
Collection interval	With the frequence of censuses (5-10 years), or more regularly if based on the combination of registers.
Expected reliability	If based on census data, the indicator will be very reliable.
Expected accessibility	If the indicators has been calculated by the city statistical department, it will be accessible. Individual data underlying the indicator will as a rule not be accessible.
References	
- EU-Statistics on income and living conditions: http://ec.europa.eu/eurostat/statistics-explained/index.php/Glossary:EU_statistics_on_income_and_living_conditions_%28EU-SILC%29 - http://ec.europa.eu/eurostat/statistics-explained/index.php/Housing_statistics#Housing_affordability	

Green economy

Share of certified companies	
Description incl. justification	More and more organisations have systematic attention for the environmental aspects of their business, including products and services. Often this is the consequence of increasing attention of external parties for the environmental performance of the company. These stakeholders have wishes and demands on the environmental aspects of the company, which need to be taken into account by the company to keep its “license to operate” in the longer term. The ISO 14000 series of norms for environmental management offers guidance for organisations that want to go further than compliance with rules and regulations. The norms are meant for companies that understand that implementing a systematic approach to the environmental aspects of the company and its

	products will pay itself back, for example through decrease of waste costs; reductions in energy, resources and materials; improving environmental image; better relationships with government; and new market opportunities. If a city hosts a high share of certified companies, it can be assumed that environmental quality, also locally, benefits.
Definition	Share of companies based in the city holding an ISO 14001 certificate
Calculation	(Number of companies with ISO 140001 certificate/total number of companies in the city)*100%
Strengths and weaknesses	Strenghts: Easy to understand. Possibly related with local environmental quality and the 'image' of the city. Weakness: Only a minority of companies is certified, and it is possible for non-certified companies to conduct their business in an environmentally sound manner. Due to various existing certification systems and related definitions, a certain amount of subjectivity cannot be avoided.
Data requirements	
Expected data source	The information can be retrieved from ISO registers or other business registers.
Expected availability	Good
Collection interval	Annually
Expected reliability	ISO 14001 is international standard, so the reliability and comparability of the data is expected to be high.
Expected accessibility	Good, as companies tend to use this information for the purpose of marketing
References • http://www.iso.org/iso/home/standards/management-standards/iso14000.htm • https://www.nen.nl/NEN-Shop/Vakgebieden/Managementsystemen/Milieumanagement.htm • http://www.isoregister.nl/register.html	

Share of Green Public Procurement	
Description incl. justification	Europe's public authorities are major consumers. By using their purchasing power to choose environmentally friendly goods, services and works, they can make an important contribution to sustainable consumption and production – what we call Green Public Procurement, or GPP. Although GPP is not mandatory, it has a key role to play in the EU's efforts to become a more resource-efficient

	economy. It can help stimulate a critical mass of demand for more sustainable goods and services which otherwise would be difficult to get onto the market. GPP is therefore a strong stimulus for eco-innovation. A number of European countries already have national environmental purchasing criteria for products and services per sector. Also, green labels may be helpful in identifying the extent to which environmental considerations were taken into account. The indicator leaves the flexibility to define the use of environmental criteria according to local circumstances.
Definition	Percentage annual procurement using environmental criteria as share of total annual procurement of the city administration
Calculation	(Millon EUR annual procurement using environmental criteria/Millon EUR total annual procurement of the city administration)*100
Strengths and weaknesses	Strength: Easy to understand. Common European guidelines for GPP are available. Weakness: This indicator is only relevant to government funded procurement; guidelines are extensive; data availablility may be limited; green labels do not necessarily tell the full story; definition of GPP is flexible..
Data requirements	
Expected data source	A first entry could be the city's corporate facilities department (but this might be limited to its own sustainable purchasing (i.e. printing paper, catering etc.). Information on the rest of the organisation will likely be scattered over different departments (e.g. the transport department for sustainable procurement of roads; the housing department for sustainable procurement of a large-scale urban development project, etc).
Expected availability	If the data are available, they are likely to be scattered.
Collection interval	Annually
Expected reliability	Reliability of the data is limited due to uncertainties in the sources (availability, what is considered and what is not)
Expected accessibility	No sensitivities expected.
References	
• https://www.pianoo.nl/sites/default/files/documents/documents/eindrapportmonitorduurzaaminkopen.pdf • http://ec.europa.eu/environment/gpp/eu_gpp_criteria_en.htm • http://www.unece.org/energy/se/eneffic.html	

Green jobs	
Description incl. justification	'Greening the economy' can boost job creation in areas directly connected to the environment such as conservation, waste, water and air quality. Smart cities are expected to show a significant growth in green jobs. UNEP 2008 defines a green job as “work in environmental service activities that contribute substantially to preserving or restoring environmental quality. Specifically, but not exclusively, this includes jobs that help to protect ecosystems and biodiversity; reduce energy, materials, and water consumption through high efficiency strategies; de-carbonize the economy; and minimize or altogether avoid generation of all forms of waste and pollution.” So a green job is any job that genuinely contributes to a more sustainable world(i.e. related to measuring, avoiding, reducing, limiting or removing environmental damages as well as the preservation of natural resources). The emplying company or organization can either be in a 'green' sector (e.g. solar energy), or in a conventional sector, but making genuine and substantial efforts to green its operations.
Definition	Share of jobs related to environmental service activities that contribute substantially to preserving or restoring environmental quality
Calculation	(Number of green jobs/Total number of jobs)*100
Strengths and weaknesses	Strengths: The indicator might show the link between environmental performance and job creation, or boosting the job creation in areas directly connected to the environment Weaknesses: Complex data collection. Often, studies covering/addressing the topics rely heavily on Environmental Protection Expenditures, therefore the assessment of money spent to protect the environment might be overestimated in comparison to the creation of jobs dependent on a good environment. Therefore the risk of high uncertainty is given.
Data requirements	
Expected data source	Usually green jobs are not accounted separately. Statistical data on environmental protection expenditures can be a source to estimate the number of green jobs.
Expected availability	Low: incidental estimates expected
Collection interval	Yearly
Expected reliability	Different approaches in calculating the indicator lower reliability and comparability.
Expected accessibility	Low: probably one can find estimates documented in reports.

References
• UNEP 2008: Green Jobs. Towards decent work in sustainable, low-carbon world. ISBN: 978-92-807-2940-5 • http://www.goodwork.ca/what-is-a-green-job • http://ec.europa.eu/environment/enveco/jobs/; • http://ec.europa.eu/environment/enveco/jobs/pdf/jobs.pdf [ECORYS2012]

Freight movement	
Description incl. justification	Freight distribution, pickups and deliveries (sometimes there is a distinction between delivery traffic and goods transport), while essential to ensure the vitality of cities, have an important contribution to high congestion levels, traffic disruptions, and, therefore increased levels of emissions, noise, and other social costs. City centres are often areas with small streets and high population densities. The performance of urban freight systems depends on a variety of factors related to vehicle types, delivery schedules, load optimisation etc. In Europe, 29% of freight vehicles on the road in 2009 was empty. From an economic as well as environmental perspective, much can be gained by bringing this number down. ICT can be an important enabler to further improve logistics management. Optimising the system should lead to less vehicle movements.
Definition	Freight movement is defined as the number of freight vehicles moving into an area (e.g. the city)
Calculation	# of freight vehicle movements
Strengths and weaknesses	Strenghts: Weaknesses: Apart from efficiency improvements, the indicator is highly dependent on economic developments. The indicator doesn't take into account a shift between larger and smaller vehicles.
Data requirements	
Expected data source	Roadside counts
Expected availability	Available if counting systems are constantly in place
Collection interval	Annually
Expected reliability	It is expected to be reliable.
Expected accessibility	Likely accessible.
References	
• 2DECIDE • CIVITAS	

- http://www.logistiek.nl/distributie/blog/2010/8/lege-vrachtwagens-probleem-of-uitdaging-101133485

Economic performance

Gross Domestic Product	
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	
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 desaggregation 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
Expected reliability	The indicator is well-known, therefore reliability should be expected.
Expected accessibility	No sensitivities expected.
References	
• http://ec.europa.eu/eurostat/statistics-explained/index.php/Glossary:Gross_domestic_product_%28GDP%29 • http://ec.europa.eu/eurostat/statistics-explained/index.php/GDP_at_regional_level	

New business registered	
Description incl.	The number of businesses can inform a city's level of economic

justification	activity and economic performance. It provides one indication of the overall business climate in a jurisdiction, and attitudes towards entrepreneurship. Strong entrepreneurial activity is closely associated with a dynamic and growing economy. The number of businesses is also used to inform competitiveness of a city. (ISO/DIS 37120, 2013) This indicator assesses the number of new businesses created (including start-ups). An enterprise birth occurs when an enterprise (for example a company) starts from scratch and begins operations, amounting to the creation of a combination of production factors with the restriction that no other enterprises are involved in the event. An enterprise birth occurs when new production factors, in particular new jobs, are created. Enterprise births do not include: • dormant enterprises being reactivated within two years; • new corporate entities being created from mergers, break-ups, spin-offs/split-offs or the restructuring of enterprises or a set of enterprises; • the entry into a sub-population resulting only from a change of activity.
Definition	Number of new businesses per 100,000 population
Calculation	(Number of new companies registered/Total Population) x 100 000 inhabitants
Strengths and weaknesses	Strengths: Weaknesses: Not each new founded enterprise has to have a positive impact on the economy or smart city development. The measurement should e.g. take into account a minimum timeframe the new founded company must stay on the market or reach a minimum turnaround to be accepted for counting.
Data requirements	
Expected data source	Business demography statistics are available at NUTS 2 level at Eurostat. City statistics office and/or economic board and the chamber of commerce might be able to provide the information.
Expected availability	Dependent per city.
Collection interval	Annually
Expected reliability	Numbers from the statistical offices, chamber of commerce and Eurostat are considered highly reliable.
Expected accessibility	No sensitivities expected
References	
• http://ec.europa.eu/eurostat/statistics-explained/index.php/Glossary:Enterprise_birth • City protocol (2015). City Anatomy - City Indicators. CPWD-PR_002_Anatomy_Indicators	

Median disposable Income	
Description incl. justification	While money may not buy happiness, a certain amount is an important means to achieve higher living standards and thus greater well-being. Higher economic wealth may e.g. improve access to quality education, health care and housing.Total disposable household income (according to SILC) is calculated by adding together the personal income received by all of the household members plus income received at household level diminished by regular taxes on wealth, regular inter-household cash transfer paid and tax on income and social insurance contributions (Urban Audit, 2012)). The median is the middle value, i.e. 50% of all observations are below the median value and 50% above it. Household disposable income includes income from economic activity (wages and salaries; profits of self-employed business owners), property income (dividends, interests and rents), social benefits in cash (retirement pensions, unemployment benefits, family allowances, basic income support, etc.), and social transfers in kind (goods and services such as health care,, education and housing, received either free of charge or at reduced prices) (OECD).
Definition	Median disposable annual household income
Calculation	In general, individual data are rarely available so income classes are used. Knowing the number of households in each class, the class of the median income is known. The “exact” amount of median income can be approximated by replacing the steps (caused by the classes) in the cumulative frequency curve by a smooth curve of distribution, at least for the class in which the median is situated.
Strengths and weaknesses	Strengths: the indicator provides an absolute value for the wealth of the city. Weaknesses: Insight in the disposable income does not have a direct relation with wealth and welfare of the population. Different methods to calculate this indicator might make it less reliable for benchmarking.
Data requirement	
Expected data source	The information might be available at the Urban Audit database, the cities statistics bureau
Expected availability	it is a commonly used indicator, so availability is expected to be high
Collection interval	Annually
Expected reliability	Information from the above mentioned sources are regarded as highly reliable. However, due to possible differences in calculations the indicator might not be 100% reliable for benchmarking.
Expected accessibility	As it is calculated using income classes, no sensitivities are expected
References	

- http://www.oecdbetterlifeindex.org/topics/income/
- Urban audit (2012). Methodological Manual on City Statistics.

Innovation

Creative industry	
Description incl. justification	The term refers to the socio-economic potential of activities that trade with creativity, knowledge and information. Governments and creative sectors across the world are increasingly recognizing its importance as a generator of jobs, wealth and cultural engagement. At the heart of the creative economy are the cultural and creative industries that lie at the crossroads of arts, culture, business and technology. What unifies these activities is the fact that they all trade with creative assets in the form of intellectual property (IP); the framework through which creativity translates into economic value. The UK's definition of the creative industries - 'those industries that are based on individual creativity, skill and talent with the potential to create wealth and jobs through developing intellectual property' - includes thirteen sectors: advertising, architecture, the art and antiques market, crafts, design, designer fashion, film, interactive leisure software (ie. video games), music, the performing arts, publishing, software, and television and radio. Because it was the first definition offered by a government, this original UK definition has been widely adopted by other countries, with sectors adapted based on local commercial and cultural importance.
Definition	Share of people working in creative industries
Calculation	(people working in creative industries/total workforce)*100%
Strengths and weaknesses	Strengths: Weaknesses: the interpretation and definition of 'creative industry' may be different. How creative industry is linked to other industry is often unclear. A proxy such as revenues from creative sectors may be necessary to estimate the indicator. The direct contribution of creative industry to innovation is not clear
Data requirements	
Expected data source	The percentage of employment in the creative class is available at NACE2 and NUTS 3 level by Eurostat. Possibly also city statistics office and/or economic board, chamber of commerce etc.
Expected availability	The availability of employment information per sector will be readily available with the above sources, but defining which ones represent 'creative industry' might require more effort.
Collection interval	Annually

Expected reliability	Information from the above mentioned sources are regarded as highly reliable. However, due to possible differences in calculations the indicator might not be 100% reliable for benchmarking.
Expected accessibility	No sensitivities expected.
References	
- http://www.teraconsultants.fr/en/issues/The-Economic-Contribution-of-the-Creative-Industries-to-EU-in-GDP-and-Employment - http://creativecities.britishcouncil.org/creative-industries/what_are_creative_industries_and_creative_economy - http://ec.europa.eu/eurostat/web/structural-business-statistics/entrepreneurship/business-demography	

Innovation hubs in the city	
Description incl. justification	Innovation hubs imply building and increasing intelectual capital and skills. It exposes the interest in creation of value and development of knowledge. It may create links between sectors and fields of development, which previously did not exist and thus positively impact socio-economic development of an urban area. For this indicator, physical co-working spaces for knowledge institutions, business and government should be counted.
Definition	# of innovation hubs in the city, whether private or public, per 100.000 inhabitants
Calculation	
Strengths and weaknesses	Strengths: Weaknesses: The number of facilities is not placed in relation to the quality of facilities, which may have impact on the overall performance of such institutions.
Data requirements	
Expected data source	Universities and other research institutes, city government (smart city or economic affairs department)
Expected availability	Data is probably available but might be scattered.
Collection interval	Annually

Expected reliability	High
Expected accessibility	No sensitivities expected

References

- http://openinnovation.net/
- http://www.journal-jger.com/content/pdf/s40497-015-0022-y.pdf
- http://druid8.sit.aau.dk/acc_papers/rdv4by82h7nbyph96iuix18cu71s.pdf
- http://erc-assoc.org/sites/default/files/topics/policy_studies/DJackson_Innovation%20Ecosystem_03-15-11.pdf
- http://www.innovationmanagement.se/2014/12/15/learning-from-innovation-hubs-fluidity-serendipity-and-community-combined/

Accessibility of open data sets	
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 city 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 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), e.g. to create new applications. Therefore, evaluating the quality of the open data from this perspective is important to promote the ease of use and the openness of city data
Definition	The extent to which the open city data are easy to use
Calculation	Total stars of all datasets/total # datasets Each dataset has to be rated according to below scheme. All the stars of all the datasets are added up and divided by the total number of datasets. Average stars across all datasets according to the 5 star deployment scheme for Open Data defined by Tim Berners Lee (5stardata.info): 1. Making data online available in whatever format under an open license 2. Making data available as structured data (e.g. Excel instead of image scan of a table) 3. Making data available in a non-proprietary open format (e.g. CSV)

	4. Use URIs to denote things, so that people can point at your data 5. Link your data to other data to provide context
Strengths and weaknesses	Strengths: The 5 star system makes the qualification of the datasets much more objective and comparable across cities. 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. 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	The indicator ' Open data' provides a list of open datasets relevant to the city and in which format they are available.
Expected availability	Depends on the local context
Collection interval	Annually
Expected reliability	Unknown
Expected accessibility	Good (data is open)
References • http://5stardata.info/en/ • http://opendatahandbook.org/guide/en/why-open-data/	

Research intensity	
Description incl. justification	The OECD Frascati Manual 2002 methodology defines R&D as - "creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of man, culture and society, and the use of this stock of knowledge to devise new applications" (oecd-ilibrary.org). The main aggregate used for international comparisons of R&D expenditures is gross domestic expenditure on R&D (GERD). GERD is usually broken down among four sectors of performance: business enterprise, higher education, government and private not-for-profit

	institutions serving households (PNP). GERD is often reported in relative terms as a percentage of GDP, to denote the R&D intensity of an economy. This indicator analyses the total expenditure on R&D by all stakeholders as a percentage of the GDP of the city.
Definition	R&D expenditure as percentage of city's GDP
Calculation	(total expenditure on R&D/city GDP)*100
Strengths and weaknesses	Strengths: This is a solid indicator and comparable across cities Weaknesses: Usually measured on the national and regional level, getting data specific to an urban area might be more complicated. Also the funding may come from a different place, i.e. theoretically it is possible that expenditure on R&D exceeds city GDP in university towns.
Data requirements	
Expected data source	For city's GDP, see indicator 'Gross domestic product'. The expenditures on R&D might be available in the municipal Economics department. Eurostat contains the GERD on the NUTS 2 level if no city statistics are present.
Expected availability	Low
Collection interval	Annually
Expected reliability	High
Expected accessibility	For a large part, there are no sensitivities expected. However, it is possible that R&D expenditure from companies is not disclosed.
References • http://www.oecd-ilibrary.org/sites/sti_scoreboard-2011-en/02/05/index.html?itemId=/content/chapter/sti_scoreboard-2011-16-en	

Open datasets	
Description incl.	Open data is data that can be freely used, re-used and redistributed by anyone - subject only, at most, to the requirement to attribute and sharealike (opendatahandbook.org; opendefinition.org). Open data,

justification	especially open government data, is a tremendous resource that is as yet largely untapped. Government is particularly significant in this respect, both because of the quantity and centrality of the data it collects, but also because most of that government data is public data by law, and therefore could be made open and made available for others to use. 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. Since open datasets can stimulate innovation, this indicator analyses the number of open government datasets. In addition, the format of the available datasets is collected as this is important information for the indicator 'quality of open data'.
Definition	# of open government datasets per 100.000 inhabitants
Calculation	(number of open government datasets/total population) x 100.000 Nb. List all open government datasets and the format they are published in.
Strengths and weaknesses	Strenghts: This is a solid indicator on the actual datasets available and it is comparable across cities. Weaknesses:
Data requirements	
Expected data source	The knowledge, planning or economic department should be able to provide an overview. Open data platforms in the city could also provide insight.
Expected availability	the information will be available, but collecting all datasets from various sources might require sufficient effort.
Collection interval	Annually
Expected reliability	High
Expected accessibility	Good (data is open)

References

- http://opendatahandbook.org/guide/en/http://opendefinition.org/od/2.0/en/index.html

Attractiveness and competitiveness

Congestion	
Description incl. justification	Cities and traffic have developed hand-in-hand since the earliest large human settlements (internationaltransportforum.org). The same forces that draw inhabitants to congregate in large urban areas also lead to sometimes intolerable levels of traffic congestion on urban streets and thoroughfares. It is necessary to manage congestion in such a way as to reduce its overall impact on individuals, families, communities and societies. Effective urban governance requires a careful balancing between the benefits of agglomeration and the dis-benefits of excessive congestion. Also, the Strategic Implementation Plan on Smart Cities and Communities (EIP-SCC, 2013) defines more efficient urban transport as one goal of Smart City Development.
Definition	Increase in overall travel times when compared to free flow situation (uncongested situation)
Calculation	This indicator can be calculated as indicated by tomtom (tomtom.org): ((travel times in peak hours - travel times during non-congested periods (free flow*))/travel times during non-congested periods)*100% NB There are other was to calculate congestion, see below. We would like to hear from the cities what method they use. For the moment, therefore, the calculation method is flexible, as long as it is specified. <u>2 Decide</u> • Average delay per vehicle kilometre (congestion), with unit: hour delay/vehicle-km; • Vehicle kilometres travelled in congestion, with unit: vehicle-km/time unit Travel time (average per traffic unit), with unit: hour; • Additional travel time caused by incidents, with unit: hour; <u>EEA</u> • Average daily km of traffic jams per 1000 inhabitants in city <u>City Protocol</u> • Average daily traffic jam in hours

Strengths and weaknesses	Strenghts: the indicator is very recognizable and relevant to the attractiveness and competitiveness, as it goes to the accessibility of the city. Weaknesses: -
Data requirements	
Expected data source	Within the city, the traffic and transportation management department should be able to provide this statistic. Several commercial services also exist based on route navigation, e.g. https://www.tomtom.com/en_gb/trafficindex/#/list provides congestion levels for 103 European cities. TomTom uses their database on speed measurements to calculate the travel times on individual road segments and entire networks.
Expected availability	Measurements on traffic speed and congestion will not always be readily available.
Collection interval	Annually
Expected reliability	High
Expected accessibility	No sensitivities expected
References	

- http://www.internationaltransportforum.org/jtrc/infrastructure/congestion/CongestionSummary.pdf
- TomTom (2013).TomTom Australia & New Zealand Congestion Index.
- www.tomtom.com/congestionindex.
- EIP-SCC (2013). European Innovation Partnership on Smart Cities and Communities Strategic Implementation Plan

Public transport use	
Description incl. justification	Transport usage is a key indicator of how easy it is to travel in the city by modes other than single occupancy vehicles (iso/dis 37120, 2013). The indicator might also provide insight into transportation policy, traffic congestion, and urban form. Cities with higher transport ridership rates tend to invest more in their transport systems and are more geographically compact. Transport usage also addresses overall travel patterns in the city, and not just the journey to work. In addition, less vehicle use contributes to an accessible, green and healthy city and moreover contributes to European policy goals for sustainable mobility and transport development. While walking and cycling are alternative modes of transport for short distances, public transport connections are needed

	for longer trips.
Definition	Annual number of public transport trips per capita
Calculation	This indicator shall be calculated as the total annual number of transport trips originating in the city - “ridership of public transport” - (numerator), divided by the total city population (denominator) (ISO/DIS 31720). Transport trips shall include trips via heavy rail metro or subway, commuter rail, light rail streetcars and tramways, organized bus, trolleybus, and other public transport services. Cities shall only calculate the number of transport trips with origins in the city itself. Note: Transport systems often serve entire metropolitan areas, and not just central cities. The use of number of transport trips with origins in the city itself will still capture many trips whose destination are outside the city, but will generally capture the impact that the city has on the regional transport network.
Strengths and weaknesses	Strenghts: Weaknesses: the quality of the trips is not taken into account Public transport use does not have a direct relation to the attractiveness and competitiveness of the city. While higher transport ridership rates are generally considered desirable, extremely high ridership rates can also indicate cities with overcrowding problems or with disproportionately large low-income populations.
Data requirements	
Expected data source	Transport data should be gathered from a number of sources, including: official transport surveys, revenue collection systems (e.g. number of fares purchased), and national censuses (ISO/DIS 37120, 2013). NOTE 1 Farebox records (e.g. transport fares paid) are usually the primary source of data for this indicator. However, the relationship between fares purchased and trips taken is not always exact. For example, many transport systems do not actively check for proof of fare purchase – often, riders are expected to have valid tickets, and are severely fined if a ticket is not presented, but enforcement of such rules is not uniform for every rider on every trip. Other transport systems offer monthly or weekly passes, which do not necessarily allow for accurate counts of each trip. NOTE 2 In many countries, a large number of trips are made via “informal transport” services (e.g. minibuses not operated by the government or municipal transport corporation). These informal trips are not part of the official transport network and

	shall not be counted.
Expected availability	High
Collection interval	Annually
Expected reliability	High
Expected accessibility	No sensitivities expected

References

- ISO/DIS 37120 (2013). Sustainable development and resilience of communities — Indicators for city services and quality of life. ICS 13.020.20

Net migration	
Description incl. justification	The rate of migration is a direct indicator for the attractiveness of the city to citizens and their willingness to live there. In addition, there is a general movement of people from the countryside towards cities (urbanisation).
Definition	Rate of population change due to migration per 1000 inhabitants
Calculation	((Move-ins – move-outs)/total population)*1000 (CASBEE, 2012; Telos, 2015)
Strengths and weaknesses	Strenghts: Solid indicator and comparable to with other cities Weaknesses: It is not always a choice to live or leave some place.
Data requirements	
Expected data source	City's statistics office The ESPON database contains information on migration at NUTS3 level, averaged over 5 years.
Expected availability	High
Collection interval	Annually
Expected reliability	High
Expected accessibility	No sensitivities expected

References

- http://database.espon.eu/db2/home;jsessionid=df119da8de9311708c9fbdc37de3
- Telos (2015). Integrated Sustainability Monitoring of 58 EU-Cities. study of European Green Capital Award applicant cities. Document Number: 15.123

Population dependency ratio	
Description incl. justification	Dependency ratios indicate the potential effects of

	changes in population age structures for social and economic development, pointing out broad trends in social support needs (un.org). By relating the group of the population most likely to be economically dependent (net consumers) to the group most likely to be economically active (net producers), changes in the dependency ratio provide an indication of the potential social support requirements resulting from changes in population age structures (ibid). In addition, the ratio highlights the potential dependency burden on workers and indicates the shifts in dependency from a situation in which children are dominant to one in which older persons outnumber children as the demographic transition advances (that is, the transition from high mortality and high fertility, to low mortality and low fertility). A healthy dependency ratio contributes to an attractive and competitive city.
Definition	Number of economically dependent persons (net consumers) per 100 economically active persons (net producers)
Calculation	100 x ((Population (0-14) + Population (65+)) / Population (15-64) (un.org)
Strengths and weaknesses	Strenghts: Weaknesses: In many populations, people do not stop being economically active at age 65, nor is it true that all persons aged 15-64 are economically active. Although older persons often require economic support from others, in many societies they have economic resources of their own and provide support to their adult children. As the period of training for a productive life increases, most adolescents and young adults remain in school and out of the labour force, effectively extending the period of young-age dependency well beyond age 15. The indicator is more relevant at national level than at local level.
Data requirements	
Expected data source	City’s statistics office
Expected availability	High
Collection interval	Annually
Expected reliability	High

Expected accessibility	No sensitivities expected
References - http://www.un.org/esa/sustdev/natlinfo/indicators/methodology_sheets/demographics/dependency_ratio.pdf	

International events held	
Description incl. justification	The number of international events held is an indication of the attractiveness and competitiveness of the city. International events are, for example, congresses and fairs.
Definition	The number of international events per 100.000 inhabitants
Calculation	
Strengths and weaknesses	Strenghts: Weaknesses: difficult to compare between cities, i.e. cities that are the seat to national governments, international organizations, country representations, have large venues, are easily accessible etc. will host more events than those who do not.
Data requirements	
Expected data source	City administration and city tourism office
Expected availability	High
Collection interval	Annually
Expected reliability	High
Expected accessibility	No sensitivities expected
Expected data models	None
References -	

Tourism intensity	
Description incl. justification	The number of tourists visiting the city is an indication of the attractiveness of the city to foreigners. A study by ECM shows that city tourism has experienced exponential growth compared to tourism on a national level, making cities the engine of tourism development in Europe (europeancitiesmarketing.com). In addition, tourism as an industry adds value to the local economy.
Definition	Number of tourist nights per year per 100.000 inhabitants
Calculation	
Strengths and weaknesses	Strenghts:

	Weaknesses: difficult to compare between cities, i.e. cities that are the seat to national governments, international organizations, country representations, have large venues, rich culture, are easily accessible etc. will host more tourists than those who do not.
Data requirements	
Expected data source	City's tourism office, tourism tax information, European Cities Marketing Benchmarking Report
Expected availability	High
Collection interval	Annually
Expected reliability	High
Expected accessibility	No sensitivities expected
References	
- http://www.europeancitiesmarketing.com/benchmarking-report-2013/	

Governance

Organisation

Cross-departmental integration	
Description incl. justification	Smart city projects are multi-disciplinary projects. Therefore, they can benefit from an integrated approach and the involvement of many disciplines and departments within the city administration. This is referred to as the "mainstreaming approach": all policy domains are conscious of the fact that smart city initiatives touch their policy domain and they see it as an added value. The level of cross-departmental integration will be estimated by analyzing the number of departments involved in smart city initiatives, whether by contributing financial, data sources or human resources.
Definition	The extent to which administrative departments contribute to "Smart City" initiatives and management
Calculation	Likert scale (adapted to Transform (2013)): Only one department involved – 1 – 2 – 3 – 4 – 5 – All departments are actively involved 1. There is a silo-ed smart city governance structure, only one department actively contributes to smart city initiatives and decides on the strategy. 2. The local authority is poorly oriented towards cross-departmental "smart city" management: officially there is no "mainstreaming approach", some civil servants from a

	few departments work on this portfolio on the side or provide data for the initiatives, but there is no real strategy and commitment. 3. The local authority is somewhat oriented towards cross-departmental “smart city” management: there is a strategy for a “mainstreaming approach” and several departments contribute in human, data or financial resources. 4. The local authority is clearly oriented towards cross-departmental “smart city” management: there is a strategy for a “mainstreaming approach” and almost all departments provide financial, data and human resources for the smart city themes. 5. The local authority is committed towards cross-departmental “smart city” management: there is a well-anchored “mainstreaming approach” with shared performance targets and all departments are actively contributing to the smart city themes in financial, data and human resources.
Strengths and weaknesses	Strengths: The actual involvement of departments in terms of various resources is taken into account. 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	To be derived from interviews with the smart city coordinator, administration documentation and proposals/reports on smart city project initiatives
Expected availability	The smart city coordinator should be able to provide all the documentation and information.
Collection interval	Yearly
Expected reliability	Because of the subjectivity that cannot be excluded, this indicator is not 100% reliable.
Expected accessibility	It is expected that information on the smart city governance structure is public information
References	
• Transform (2013). Definition of Smart Energy City - Definition, key elements and indicators. Transform, Deliverable 1.2	

Establishment in the administration	
Description incl. justification	Although many disciplines and municipal departments are ideally involved in the execution of the smart city strategy, a clear primary responsibility lying with one department or a director is an important factor for success. Another element of strong and dedicated establishment is the labour force allocated towards smart

	city initiatives. This indicator estimates the combined extent to which both elements are established in the city administration.
Definition	The extent to which the smart city strategy has been assigned to one department/director and staff resources have been allocated
Calculation	Likert scale: Not at all – 1 – 2 – 3 – 4 – 5 – Very much 1. Not at all: The municipal efforts regarding smart city are not at all reflected by the organizational structure and staff resources. 2. Poor: some civil servants manage this portfolio on the side but there is no real commitment to the subject. 3. Moderate: responsibility has been assigned to a director and a small team is working on the topic. 4. Much: responsibility has been assigned to a director and a large team is working on the topic. 5. Very much: the smart city strategy is a well-anchored in the administration reflected by the assigned responsiblity to a large team and the strong commitment to achieve the smart city targets.
Strengths and weaknesses	Strengths: 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	To be derived from administration documentation and interviews with the smart city coordinator
Expected availability	Most successful smart city administrations will have paid specific attention to their structure in relation to the facilitation of projects. If there is no documentation available, involved actors/stakeholders and the project leader itself should be able to provide insight upon which the assessor can base the score.
Collection interval	Yearly
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 in a general sense.
References	
•	

Monitoring and evaluation	

Description incl. justification	Continued monitoring of performance and compliance with the requirements is an essential stimulating factor for success and allows the presentation of the actual progress made (Fortune and White 2006). Continued monitoring and reporting refers to the control processes by which at each stage of development, key personnel report on how the smart city programme progresses with regards to the initial goals, schedule and budget. Adequate monitoring and reporting mechanisms allow for an anticipation on problems, to oversee corrective measures, and warrants that no deficits are overlooked.
Definition	The extent to which the progress towards a smart city and compliance with requirements is being monitored and reported
Calculation	Likert scale no continued monitoring – 1 — 2 — 3 — 4 — 5 — Extensive monitoring 1. No monitoring & reporting: No monitoring and reporting at all was used to verify the progress of policies/strategies/projects. 2. Little monitoring & reporting: there is a basic monitoring scheme in place: a basic set of indicators assessed at irregular time intervals. 3. Some monitoring & reporting: there is a city-wide monitoring scheme in place with an elaborate set of indicatorsmeasurement intervals, backed by well-defined (SMARTY) goals of the smart city strategy. 4. Very much monitoring & reporting: there is a city-wide monitoring scheme in place with anelaborate set of indicators and measurement intervals, the findings of which are yearly reported upon. 5. Extensive monitoring & reporting: there is a city-wide monitoring scheme in place addressing all stages of the process, the findings of which are yearly reported upon and published transparently online.
Strengths and weaknesses	Strengths: Various aspects of the monitoring and evaluation are combined into one indicator and it allows for comparison among cities. 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	To be derived from the Smart city strategy document, interviews with the smart city coordinator and monitoring reports.
Expected availability	It is expected that the strategy document is easily available (online?) and the smart city coordinator can be contacted easily. The

	availanility of the monitoring reporting depends on the extent of monitoring and reporting.
Collection interval	Yearly
Expected reliability	Because of the subjectivity that cannot be excluded, this indicator is not 100% reliable.
Expected accessibility	Information on the progress towards a smart city is public information and no problems are expected with regards to the accessibility.
References	
• Eurbanlab (2014). The Eurbanlab Selection of Indicators. Version 4. • Fortune, J., and D. White. "Framing of project critical success factors by a systems model." International Journal of Project Management, 2006: 53-65.	

Availability of government data	
Description incl. justification	Open information flows increase transparency and prevent information asymmetry, thereby enhancing participation. This indicator investigates the ratio of unclassified government documents available to citizens, journalist, developer, communities, etc. and whether they are available online in digital form, which is better for share storage (ITU)Unclassified government documents include urban planning, operation, budget, strategy and statistics documents.
Definition	The extent to which government information is published
Calculation	Likert scale Not at all – 1 – 2 – 3 – 4 – 5 – Excellent 1. Not at all: most of the information is not available to the public or only upon appointment with an expert 2. Poorly: most of the information is available to the public, but available in the form of a hard copy which cannot leave city hall 3. Somewhat: most of the information is available to the public, some in the form of a hard copy, some online. 4. Good: most of the information is available online, but structure is lacking 5. Excellent: all government information is available online and neatly structured.
Strengths and weaknesses	Strengths: This indicator combines insight in the accessibility of documents with online availability. The indicator doesn't require an absolute figure for the percentage of (easily) accessible documents, which would be difficult to measure.

	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	The municipal archivist and website management team can provide information on the accessibility and online availability of government documents. Whether the structure of the website is user-friendly can be assesses with an online websurvey that pops-up when surfing the government website.
Expected availability	Information on the correct structure of the website is more difficult to get, but an estimation of the accessibility and online availability should be easy to make by the experts mentioned.
Collection interval	Yearly
Expected reliability	Because of the subjectivity that cannot be excluded, this indicator is not 100% reliable.
Expected accessibility	In rare cases, governments might be hesitant to reveal how transparent they are, but in general, no issues are expected with accessibility of the information.
References	
• ITU (2014). Key performance indicators (KPIs) definitions for Smart Sustainable Cities. SSC-0162-rev3	

Community involvement

Citizen participation	
Description incl. justification	A growing body of literature is exemplifying the importance of civil society/community participation in sustainable urban planning and execution, for example by means of smart city projects, to bring together information, knowledge and skills from diverse backgrounds to articulate the often ambiguous targets of smart cities and to create a sense of ownership over the outcomes (Healy 1999, Kasioumi 2011, Pollock and Sharp 2012). Moreover, public involvement is identified to have a positive effect on the agreement over solutions and acceptance of policy interventions through the creation of awareness (Driessen, Glasbergen and Verdaas 2001, Abdalla 2012). This indicator analyses the projects that were executed with active citizen participation. Active participation is defined as minimum level 3, 'Advise', based ob the scale of Arnstein (1969): 1. Not at all: No community involvement. The project idea came from the municipality and the project was designed and implemented without the community. 2. Inform and consult: The more or less completed project is announced to the community either for information only, or

	for receiving community views. The consultation, however, is mainly seeking community acceptance of the project. 3. Advise: the project implementation is done by a project team and then presented to community actors, who are invited to ask questions, provide feedback and give advice. Based on this input the planners may alter the project. 4. Partnership: community actors are asked by the project planners to participate in the implementation process. The local community is able to influence the implementation process. 5. Community self-development: the project planners have empowered community actors to outline their needs, to make action plans, to manage the project implementation and evaluate the results
Definition	The number of projects in which citizens actively participated as a percentage of the total projects executed
Calculation	
Strengths and weaknesses	Strengths: this indicator determines the actual result in citizen participation efforts and allows benchmarking with other cities. 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	The smart city coordinator and the strategy document should be able to provide the above information.
Expected availability	The information should be known/provided by the above sources.
Collection interval	Yearly
Expected reliability	Because of the subjectivity that cannot be excluded, this indicator is not 100% reliable.
Expected accessibility	The level of citizen participation is not regarded as sensitive information
References	
• Healy, P. “Institutional analysis, communicative planning and shaping places.” Journal of Planning Education and Research 19, no. 2 (1999): 111-121. • Kasioumi, E. “Sustainable Urbanism: Vision and Planning Process Through an Examination of Two Model Neighborhood Developments.” Berkeley Planning Journal 24 (2011): 91-114. • Pollock, V.L., and J. Sharp. “Real Participation or the Tyranny of Participatory Practice? Public Art and Community Involvement in the Regeneration of the Raploch, Scotland.” Urban Studies 49, no. 1 (2012): 3063-3079. • Driessen, P.P.J., P. Glasbergen, and C. Verdaas. “Interactive policy-making: A model of management for public works.” European Journal of Operational Research (Elsevier), no. 128 (2001): 322-337.	

- Abdalla, G. Sustainable Residential Districts: The residents' role in project success. Eindhoven: University of Technology, 2012. - Arnstein, S.R. “A Ladder of Citizen Participation.” JAIP 35, no. 4 (1969): 216-224. - Transform (2013). Definition of Smart Energy City - Definition, key elements and indicators. Transform, Deliverable 1.2

Open public participation	
Description incl. justification	Public participation encompasses varied opportunities for citizens, nongovernmental organizations, businesses, and others outside the federal government to contribute to and comment on proposed rules. The city will widen public exposure to the processes of policy planning and determination and will invite the public to respond to key issues on its agenda. It promotes democratic legitimacy by strengthening the connections between government agencies and the public they serve. This indicator shows the citizens level of commitment to the politics of this city. Higher amount of public participation processes promote an increased sense of belonging to the community and a better adjustment between what the citizens want and what is decided.
Definition	Number of public participation processes per 100.000 per year
Calculation	Calculation: (Total amount of open public participation processes/City population)*1000
Strengths and weaknesses	Strengths: This indicator is an absolute measure of the amount public participation processes and can be compared across cities. Weaknesses: definitions and interpretations of open public participation processes can vary.
Data requirements	
Expected data source	City administration
Expected availability	It is expected that this information is available with the above sources
Collection interval	Yearly
Expected reliability	The calculation can be made reliably.
Expected accessibility	Information on open public participation processes is by definition publicly available.
References	
- City protocol (2015). City Anatomy - City Indicators. CPWD-PR_002_Anatomy_Indicators	

Voter participation	

Description incl. justification	The percentage of the eligible voting population that voted in the last municipal election is an indicator of the public's level of participation and degree of interest in local government (ISO/DIS 37120, 2013). The vast majority of analysts, consider a high voter turnout to be preferable to a low turnout because it means that the government will more likely reflect the interests of a larger share of the population. Low voter turnout implies that the democratic system may not be reflecting the interests of all citizens. However, This indicator will only reveal the level of participation, not the level of satisfaction of the population. In some cases, high rates of participation will mean that the population is not satisfied with its local government's leadership and actions.
Definition	% of people that voted in the last municipal election as share of total population eligible to vote
Calculation	The voter participation in the last municipal election shall be calculated as the number of persons that voted in the last municipal election (numerator) divided by the city population eligible to vote (denominator). The result shall then be multiplied by 100 and expressed as a percentage: (people who voted/total voting population)*100 A result of zero shall be indicated if there have been no municipal elections in the last five years and this shall be noted in the comments. In countries where voting is mandatory, the per cent of votes (ballots) that are not blank or spoiled shall be reported. This will indicate the share of positive voter participation. There is a distinction between eligible to vote and registered to vote. In some countries people have to register (actively) in order to be allowed to vote. In all other countries, eligible and registered voters are one and the same. This should be noted.
Strengths and weaknesses	Strengths: This is an absolute indicator reflecting well the level of political participation. Weaknesses: Determining the underlying influences of declining voter turnout rates can be difficult. A low turnout may be due to disillusionment or indifference, or even complacent satisfaction with the way the country is being governed. Conversely, a high turnout rate may reflect compulsory voting laws (as in Australia and Belgium) or coercion.
Data requirements	
Expected data source	Information should be obtained from the local authorities, officials or the Ministry responsible for local governments.
Expected availability	It is expected that these numbers are available throughout Europe.

Collection interval	In accordance with the local political cycle (e.g. 4 years)
Expected reliability	The number of voters is expected to be highly reliable.
Expected accessibility	It is expected that these numbers are publically accessible.
References	
• ISO/DIS 37120 (2013). Sustainable development and resilience of communities — Indicators for city services and quality of life. ICS 13.020.20 • http://www.conferenceboard.ca/hcp/details/society/voter-turnout.aspx	

Multi-level governance

Smart city policy	
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
Calculation	Likert scale: Not at all – 1 — 2 — 3 — 4 — 5 — Very supportive 1. Not at all: the complete absence of a long-term smart city vision (including and absence of long-term targets & goals) from the side of the government or an opposing vision create a difficult environment for starting smart city initiatives. 2. Poor: The long-term vision of the government does, to some extent, hamper the environment for smart city initiatives. 3. Neutral: The long-term vision of the government has had

	no significant, positive or negative, impact on the environment for smart city initiatives. 4. Somewhat supportive: The long-term vision of the government has to some extent benefitted the environment for smart city initiatives. The city has created roadmaps and actions to support vision implementation 5. Very supportive: The comprehensive long-term vision on the future of the city stimulates the environment for smart city initiatives to a great extent.
Strengths and weaknesses	Strengths: This indicator assesses various aspects of the local policy (e.g. vision, targets, roadmaps) and still allows for benchmarking with 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 Smart city may differ between cities.
Data requirements	
Expected data source	To be derived from policy documents and/or an interview with the smart city coordinator
Expected availability	The required information will be easily available with the above sources.
Collection interval	Yearly
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	
• 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. • Glemarec, Y. Catalysing Climate Finance: A Guidebook on Policy and Financing Options to Support Green, Low-Emission and Climate-Resilient Development. New York: United Nations Development Programme, 2011. • 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.	

Expenditures by the municipality for a transition towards a Smart City	
Description incl. justification	One of the ways in which the municipality can support the transition towards a smart city, next to a supportive framework, establishment within the administration and cross-departmental integration, is by providing financial resources. Smart city expenditures include process relevant expenditures and fundings.
Definition	Annual expenditures by the municipality for a transition towards a Smart City
Calculation	(Total annual expenditures by the municipality for a transition towards a Smart City/total population)
Strengths and weaknesses	Strengths: This indicator is relevant to the support for smart city initiatives Weaknesses: Further definition on what are smart city expenditures is necessary. Progress towards a smart city is seen as a cooperative and co-creative process in which the city administration does not play a dominant role. This implies that large annual expenditures are not necessarily preferable ('more' does not automatically 'better').
Data requirements	
Expected data source	City administration
Expected availability	Information on city budgets should be easy to retrieve from the above source, but allocation of the expenditures to smart city objectives might proof more difficult.
Collection interval	Yearly
Expected reliability	The reliability is expected to be good
Expected accessibility	Information on city expenditures is public information
References	
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Multilevel government	
Description incl. justification	Smart city developments benefit from alignment of objectives throughout layers of government, both vertically (regional/national level) and horizontally (other cities). This makes it easier to implement projects in general and in different cities in particular. Moreover, lessons learned can be transferred. The level of cooperation with other municipalities and/or other

	levels of government will be evaluated by analyzing the frequency of consultation or coordination in the planning and decision-making processes and the extent to which partnerships have been established atlocal, regional level, national level, European and/or international level.
Definition	The extent to which the city cooperates with other authorities from different levels
Calculation	Likert scale: Not at all – 1 – 2 – 3 – 4 – 5 - Very much 1. Not at all: there is no cooperation or coordination with other municipalities and/or other levels of government whatsoever. 2. Poorly: there is little cooperation with other authorities, but this is irregularand very dependent of the people involved. 3. Somewhat: there is some cooperation or coordination with other municipalities and/or other levels of government, which is formalized in a partnership policy. 4. Good: there is good cooperation or coordination with other municipalities and/or other levels of government, which is formalized in partnership policies and in process through regular participation in meetings. 5. Excellent: the city is a driving force in the cooperation or coordination with other municipalities and/or other levels of government, which is formalized in policy and in process through regular meetings initiated by the city.
Strengths and weaknesses	Strengths: 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 administration and smart city coordinator
Expected availability	Information on meetings and policies will be regularly available.
Collection interval	Yearly
Expected reliability	Because of the subjectivity that cannot be excluded, this indicator is not 100% reliable.
Expected accessibility	This information is not regarded as sensitive
References	
• RFSC: http://www.rfsc-community.eu/resources/rfsc-step-by-step/	

APPENDIX 3: RELATION BETWEEN CITY AND PROJECT INDICATORS

People

Health

PROJECT indicator (title)	Unit	Related CITY indicator(s) (title)	Unit
Improved access to basis health care services	Likert	Access to basic health care services	% of people
Encouraging a healthy lifestyle	Likert	Encouraging a healthy lifestyle	Likert
Waiting time	% in hours		

Safety

PROJECT indicator (title)	Unit	Related CITY indicator(s) (title)	Unit
Reduction of traffic accidents	% of fatalities	Traffic accidents	#/100.000
Reduction in crime rate	% of crimes	Crime rate	#/100.000
Improved cybersecurity	Likert	Cybersecurity	Likert
Improved data privacy	Likert	Data privacy	Likert

Access to (other) services

PROJECT indicator (title)	Unit	Related CITY indicator(s) (title)	Unit
Access to public transport	Likert scale	Access to public transport	% of people
Quality of public transport	Likert scale		
Improved access to vehicle sharing solutions	Likert scale	Access to vehicle sharing solutions for city travel	#/100.000
Extending the bike route network	% in km	Length of bike route network	% in km
Access to public amenities	Likert scale	Access to public amenities	% of people
Access to commercial amenities	Likert scale	Access to commercial amenities	% of people
Increase in online government services	Likert scale	- Access to high speed internet - Access to public free WiFi	#/100 % in m2
Improved flexibility in delivery services	Likert scale	Flexibility in delivery services	Likert scale

Education

PROJECT indicator (title)	Unit	Related CITY indicator(s) (title)	Unit
Improved access to educational resources	Likert	Access to educational resources	Likert
Increased environmental awareness	Likert	Environmental education	% of schools
Improved digital literacy	Likert	Digital literacy	% of people

Diversity and social cohesion

PROJECT indicator (title)	Unit	Related CITY indicator(s) (title)	Unit
People reached	% of people		
Increased consciousness of citizenship	Likert		
Increased participation of vulnerable groups	Likert		

Quality of housing and the built environment

PROJECT indicator (title)	Unit	Related CITY indicator(s) (title)	Unit
Diversity of housing	Simpson Diversity Index/Social housing	Diversity of housing	Simpson Diversity Index/Social housing
Connection to the existing cultural heritage	Likert scale	Preservation of cultural heritage	Likert
Design for a sense of place	Likert scale		
Increased use of groundfloors	% in m2	Ground floor usage	% in m2
Increased access to urban public outdoor recreation space	m2	Public outdoor recreation space	m2/cap
Increased access to green space	m2	Green space	hectares/ 100.000

Planet

Energy & mitigation

PROJECT indicator (title)	Unit	Related CITY indicator (title)	Unit
Reduction in annual final energy consumption	% in kWh	Annual final energy consumption	MWh/cap/yr
Reduction in lifcycle energy use	% in kWh		
Reduction of embodied energy of products and services used in the project	Likert		
Increase in local renewable energy production	% in kWh	Renewable energy generated within the city	% in MWh
Carbon dioxide emission reduction	% in tonnes	CO2 emissions	t CO2/cap/yr
Reduction in lifecycle CO2 emissions	% in tonnes		
Maximum Hourly Deficit	MHDx		
Local freight transport fuel mix	% in kms	Local freight transport fuel mix	% in kms

Materials, water and land

PROJECT indicator (title)	Unit	Related CITY indicator (title)	Unit
Materials			
Increased efficiency of resources consumption	% in tonnes	Domestic material consumption	t/cap/year
Share of recycled input materials	% in tonnes		
Share of renewable materials	% in tonnes		
Share of materials recyclable	% in tonnes		
Life time extension	Likert		
Water			
Reduction in water consumption	% in m3	- Water consumption - Water losses	liters/cap/year % of m3
Increase in water re-used	% in m3	Grey and rain water use	% of houses
Self-sufficiency - Water	% in m3	Water Exploitation Index	% of m3
Land			
Increase in compactness	% of people or workplaces	Population density Brownfield use	#/km2 % of km2
Self-sufficiency - Food	% in tonnes	Local food production	% of tonnes

Climate resilience

PROJECT indicator (title)	Unit	Related CITY indicator (title)	Unit
Climate resilience measures	Likert scale	- Climate resilient strategy - Urban Heat Island	Likert scale °C UHImax

Pollution and waste

PROJECT indicator (title)	Unit	Related CITY indicator (title)	Unit
Decreased emissions of Nitrogen oxides (NOx)	% in tonnes	Nitrogen oxide emissions (NOx)	g/cap
Decreased emissions of Particulate Matter (PM2,5)	% in tonnes	Fine Particulate Matter emissions (PM2.5)	g/cap
		Air quality index	Index
Reduced exposure to noise pollution	% in dB	Noise pollution	% of people
Reduction in the amount of solid waste collected	% in tonnes	Municipal solid waste Recycling rate	tons/cap/yr % of tonnes

Ecosystem

PROJECT indicator (title)	Unit	Related CITY indicator (title)	Unit
Increase in green and blue space	% in m2	Share of green and water spaces	% in km2
Increased ecosystem quality and biodiversity	Likert	Change in number of native species	# of species

Prosperity

Employment

PROJECT indicator (title)	Unit	Related CITY indicator (title)	Unit
Increased use of local workforce	% in euros		
Local job creation	# of jobs	- Uneployment rate - Youth unemployment rate	% of people % of people

Equity

PROJECT indicator (title)	Unit	Related CITY indicator (title)	Unit
Fuel poverty	%-points in euros	Fuel poverty	% of households
Costs of housing	% in euros	Affordability of housing	% of people

Green economy

PROJECT indicator (title)	Unit	Related CITY indicator (title)	Unit
Certified companies involved in the project	% of companies	Share of certified companies	% of companies
Green public procurement	Likert scale	Share of Green Public Procurement	% in €
CO2 reduction cost efficiency	€/ton CO2 saved/year		
		Green jobs	% of jobs
		Freight movement	# of movements

Economic performance

PROJECT indicator (title)	Unit	Related CITY indicator (title)	Unit
Financial benefit for the end-user	€/household/yr		
Net Present Value (NPV)	€		
Internal rate of return (IRR)	% (interest)		
Payback Period	yrs		
Total cost vs. subsidies	% in euros		
		Gross Domestic Product	€/cap
		New business registered	#/100.000
		Median disposable lncome	€/household

Innovation

PROJECT indicator (title)	Unit	Related CITY indicator (title)	Unit
Involvement of extraordinary professionals	Likert		
Stimulating an innovative environment	Likert scale	- Creative industry - Innovation hubs in the city - Open data - Research intensity	% of people #/100.000 #/100.000 % in euros
Quality of open data	# stars	Accessibility of open data sets	# stars
New startups	# of startups		
Improved interoperability	Likert scale		

Competitiveness and attractiveness

PROJECT indicator (title)	Unit	Related CITY indicator (title)	Unit
Decreased travel time	% in hours	Congestion	% in hours
		Public transport use	#/cap/year
		Net migration	#/1000
		Population Dependency Ratio	#/100
		International Events Hold	#/100.000
		Tourism intensity	#/100.000

Governance

Organisation

PROJECT indicator (title)	Unit	Related CITY indicator (title)	Unit
Leadership	Likert scale		
Balanced project team	Likert scale	Cross-departmental integration	Likert scale
Involvement of the city administration	Likert scale	Establishment within the administration	Likert scale
Clear division of responsibility	Yes/no		
Continued monitoring and reporting	Likert scale	Monitoring and evaluation Availability of government data	Likert scale Likert scale
Market orientation	Likert scale		

Community involvement

PROJECT indicator (title)	Unit	Related CITY indicator (title)	Unit
Professional stakeholder involvement	Likert scale		
- Bottom-up or top-down initiative - Local community involvement in planning phase - Local community involvement in implementation phase	Yes/no Likert scale Likert scale	Citizen participation	% of projects
Participatory Governance	% of people	Open public participation	#/100.000
		Voter participation	% of people

Multi-level governance

PROJECT indicator (title)	Unit	Related CITY indicator (title)	Unit
Smart city policy	Likert scale	Smart city policy	Likert scale
Municipal involvement - Financial support	Likert scale	Expenditures by the municipality for a transition towards a Smart City	€/capita
		Multilevel government	Likert scale

Propagation

No indicators on the city level.