CITYkeys

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Deliverable 3.3
Recommendations for a smart city index

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Lead contractor............................. TNO

Authors:

Peter Bosch .... TNO
Sophie Jongeneel......................... TNO
Hans-Martin Neumann.................. AIT
Iglar Branislav............................... AIT
Aapo Huovila .... VTT

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No & name	**D3.3 Recommendations for a smart city index**									
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Description of the related task and the deliverable in the DoW	Participants: TNO (leader), VTT, EUR, TAM, ROT, VIE, ZGZ, ZAG Estimated effort: 6.3 person months. Time schedule: m17 -23 This task will draft concepts for a European certification scheme and for a smart city index. To do so, it will: • Build on existing efforts for smart city indexes • Define / develop a standardisation system that enables the comparability of smart city projects between European cities, and • Elaborate a recommendation for a smart city index that aggregates project KPI's to an overall score The aim is to develop a smart city index that can be aggregated to the city level or disaggregated to the project level, for example: "x smart projects in y neighbourhoods lead to a CO2 emission reduction of z on the scale of the city". This quantification of impacts also means that the KPI's used need to be added up (e.g. total CO2 emission reduction), or they can be of a more qualitative nature (e.g. amount of hectares of the city involved in smart projects). Moreover, the smart city index should be flexible enough for different kinds of projects and cities to work with (e.g. small/large, good data management system y/n, simple or advanced projects etc.), yet there will be a minimum amount of information that needs to be available in order to be able to serve its purpose.									
Planned resources PM	VTT	AIT	TNO	EUR	TAM	ROT	VIE	ZGZ	ZAG	Total
	1	1,5	1	0,5	0,2	0,7	1	0,2	0,2	6,3
Comments										

V	Date	Authors	Description
0	2016-06-24	Sophie Jongeneel	Memo turned into deliverable
0	2017-01-04	Peter Bosch	Almost final for AIT and VTT
0	2017-01-16	Peter Bosch	Review version
0	2017-01-30		

Table of contents

PUBLISHABLE EXECUTIVE SUMMARY

The CITYkeys project has resulted in a set of indicators for assessing the success of smart city projects, which is linked to a set of indicators for smart cities. Since the 1990s various city sustainability indices have been developed that aim to provide a ranking of cities. More recently organisations supplying green certification schemes for buildings have moved into green certification of neighbourhoods, districts and in an extreme case even cities. Both developments provide inputs on indicators selection, aggregation methods, weighting of variables into the discussion on a possible aggregation of the CITYkeys indicators into, eventually, a smart city index.

Cities themselves indicate that there is very limited use of (if not aversion to) city indices in city governance. They note that several of the “green” or sustainability indices are being made by commercial parties who seem to have identified a business case in providing services to cities that want to improve their ranking on a specific index. For their own policy making, the unicity of each city is what counts and not the position on a smart city index ranking.

In addition, many rankings produced are based on relative positions among the other entities. That does not provide much information on the absolute state of a city, which may be unsustainable.

Nevertheless, the CITYkeys project indicators can easily be aggregated into scores per theme, that eventually might be added to one score. An additional KPI coverage score is proposed as indicator for the quality of such an assessment.

1. INTRODUCTION

1.1 Purpose and target group

CITYkeys aims to speed up the transition to low carbon, resource-efficient cities by facilitating and enabling stakeholders in smart city projects and cities to learn from each other, create trust in solutions, and monitor progress, by means of a common performance measurement framework.

The ultimate goal is to support the wide-scale deployment of smart city solutions and services in order to create impact on major societal challenges related to the cities' fast growth and the Union's 20/20/20 energy and climate targets.

- Cities will benefit from the CITYkeys results as they support their strategic planning and allow measuring their progress towards smart city goals. In addition, benefits are created from the enhanced collaboration within and between cities, providing the possibility to compare solutions and to find best practices.
- Solution providers will benefit from better insight into business opportunities for their products and services, and into the possibilities for replication in a different city or context.
- Industrial stakeholders will benefit from the recommendations for new business, e.g. based on open data.

All these opportunities should bring environmental benefits such as reduction of CO_2 emissions, increased energy efficiency, increased share of renewables, as well as improve the quality of life through better mobility, better communication between local authorities and their citizens, empowerment of citizens.

The CITYkeys indicator framework focuses on the assessment of individual smart city projects and therefore provides a range of project indicators applicable for a large variety of smart city projects. These indicators are linked to corresponding indicators on the city level. Both for the project and the city-level, the basis of the CITYkeys indicator framework are the traditional sustainability impact categories **People, Prosperity and Planet**. The framework however goes beyond these by including indicators of the success factors for smart city endeavours (**Governance**) and the suitability for dissemination of projects to other cities and circumstances (**Propagation**).

The transparent and flexible CITYkeys performance measurement framework can be applied to a large variety of smart city projects and works for cities of different size and in different stage of smart city development. For comparison between projects and cities, aggregations of indicators in a single number score are sometimes considered useful

This report explores existing city indices and certification schemes, and confronts this to the requirements of cities and city stakeholders. It is written for an audience of indicator developers in cities and (inter)national organisations.

1.2 Contributions of partners

This report has been compiled by AIT and TNO, on the basis of a cooperative city index analysis by TNO, VTT and AIT. Following on the inventory of existing city indices, all the project partners, including the Cities of Vienna, Tampere, Zaragoza, Zagreb and Rotterdam, have evaluated the existing indices and designed recommendations for the use of aggregation methods in the CITYkeys context.

1.3 Baseline

In recent years, several indicator frameworks for the performance measurement of urban systems have been developed within the European Framework programs FP6, FP7, and H2020, as well as part of other European initiatives, such as the Covenant of Mayors, the Reference Framework for Sustainable Cities, or the Green Digital Charter ((Neumann et al, 2015). However, many of these initiatives are either focused on performance on the city level (i.e. measuring a state, but not the performance of projects that influence this state) or on a specific sector (e.g. ICT, transport, energy). Before the CITYkeys project, there was is no European Indicator Framework so far for assessing success and progress in smart city projects and smart cities, as described in the Strategic Implementation Plan (EIP, 2013) and the Operational Implementation Plan on Smart Cities and Communities (EIP,n.d.). Needless to say that none of the initiatives has developed a single index to assess the smartness of cities. The CITYkeys project has so far proposed a set of indicators for assessing smart city projects with linked indicators on the city level[1]. This report continues the exploration of existing developments in indices and certification schemes to arrive at recommendations for aggregation and presentation of a smart city index.

1.4 Relation to other activities

This report builds on D4.1 the selection of project and city-indicators[1] and D2.4 the testing of the indicator framework in the partner cities. Like all CITYkeys products it builds on the experience gained in academic and commercial work on city sustainability indices and building- and neighbourhood certification schemes.

[1] Peter Bosch, Sophie Jongeneel, Vera Rovers, Hans-Martin Neumann, Miimu Airaksinen, Aapo Huovila, 2016. Smart City (project) KPIs and related methodology. CITYkeysCITYkeys report.

2. About Smart City Indices

2.1 What is a smart city index?

A smart city index aggregates the "smartness" of a city into one number.

An "index" is a quantitative aggregation of many indicators and aims to provide a simplified, coherent, multidimensional view of a system. Indices usually give a static overview of a system, but when calculated periodically, they can indicate whether the system is becoming more or less [smart], and can highlight which factors are most responsible for driving the system (Mayer, 2008).

Driving factors for smart cities may include smart city policies, city budget for smart city development projects, a smart city-minded leadership, desire for an innovative environment etc. Progress can be measured using a composite of indicators. A composite of output indicators may give insight into the extent to which the city is becoming "smarter" in terms of the amount of technology that is used; however a composite of impact indicators may be more useful if you consider the smartness as a means to an end (i.e. providing a better quality of life, economic climate and an improved environment).

2.2 How are they used/should they be used?

Indices can be powerful tools to influence policy in a competitive environment as they make it possible to do rankings. On the other hand, to really understand the factors influencing the index, it is necessary to know the underlying indicators and data. In many cases, there is no transparency with regard to these underlying information.

There is a strong political desire of governments for the comprehensive assessment of changes in economic, environmental, and social conditions. With regards to city sustainability, the triple bottom line plays an important role because cities mainly contribute to economic and social aspects rather than environmental aspects of sustainability due to environmental externalities. An important requirement is that cities should remain in a healthy condition over time without paralysis and malfunction in terms of environmental, economic and social dimensions (Mori, 2012).

Indicators and composite indices are gaining a lot of importance and are increasingly recognized as a powerful tool for policy making and public communication in providing information on countries and corporate performance in fields such as environment, economic, social, or technological improvement (Singh 2012).

Four major purposes in assessment are identified:

- decision making and management,
- advocacy,
- participation and consensus building,
- and research and analysis.

Ideally, the goal of city indices is to help city stakeholders to better understand their specific challenges, provides them insights into effective policies and best practices and supports their decision making (Siemens Green City Index).

Policy makers demand an aggregate index that can be unambiguously interpreted and easily communicated to the general public (Bohringer, 2007). Developers of [smart city] indices must make the limitations of the index very clear, particularly to decision-makers who may have little insight into methodological issues. Without a clear understanding of how the indicators interact with each other and influence the index results, policy decisions could increase economic disparities, environmental damage, and decrease possibilities for long-term sustainability (Mayer, 2008).

2.3 What are they made up of?

Should the index be based on all indicators or on a (to be determined) core set of indicators?

Indices are built up of indicators (Bohringer, 2007). In the same way as it is necessary for the development a set of indicators, also for constructing a composite index a policy goal has to be clearly defined. The components and sub-components then need to be determined based on theory, empirical analysis, pragmatism or intuitive appeal, or some combination of these methods (Singh, 2012).

With regard to the selection of indicators to be included, depending on how the index is to be used, one could think of for example:

- Include only the indicators that are applicable in all contexts (overall smartness) or only use the indicators that apply to a certain sector (e.g. smart mobility)
- Striking a balance between output and impact indicators
- A well-thought approach on how to deal with qualitative and quantitative indicators (i.e. if the index is used to promote competition, the standards for comparability will need to be high)

2.4 Criteria for a good index

Transparency is key. The index needs to be easy to understand, yet scientifically sound.

According to Mori (2012), the key conceptual requirements for an adequate [smart city] index are:

	Requirement	**Met within CITYkeys?**
1	To consider environmental, economic and social aspects (the triple bottom line of sustainability) from the viewpoint of strong sustainability (i.e. no substitutions)	±
2	To capture external impacts (leakage effects) of city on other areas beyond the city boundaries particularly in terms of environmental aspects	±
3	To create indices/indicators originally for the purpose of assessing [smart cities]	√
4	To be able to assess [European] cities in different stages of development using common axes of evaluation.	To be seen

Bohringer (2007) states the following key requirements for setting up an indicator system from policy goals through indicators and data to index:

	Requirement	**Met within**

		CITYkeys?
1	The rigorous connection to the definitions of [smart] cities	√
2	The selection of meaningful indicators representing holistic fields	√
3	Reliability and availability (measurability) of data for quantification over longer time horizons[2]	To be seen
4	Process oriented indicator selection	√
5	The possibility of deriving political (sub) objectives	√

2.5 Aggregation

Theoretically, both from a policy perspective as from a scientific perspective, a "ranking" is not desirable. Relative positions among the spatial entities do not tell us whether they are sustainable or not. Even though a country is considered sustainable in a relative evaluation, it may be non-sustainable in absolute terms. Measuring relative performance is meaningless if all countries are on unsustainable trajectories (Mori, 2012). However, since it can be expected that rankings will be made whether we like it or not, how should they be constructed and treated?

2.5.1 Normalization and weighting

A weighting system and method employed in aggregating component scores plays a predominant role for development of composite indices. Normally implicit weights are introduced during scaling and explicit weights can be introduced during aggregation (Singh, 2012). All aggregation methods have biases which can influence the final result. No index is immune to this problem, and therefore end users of any index should understand how they are calculated and how the methodology may influence their performance. Several methodological issues should be understood when assessing [smart city] index performance, including (Mayer, 2008):

- the predetermined boundaries of the system;
- the data included in the analysis; the normalization and weighting methods;
- the aggregation method;
- and the comparability of results across systems.

Additional requirements include (Mayer, 2008):

- adequate normalization (to make data comparable);
- aggregation (to get the right functional relationship);
- and weighting (to specify the correct interrelationships)[3].

2.5.2 Calculations

One of the most straightforward and common aggregation methods is to simply add or average the data (Mayer, 2008). The aggregation rules of Table 1 provide minimal

[2] A notational system called NUSAP (an acronym for five categories: Numeral, Unit, Spread, Assessment, Pedigree) can be used to characterize the quality of quantitative information (Singh, 2012).

[3] As there are no general rules about weighting, it should be done in a very transparent way and open to sensitivity analysis (Bohringer, 2007; Singh, 2012).

methodological requirements to be met by any meaningful [smart city] index (Bohringer, 2007):

Table 1 – Aggregation rules for variables by Ebert and Welsch

	Non-comparability	Full comparability
Interval scale	Dictatorial ordering	Arithmetic mean
Ratio scale	Geometric mean	Any homothetic function[5]

Note: In dictatorial ordening exactly one variable is decisive for the ordening (Ebert and Welsch, 2004).

Furthermore, giving all indicators equal weighting assumes that they have equal influence over [smart cities]. If all indicators are weighted equally, but there are many more indicators for one subject (such as environmental conditions), the more prevalent subject is given more influence over the final index values. It is of course possible to correct for this phenomenon. While simply adding up indicators may be a simple and transparent aggregation method, an additive relationship may not accurately reflect actual [smart city] conditions, particularly if indicators are added across social, economic, and environmental dimensions with nonlinear or otherwise complex relationships (Mayer, 2008; Mori, 2012).

3. Examples of indicator selections and aggregation methods in City indices

This section provides an overview of indices for smart cities. It describes the indicators, their structure, methods for aggregating indicators into an index and target groups of each of the indices. A summary of main properties can be found at the end of this section.

3.1 Arcadis Sustainable cities index

Type of indicators: 20 input indicators were taken into account to compile the Sustainable Cities Index, comprising nine for the People sub-index; six for the Planet sub-index and six for the Profit sub-index (property prices appearing twice). Some indicators, such as transport infrastructure, are deemed to have importance to multiple sub-indices, where this is the case these indicators are suitably discounted before entering the overall score to avoid double counting. Where one indicator appears in more than one sub-index (for example, transport appears in both People and Profit indices), it enters the overall Sustainable Cities Index only once.

Calculation to compute the composite: The data behind these indicators was processed so that higher scores represent more sustainable cities, and give the highest-ranked city in each indicator a score of 100%, while the lowest-ranked city receives 0%, so that each city's performance within each category is measured relative to each of the other 49 cities. By averaging the indicators, a score for every city in each of the three sub-indices is derived and combined to deliver an overall score. The output is a percentage score: theoretically a city could attain 100% if it came top in every category, but in reality no city does – the highest score, that of Frankfurt, is 70%. Otherwise the overall Sustainable Cities Index score is comprised of one third of the scores on each of the sub-indices. Table 2 provides an overview of each of the indicators that enter the Sustainable Cities Index.

Target groups: cities are now subject to frequent assessment with the results often used by city leaders to inform decision-making and to sharpen their competitive edge. The hope of Arcadis is that city leaders find this to be a valuable tool in assessing their priorities and pathways to urban sustainability for the good of all.

Source of information: Arcadis 2015; https://s3.amazonaws.com/arcadis-whitepaper/arcadis-sustainable-cities-index-report.pdf

Table 2:
Sustainable cities indicators

Indicator		People	Planet	Profit	Source	Description
Literacy		•			World Bank World Development Indicators	Adult total literacy rate (% of over 15s who can read and write)
Education		•			QS World University rankings	University scores based on six categories
Green spaces		•			Siemens Green City Index, municipality websites, others	Percentage of green space within city area (parks or undeveloped nature)
Health		•			World Bank World Development Indicators	Life expectancy at birth
Dependency ratio		•			World Bank World Development Indicators	Ratio of economically active population to economically inactive population
Income inequality		•			World Bank World Development Indicators	Gini coefficient (0=perfect equality, 1=all income goes to one person)
Work-life balance		•			International Labour Organization, UBS and OECD	Average hours worked per employee per year
Property prices		•			UBS prices and earnings and Numbeo	Purchase price for residential property, $US per sq meter
Transport infrastructure (composed of–)	Public transport	•		•	Siemens Green City Index, others	Density of public transport network, km/km2
	Commuting time				TomTom traffic index, Numbeo commuting times	One-way commute time
	Rail infrastructure				World Metro Database	Kilometers of metro/light rail network per capita
	Airport satisfaction				Skytrax World Airport Awards	Survey of customer satisfaction in airports
Energy use and renewables mix (composed of–)	Energy consumption		•		Energy Information Administration	Primary energy consumption per capita
	Renewable consumption				Energy Information Administration	Share of renewable energy in energy mix (country-level)
Natural catastrophe exposure			•		EM-DAT: International Disaster Database	Number of categories of natural catastrophe (out of a possible 8) that a city has been affected by
Air pollution			•		World Health Organization Ambient Air Pollution Database	Annual mean concentration of fine particulate matter
Greenhouse gas emissions			•		Carbon Disclosure Project	Total CO_2 emissions
Solid waste management			•		World Bank	Rates of landfill/recycling/compost/waste-to-energy of solid waste
Drinking water and Sanitation (composed of…)	Drinking water		•		WHO/Unicef Joint Monitoring Program for Water Supply and Sanitation	Urban improved (e.g. piped) drinking water (as opposed to unimproved, e.g. surface)
	Sanitation					Urban improved sanitation facilities (as opposed to unimproved)
Energy efficiency				•	Energy Information Administration	Total energy consumption per dollar of GDP
Importance to global networks				•	Globalization and World Cities (GaWC) Research Network	Measures how integrated a city is into the world's network of cities
GDP per capita				•	Brookings institute	Gross domestic product per capita
Ease of doing business				•	World Bank Ease of Doing Business Index	Composite indicator of EoDB including regulations, corruption, etc
Cost of doing business	Goods and services costs			•	UBS Prices and Earnings	Comparison of goods and services costs across cities
	Property prices				UBS prices and earnings and Numbeo	Purchase price for residential property, $US per sq meter

Figure 1 Arcadis Sustainable Cities Index indicators

3.2 City protocol

Type of indicators: The indicator framework builds up on the existing ISO 37120 standard considering 46 core and 56 supporting indicators and enhances these with 59 additional core and 37 additional supporting indicators. A holistic concept called city anatomy is used as underlying framework. The comparison of aspects covered by the ISO standard with the city anatomy was basis for choosing additional indicators that are not covered by the current standard. City protocol defines key questions that should be placed in order to face main challenges of cities worldwide. These questions are also basis for distinguishing core indicators from supporting ones.

Calculation to compute the composite: Current public documents of the initiative refer to a certification pyramid structure, however according to this source the current work focuses on the definition of an indicator framework to build up a strong basis for a performance assessment. An aggregation method for this indicator framework could not be identified.

Target groups: ”Cities and their Initiatives are the users of City Protocol” (http://www.cptf.cityprotocol.org/CPAI/CPA-I_001-v2_Anatomy.pdf).

Source of information: http://www.cptf.cityprotocol.org/CPAPR/CPA-PR_002_Anatomy_Indicators.pdf

3.3 European Green Capital Award

Type of indicators: For the last assessment cycle (2018) twelve indicator areas have been used. Each indicator area comprises of four qualitative descriptions indicating short- and long-term commitments in the form of adopted measures and approved budgets. In a peer-review process each indicator is being evaluated by prominent experts in the respective field. The result is ranking per indicator for each of the cities. Results for (three) short-listed cities are being published in a Technical Assessment Synopsis Report. Short-listed cities are invited to submit further information for a second round of evaluation. A jury decides about the winner of the award after assessing three evaluation criteria.

Calculation to compute the composite: The aggregation resulting in the selection of short-listed cities is not explained at the website nor could be found in the description of the methodology within the assessment reports.

Target groups: The award is being granted to motivate other cities in following the role of winners and to share best practices. Main target groups are municipal administrations and politicans.

Source of information: http://ec.europa.eu/environment/europeangreencapital/wp-content/uploads/2016/05-2016/egca_2018_technical_assessment_synopsis_report.pdf

3.4 TU-Wien European Smart Cities

Type of indicators: The model considers in its fourth version 90 indicators within six key fields of urban development – smart economy, smart mobility, smart environment, smart people, smart living and smart governance. Each of the key fields consists of domains grouping one or more indicators.

Calculation to compute the composite: The aggregation is performed by adding together standardised values of indicators within the different domains. The standardisation process uses the z-transform method: $z_i = (x_i - \bar{x}) / s$. This way all indicators are transferred into values with average 0 and standard deviation 1. The aggregation considers the coverage rate of each indicator. The sum of all values is divided by the number of them. Benchmarking is performed by using a system diagram visualising the six key fields with usually three cities. A ranking of cities is possible by selecting one of the rankings within the key fields or a result thereof. A final ranking over the six domains is available as well however the method could not be identified from the available sources.

Target groups: not indicated but most likely local administrations

Source of information: http://www.smart-cities.eu

3.5 Innovation Cities Index by 2thinknow

Type of indicators: The basis of the Index is the Innovation Cities Framework analysis of Factors, Segments, Indicators and Data Points. Each of these indicators contain a mix of data points combining multiple sources. The 162 city indicators across 31 industry and community segments, weighted and are summed up into 3 “factors”: Cultural Assets of a city from arts to sports industries. Human Infrastructure, from mobility to start-ups, health, finance and more. Networked Markets, the power of a city in a networked world. Each factor is divided into “segments”. These segments are designed to capture the modern innovation economy in its completeness, across different countries and cultures.

Calculation to compute the composite: The Innovation Cities Index classifies all cities into 5 classes for innovation, based on their 3 factor band score and on 2thinknow analyst interpretation. In descending order of importance to the global innovation economy: NEXUS: Critical nexus for multiple economic and social innovation segments; HUB: Dominance or influence on key economic and social innovation segments, based on global rends; NODE: Broad performance across many innovation segments, with key imbalances; INFLUENCER: Competitive in some segments, potential or imbalanced; UPSTART: Potential steps towards relative future performance in a few innovation segments. Improvement in multiple segments is captured in the Innovation Cities Indexes by upward movement towards higher classifications.

Target groups: Cities are selected based on health, wealth, population and geographical factors. Indicators are observed and collected for all major cities. Innovation City Indexes are an introduction to Program Products and Packages which City Government can participate in to communicate and improve each cities economic and social development through innovation.

Source of information: http://www.innovation-cities.com

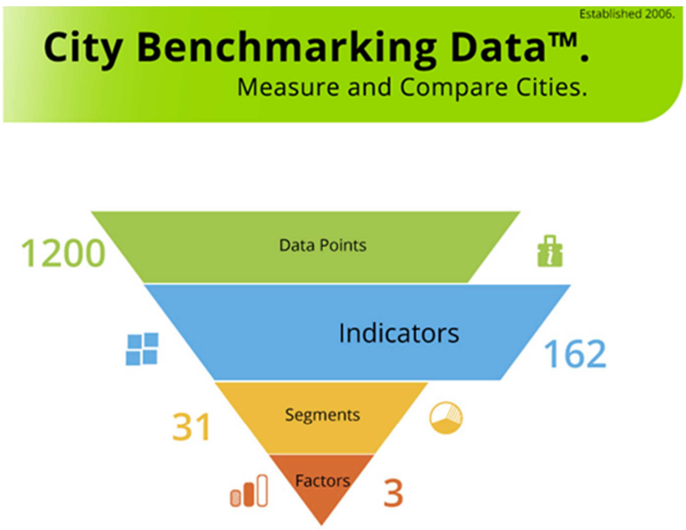

Figure 2 Indicator structure of the Innovation Cities Index (Source: http://www.citybenchmarkingdata.com/indicators)

3.6 ISO 37120 and it's application by the Global City Indicators Facility

Type of indicators: The standard consists of 100 indicators within 17 themes. 46 core (mandatory) indicators and 54 supporting (recommended) indicators are being used. Although most of the indicators are defined as percentages several have individual units depending on their kind. Core indicators include themes related to sustainability assessment (environmental, economic and social performance). (www.dataforcities.com)

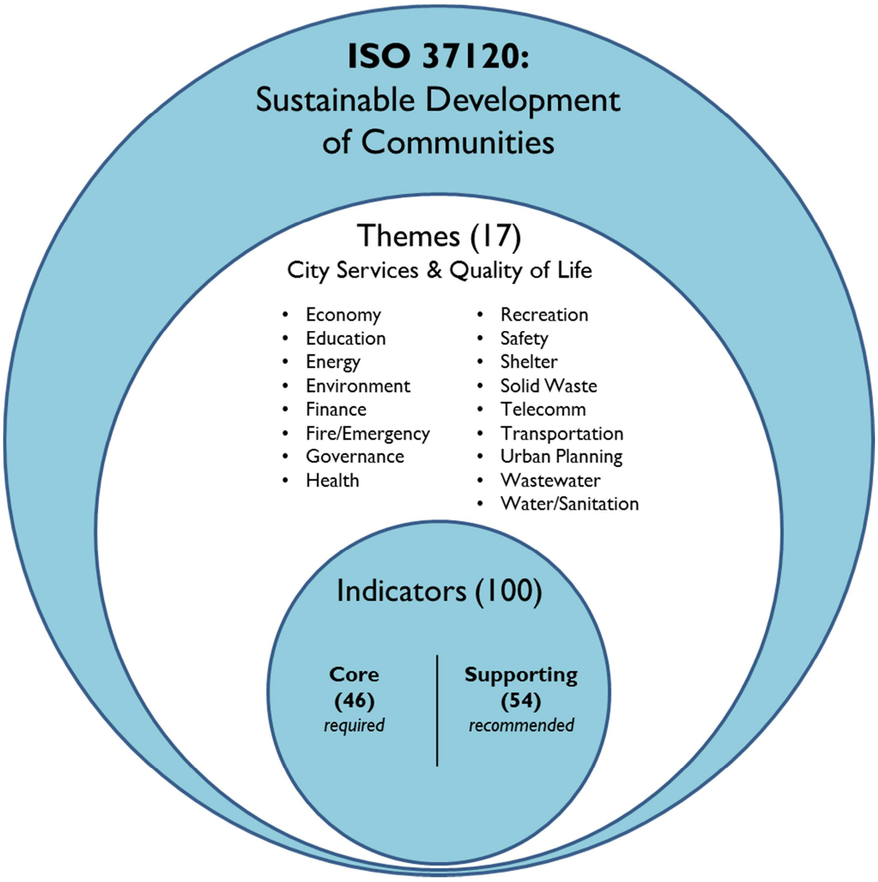

Figure 3 Composition of ISO 37120

Calculation to compute the composite: The indicators are defined in a way so that they can be aggregated to larger areas (e.g. administrative units) (ISO 37120). An aggregation of indicators throughout the areas is not foreseen. Indicators are visualised at the website www.dataforcities.com for available cities for each year a city has been evaluated. The indicators facility grants awards to cities based on the amount of data provided. This fact distinguishes the initiative from certification schemes, which provide awards mostly based on a calculated performance of a city. This approach is very interesting since it avoids benchmarking cities under different conditions and motivates municipalities to provide a larger amount of data.

Target groups: Target groups are local politicians and municipal administration as well as other stakeholders involved in the urban development process. By publishing the results of indicators to public the target group is enlarged also to citizens and all other interested individuals.

Source: http://www.deeproot.com/blog/blog-entries/how-iso-standardized-city-indicators-could-change-the-way-we-design

3.7 ITU FG-SSC

Type of indicators: The framework includes 88 indicators within six sub-dimensions: Information and communication technology, environmental sustainability, productivity, quality of life, equity and social inclusion and non-ICT infrastructure development. The framework consists of infrastructure with data layer and communications layer (ICT), sensing layer and physical infrastructure (non-ICT infrastructure) and applications (all other sub-dimensions).

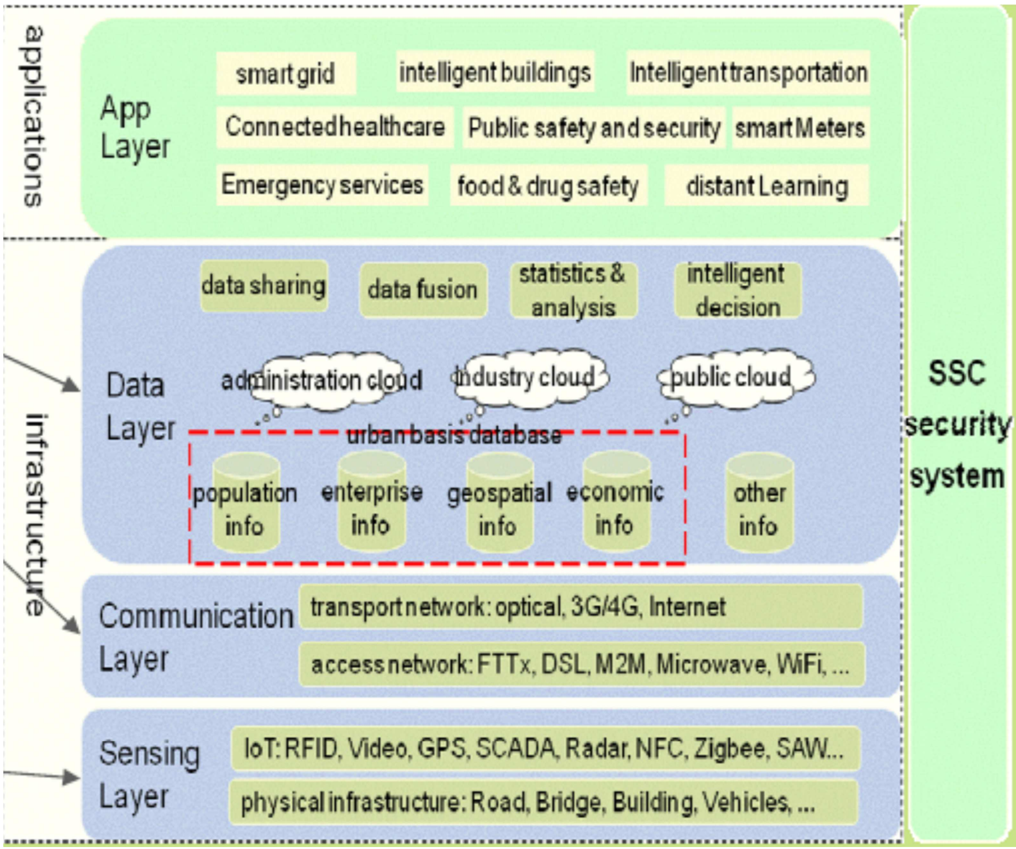

Figure 4 Structure of FG-SCC

Calculation to compute the composite: A weighting method is used for evaluation method. By normalising the values within the range of each indicator between 0 and 100 the evaluation result is achieved by summing up the values and dividing it by the number of indicators (88). The progress can be estimated by comparing the values over several years. With this method also sub-themes can be evaluated by taking into consideration only indicators of each of the indicators. Cities can then by compared pairwise by comparing the distance in each of the dimensions of the resulting vector. The aggregation is performed by using overall arithmetic mean while also a partial mean for sub-dimensions is possible.

Target groups: The framework has been developed to enable city leaders to evaluate the success of strategies in smart city development.

Source of information: https://www.itu.int/en/ITU-D/Regional-Presence/AsiaPacific/Documents/Ziqin%20smart%20city%20KPIs%20and%20monitoring%

20V2.pdf; http://wftp3.itu.int/pub/epub_shared/TSB/ITUT-Tech-Report-Specs/2016/en/flipviewerxpress.html

3.8 IUME Integrated Urban Monitoring in Europe

Type of indicators: The indicator system address metabolism of cities (urban flow indicators), their relationship to urban structures (urban patterns), socio-economic drivers (urban drivers) and aspects of quality of life (urban quality).

Calculation to compute the composite: The monitoring focuses on metabolic inputs and outputs (urban flows) within the context of the other dimensions (drivers, patterns and quality). Key information is summarised in a so-called headline indicator set since the basic set of indicators is quite comprehensive. This set of selected indicators in not being aggregated in the second step but refers directly to key areas of the Aalborg commitment and the strategy of the sustainable use of resources (Manx 2011).

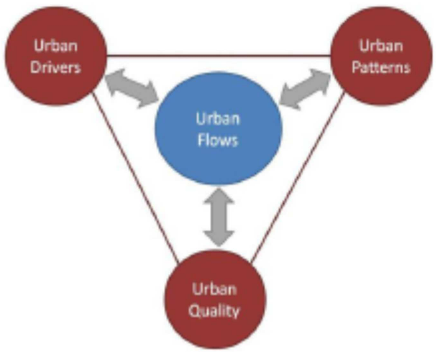

Figure 5 Indicator system in IUME (Minx 2011, adapted from Alberti 1996)

Target groups: Policy makers and stakeholders in need of understanding of urban policy background

Source of information: http://ideas.climatecon.tu-berlin.de/documents/wpaper/CLIMATECON-2011-01.pdf

3.9 Ericissons's Networked society city index

Type of indicators: Ericsson's Networked Society City Index examines and ranks 40 world cities, providing a framework for measuring ICT maturity in relation to social, economic and environmental progress. The Index measures the performance from two perspectives ICT maturity and TBL (triple bottom line) development are both divided into three dimensions. The TBL dimensions – social, economic, and environmental – reflect the three dimensions of sustainable development. ICT maturity is broken down into ICT infrastructure, ICT affordability, and ICT usage. These three dimensions capture the complexity of the connected society: a well-developed infrastructure, a competitive market that offers affordable prices to citizens and businesses, and sufficient know-how to invent, adopt, and adapt new ICT solutions. The correlation between ICT maturity and TBL shows that cities' ICT maturity largely mirrors their position on the development ladder. A high level of sustainable urban development is typically correlated to high ICT maturity. Affluent cities have reaped the benefits of early industrialization and are indeed able to invest more in ICT and are, partly due to preconditions, better at utilizing ICT investments than developing economies. The scale is between 1 and 100. 20% are added to the minimum and maximum values or theoretical maximum and minimum values are used where this is found necessary.

Calculation to compute the composite: The Index ranks cities based on their performance in sustainable urban development and ICT maturity. Each dimension is described by a set of variables. The variables are created by aggregating a set of indicators and proxies that are meaningful in terms of describing a city's performance in the variable. The Index has been supplemented with indicators of equality, R&D expenditure, and transportation and energy trends. The aggregation follows a hierarchic structure. Different methods for aggregation have been assessed. In the end geometric mean considering different weights has been selected.

Target groups: According to Ericsson the index can be used to exploit emerging possibilities associated with a connected world.

Source of information: https://www.ericsson.com/assets/local/networked-society/reports/city-index/networked-society-city-index-2014-appendix1-methodology.pdf

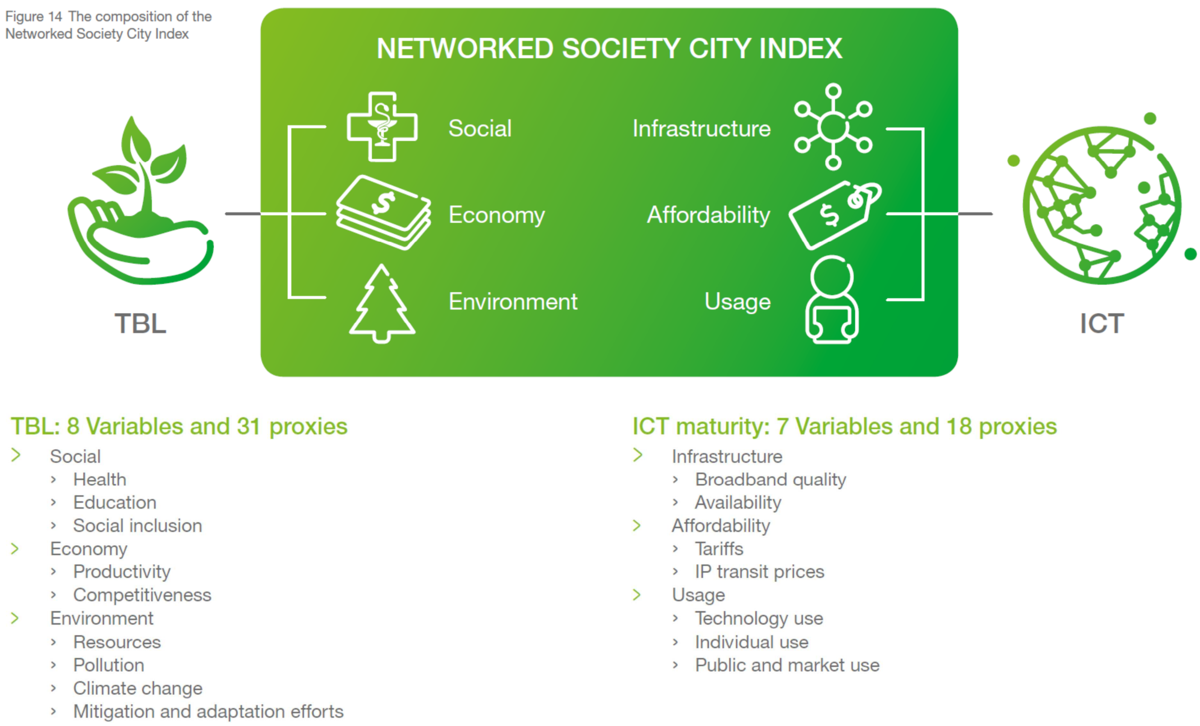

Figure 6 Structure of the Networked Society Index (Source: http://emeshing.blogspot.co.at/2016/08/network-society-city-index-2016-by.html)

3.10 Siemens Green City index

Type of indicators: The index takes into account 30 individual indicators per city that touch on a wide range of environmental areas — from environmental governance and water consumption to waste management and greenhouse gas emissions — and ranks cities using a transparent, consistent and replicable scoring process. The relative scores assigned to individual cities (for performance in specific categories, as well as overall) is also unique to the index and allows for direct comparison between cities.

Calculation to compute the composite: the average of the scores in the 8 subthemes. Equal weighting is being used to aggregate the subthemes. Each city receives an overall Index ranking and a separate ranking for each individual category. The results are presented numerically (for the European, and the US and Canada Indices) or in five performance bands from "well above average" to "well below average" (for the Asian, Latin American and African Indices).

Target groups: The goal of the index is to allow key stakeholder groups — such as city administrators, policymakers, infrastructure providers, environmental non-governmental organisations (NGOs), urban sustainability experts, and citizens — to compare their city's performance against others overall, and within each category. The index also allows for comparisons across cities clustered by a certain criteria, such as geographic region or income group.

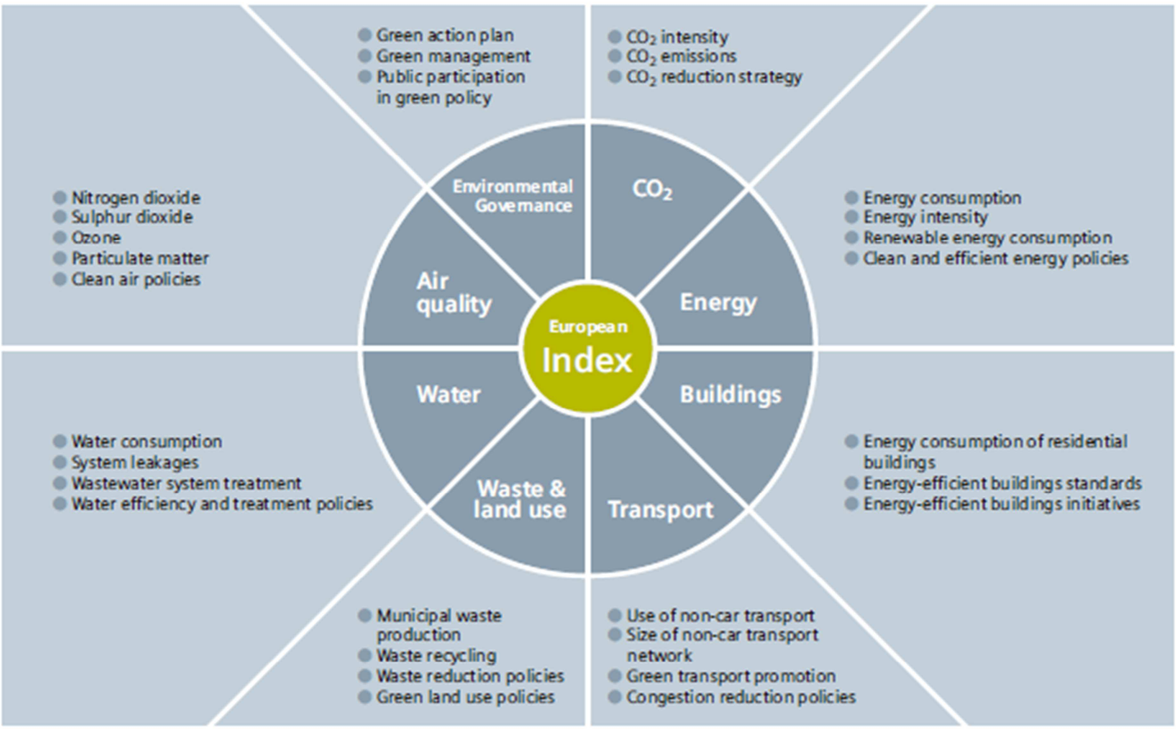

Figure 7 Structure of the Siemens Green City Index (Source: https://www.siemens.com/entry/cc/features/greencityindex_international/all/en/pdf/gci_report_summary.pdf)

3.11 UNECE United Smart Cities

Type of indicators: The framework consists of 71 indicators in total structured within three areas corresponding to the three pillars of sustainability. Indicators form 18 topic groups describing an area of potential development. The standard furthermore distinguishes core indicators to be applied by all cities and additional indicators to be used optionally by

”smarter” cities for seld-benchmarking purposes. Indicators are defined used different units depending on the kind of indicator. (http://www.unece.org/housing/smartcities.html)

Calculation to compute the composite: No guidelines for the calculation of composite are given. The project refers to a pre-project performed by the contractor Environment Agency Austria called Smart City Profiles (http://www.smartcities.at/activities/smart-city-profiles-en-us/). The project compares city indicators by allocating a percentage where 100% are given to the best performing city for an indicator within the given sample. Each indicator is then compared to the average on a system diagram.

Target groups: Municipal administrations and related stakeholders in developing countries.

3.12 Overview of calculation methods

The following table summarises properties of indicator systems. This includes composition, aggregation method and scale of each scheme. The last row indicates whether the scheme foresees a comparison method and if so which one is used.
Most of the index systems use a hierarchic structure where single indicators are structured in sub-themes. Such systems could include two or more levels. The aggregation results then in a rank for each of the subthemes as well as in a final result considering all sub-themes. Even if the aggregation to sub-themes is an intermediate step towards an overall index it is still seen as essential that rankings are available on the level of sub-themes too. In this way the position of a city within special fields (dimensions of sustainability, energy, mobility etc.) can be derived and used.

Most of the reviewed indices use arithmetic mean as the aggregation methods. Only Ericsson Networked Society Index uses geometric mean for aggregation. Both methods use weights to trade the sub-themes off. This fact allows for the compensation of one sub-theme by another. In linear aggregation the compensation is constant while in the case of geometric aggregation the compensability is lower for indicators with low values (OECD 2005 quoted in Ericsson AB 2014). Geometric aggregation thus rewards cities that are characterised by a balanced performance in several dimensions (Ericsson AB 2014). Other aggregation methods use analytical methods. The major disadvantage of this is the lack of transparency that does not allow for the reproduction of the composite by other parties.
Since CITYkeys groups indicators to sub-themes that could be aggregated into a single index the weights in the aggregation play a crucial role. To minimise the effect of compensation and privilege balanced performance the geometric mean seems to be the most preferable method to be chosen.

For the scale, normalisation is used to get comparable results. Usually a scale between 0 and 100 is used. This can be expressed in points or as a percentage. The Ericsson Networked Society Index adds 20% to each the minimum and maximum values of the cities in the index. Alternatively theoretical minimum and maximum values are being used where this is seen as essential. This measure ensures that in case new cities are included into the index these do not fall out of the interval that is being used[4].

The result of most of the indices is ranking of cities and in some cases also ranking of cities within sub-themes. In some cases (Global Cities Indicator Facility or UNECE United Smart

[4] https://www.ericsson.com/assets/local/networked-society/reports/city-index/networked-society-city-index-2014-appendix1-methodology.pdf

Cities) the result is comparison between cities selected by the user and shown in a chart (e.g. system chart or bar charts).

Index	Arrangement	Calculation	Scale	Comparison
Arcadis Sustainable Cities Index	20 indicators in 3 subthemes	Averaging of indicators within subthemes; averaging subthemes to receive a composite	rating highest indicator value with 100%, lowest with 0% of 50 selected cities	Ranking
City Protocol	105 core, 93 supporting indicators	Unknown	Unknown	Unknown
European Green Capital Award	12 indicator areas with 4 qualitative descriptions each	Unknown	Rank within selected cities	Ranking
European Smart Cities	6 key fields, 90 indicators	Arithmetic mean	$z_i = (x_i - \overline{x}) / s$, average 0, standard deviation 1	Ranking
Innovation Cities Index	3 factors. 31 segments, 162 indicators	Analytics	Score out of 60	Ranking
ISO 37120 & Global City Indicators Facility	100 indicators (46 core, 54 supporting) within 17 themes	No aggregation used	Individual scale for each indicator	For each indicator
ITU FG-SSC	88 indicators in 6 sub-dimensions	Overall arithmetic mean, partial mean for sub-dimensions possible	0-100	Pairwise
IUME Integrated Urban Monitoring in Europe	4 dimensions, 56 indicators	Selection of 15 headline indicators	Sample average normalisation in range 0-3, x<1 below average, x>1 above average	System chart comparing selected cities
Networked Society City Index	2 perspectives, 6 dimensions, 15 variables, 35 indicators represented by 41 proxies (2 foreseen indicators are not in use)	Hierarchic structure by using a geometric mean considering different weight of categories	1-100, addition of 20% to the max/min value or by using theoretical max/min values	Ranking
Siemens Green City Index	30 indicators in 8 subthemes	Average of scores in each subtheme, equal weighting	0-10 per indicator, 0-100 overall	Ranking

UNECE United Smart Cities	3 areas, 18 topic groups, 71 indicators	Unknown	Unknown	In a system chart

4. EXAMPLES OF INDICATOR SELECTIONS AND AGGREGATION METHODS IN NEIGHBOURHOOD CERTIFICATION SCHEMES

Following on the development of sustainability certification schemes for buildings, such as BREEAM, LEED, CASBEE, HQE, DGNB a number of organisations have developed comparable certification schemes for neighbourhoods, districts or even cities. This section presents an overview of the methodology of aggregating existing indicator sets in these neighbourhood certification schemes. The following table illustrates which key aspects in the framework may be relevant. One of the most important aspects for scoring is the amount or degree of sustainable action. Since certification has the target to rate and highlight the quality of the object, the result is given in the form of an award or certificate level.

The overview below is not comprehensive; however many other certification schemes can be compared with LEED.

Table 1 Key aspects and scale of neighbourhood certification schemes

Name of initiative	key aspects/Quality	Scale
CASBEE	Environment aspects , social aspects, economic aspects	Excellent (S) very good (A) good (B+) fairy poor (B-), poor (C)
DGNB	environmental, economic, sociocultural and functional aspects, technology, processes, site	Bronze Silver Gold Platinum
European Energy Award	urban management & planning, municipal buildings & facilities, supply & removal, mobility, internal organisation, communication & cooperation	European Energy Award European Energy Award Gold
LEED	Energy performance, Water performance, Indoor Environmental Quality, Sustainable sites, Materials and resources, Innovation in design,	Certified: 40–49 points Silver: 50–59 points Gold: 60–79 points Platinum 80+

4.1 CASBEE for Cities

Type of indicators: CASBEE for Cities is a system for comprehensively evaluating the environmental performance of cities, using a triple bottom-line approach of "environment," "society" and "economy." The indicators have been selected from studies and documents published by international organisations such as UN Sustainable Development Goals and ISO 37120 (http://www.ibec.or.jp/CASBEE/english/toolsE_city.htm).

Calculation to compute the composite: When evaluating a city, CASBEE City sets a hypothetical boundary to enclose the city. In doing so, it can evaluate the Built-Environment Efficiency (BEE) of the city. Improvement in environmental quality and activities (referred to as “Quality,” or “Q”) within the enclosed space and reduction in negative environmental impact (referred to as “Load,” or L”) on the area beyond the boundary lead to higher BEE values, thus a better rating. CASBEE City calculates Environmental Load (L) of cities and evaluates Quality (Q) in cities from the following assessment items.

Target groups: local governmental officers, administrative officers citizens and other stakeholders.

Source of information: http://www.ibec.or.jp/CASBEE/english

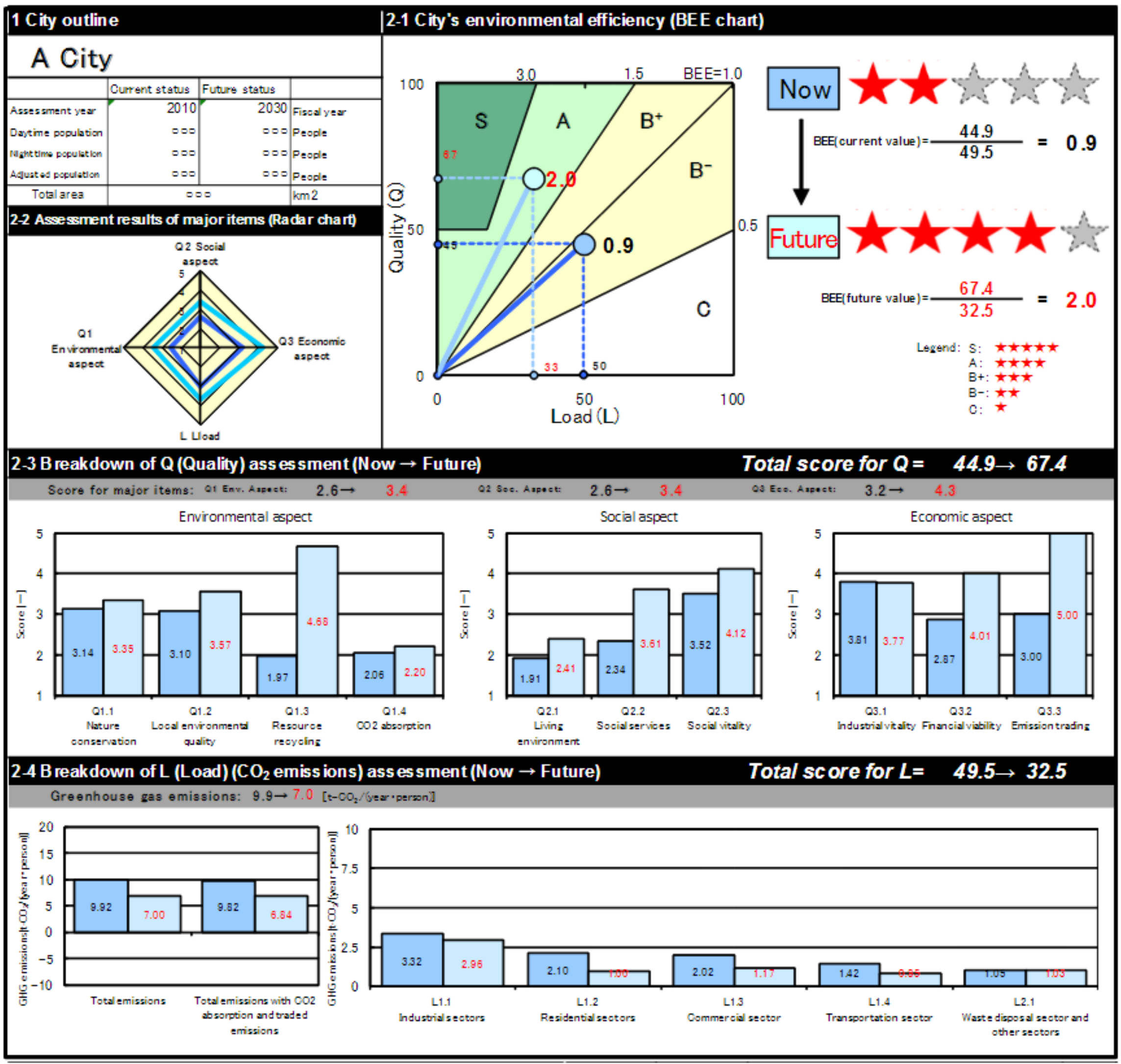

Figure 8 Assessment software interface for CASBEE (Source: http://www.ibec.or.jp/CASBEE/english/)

4.2 DGNB

Type of indicators: The DGNB System covers all of the key aspects of sustainable building: environmental, economic, sociocultural and functional aspects, technology, processes and site. The first four quality sections have equal weight in the assessment. The System has defined target values for each criterion.

Calculation to compute the composite: Up to 10 evaluation points are awarded for reaching the target specifications. The concrete score for the six topics is calculated from the combination of the evaluation points with the relevant weighting. The total score for the overall project is calculated from the five quality sections based on their weighting. The DGNB system evaluates according to performance indices: If the total performance index is at least 50 %, the building will receive a DGNB Certificate in silver. If the total performance index is at least 65 %, a DGNB Certificate in gold is granted. To achieve a DGNB Certificate in platinum, the project has to achieve a total performance index of at least 80 %. For existing buildings, the same system applies with the addition that bronze is conferred as the lowest award with a total performance index of at least 35 %.

Total-Performance Index	Minimum Performance Index	Awards
from 35 %	— %	Bronze*
from 50 %	35 %	Silver
from 65 %	50 %	Gold
from 80 %	65 %	Platinum

*This award is valid only for existing buildings

Figure 9 Award structure in DGNB (Source: Deutsche Gesellschaft für nachhaltiges Bauen e.V.: Neubau Stadtquartiere. DGNB Handbuch für nachhaltiges Bauen 2012)

The DGNB aims to promote a uniform quality standard for buildings. Therefore the total performance index alone is not decisive in achieving a specific certificate. Rather, the result-relevant topics must each achieve a minimum performance index in order to be able to obtain the certificate. To achieve platinum, for example, a minimum performance index of at least 65 % must be achieved in the first five quality sections. A minimum performance index of at least 50 % is necessary in order to achieve a gold certificate. For silver, a minimum of 35 % must be achieved for each area being tested. When awarding existing buildings, there is no minimum performance index for the lowest award level, bronze.

Target groups: Municipal administration, planers, project developers.

Source of information: Deutsche Gesellschaft für nachhaltiges Bauen e.V.: Neubau Stadtquartiere. DGNB Handbuch für nachhaltiges Bauen 2012.

4.3 European Energy Award

Type of indicators: The programme lists 79 measures where a municipality can actively set and influence its energy policy. These are structured along six thematic fields. The assessment is performed by an indenpendent experienced assessor within a country-specific certification programme. Similar measure implementation assessment system exists also for regions, e.g. in Germany with 57 possible measures for German districts (Landkreise).

Calculation to compute the composite: The calculation and assessment considers individual conditions of each municipality. The independent assessor analyses the state of the art of measures that are to be implemented but also the extent to which the measures can be implemented. This considers maximal possibilities of each municipality and does not set a unique benchmarking among different conditions of municipalities. The extent of implementation for each of the measures is then assessed as percentage of implementation. Possible and reached points are then added together. The result is the proportion of these two values.

EEA grants awards to municipalities that have reached a high score. For 50% of implemented measures out of all potential ones the European Energy Award is granted, for 75% the municipality can reach the golden status (http://www.e5-gemeinden.at).

Target groups: Municipal administrations, politicians and citizens (http://www.e5-gemeinden.at)

Source of information: http://www.european-energy-award.de/fileadmin/Downloads/Oeffentliche_Downloads/Benchmarks/Erlaeuterung_zum_Benchmark.pdf

4.4 LEED-ND

Type of indicators: This certification uses 47 credits and 12 prerequisites that are allocated in 5 credit categories. These include smart location and linkage, neighbourhood pattern and design, green infrastructure and buildings, innovation and regional priority. There are two certification schemes available on neighbourhood level – ND plan and ND for built project.

Calculation to compute the composite: The calculation is a simple method that sums up all reached points. Each credit has different weight and can provide a maximum of one to ten points. Prerequisites need to be fulfilled in any case. As maximum 110 points can be reached. At least 40 points are necessary to obtain a certificate.

Target groups: not given

Source of information: http://www.usgbc.org/leed

4.5 Overview of calculation methods

In the following table an overview of properties of neighbourhood certification schemes is shown. The table summarises the composition, aggregation method and scale of each scheme. In this case the comparison within an index is not available since the focus is on a particular award level.

Even if the aim of certification schemes is not a ranking but a categorisation within a certain award level, a comparison as in the case of smart city indices is possible. Similar to the city indices the arrangement consists of sub-themes that form a hierarchic structure. The aggregation is performed either by a formula (as in the case of CASBEE) or by simply summing up the points reached in each of the categories. Weights for indicators or sub-themes are used as in the case of indices. A different approach is used by the European Energy Award where the maximum amount of points is set according to the real possibilities of each municipality. This method is particularly interesting since it takes into account different environments and possibilities of municipalities. The disadvantage of this method is the necessary evaluation of possibilities before the assessment, which is done by an assessor. The result is then expressed as a percentage of reached points within maximal possible points. This allows comparison of different municipalities even if these are in different environments and face different conditions.

Index	**Arrangement**	**Calculation**	**Scale**	**Comparison**
CASBEE	Score for environmental quality and load, each with 3 medium-level categories each and below 3 low-level categories each	BEE=Q/L	BEE 0-5 (overall result), subresult (0-5 to 0-100) normalisation Q=25(SQ-1), L=25(5-SLR)	Possible although the focus is on a particular award level
DGNB	5 thematic fields, 14 criteria groups, 45 criteria	Multiplication of criterion points with given significance factor, thereafter sum according to criteria groups	0-100 per criterion, under special circumstances a reduction is possible	Possible although the focus is on a particular award level
European Energy Award	79 measures, 6 thematic fields	Fraction of total reached and possible points	Individual upper limiting value, result is expressed as percentage	Possible although the focus is on a particular award level
LEED	47 credits and 12 prerequisites in 5 credit categories	Sum of points	Max. 110 points and fulfilled prerequisites	Possible although the focus is on a particular award level

5. SMART CITY PROJECT INDICES

5.1 CITYkeys index for comparison of smart city projects

The CITYkeys assessment methodology contains a uniform Key Performance Indicator (KPI) framework for both project and city scale assessment of smart cities. The framework is structured in a hierarchy of themes and sub-themes. Both qualitative and quantitative indicators are used and in many cases there is a city KPI corresponding to associated project KPI. All the project KPIs have a uniform five-level assessment scale (ranging from 1= worst to 5 = best performance level). This makes the KPIs comparable between each other which also enables easy scoring of the KPIs throughout the framework on the same scale.

One could imagine a CITYkeys smart city index for project scale consisting of one overall index and sub-indices for each CITYkeys main themes (People, Planet, Prosperity, Governance, Propagation). The indices can be aggregated by using simple averages as follows:

- The sub-indices for each main CITYkeys theme are calculated as an average of the scores of each assessed KPI under that theme. The index is thus a number between 1 (worst score) and 5 (best score).
- The overall index is an average of all the five sub-indices.

These simple indices are easily understandable and allow the comparability of different smart city projects. The sub-indices give a quick understanding on which aspects the project is performing better than others which can be then further investigated but studying the scores of individual KPIs and reasons behind those scores.

The following Figures 10 and 11 provide fictive examples of how such sub-indices and the overall index could be calculated and illustrated. Figure 10 presents a spider visualization resulting from a fictive project assessment with 11 KPIs assessed on the scale from 1 (worst level) to 5 (best level) with 1 to 3 KPIs assessed in each CITYkeys main theme (People, Planet, Prosperity, Governance, Propagation). The bar diagram of Figure 11 then illustrates the resulting sub-indices and overall index. The sub-indices of each CITYkeys main theme are calculated as an average of all KPI performance levels under that theme and the overall index is the average of all those five sub-indices.

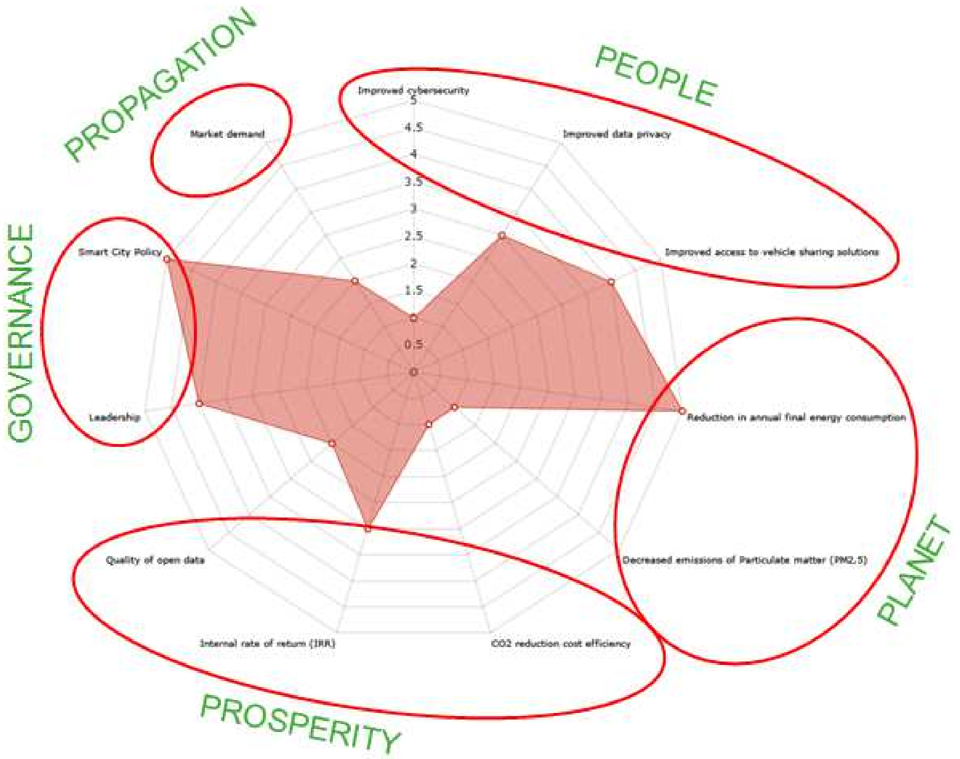

Figure 10. Fictive example of a spider diagram resulting from a project assessment with 11 CITYkeys project KPIs

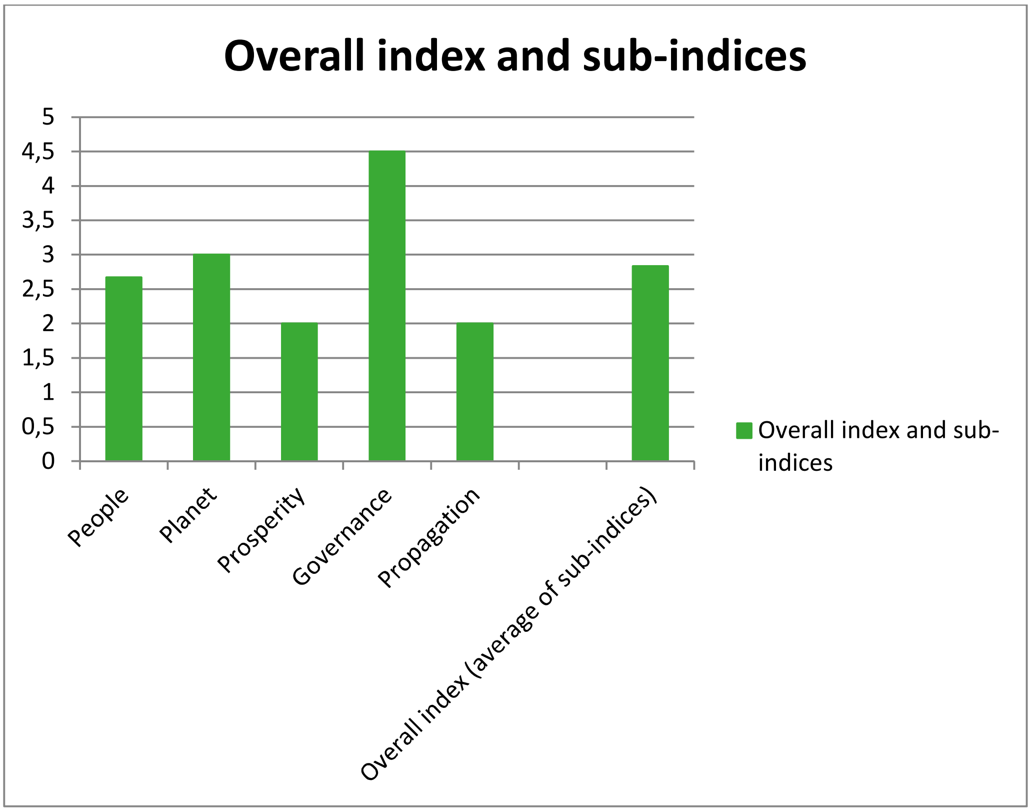

Figure 11. Example of sub-indices and overall index resulting from the project assessment illustrated in Figure 10

5.2 Weighting

Many certification schemes and indices use weighting methods to indicate the mutual importance of KPIs and/or categories in a framework. Weights are then taken into account in the calculation of the overall score. The importance of various aspects in a framework depends on the stakeholder that uses the framework and on the context where the indicators are applied. However, at this stage it remains open who potentially would use CITYkeys index and in which context. Therefore, for the time being, no explicit weights are defined. Another option is to develop the CITYkeys assessment scheme as a full- fledged multi-criteria multi-stakeholder decision support system, whereby each of the stakeholders will be able to attach his or her own weightings to indicators or policy themes. These weightings then become an explicit element in a decision making process (OConnor and Spangenberg, 2007).

5.3 "KPI coverage" score

Since the beginning of CITYkeys project it has become clear that there is a wide range of smart city projects having very different characteristics and focusing on various aspects. Therefore the consortium ended-up in a KPI framework consisting of a long list of 101 KPIs available for the assessment of various types of smart city projects. It is clear that not all of those available KPIs are relevant in a specific smart city project and the flexible methodology allows for selecting and assessing only those KPIs that are relevant in that specific project. However, it has to be kept in mind that, stemming from the CITYkeys definition, a smart city project is an integrated project, combining multiple sectors and having a significant impact in supporting a city to become a smart city along the four axes (People, Planet, Prosperity, Governance)[5]. It is clear that a project that has been assessed with only a very small number of KPIs probably doesn't comply very well with the previous requirement. Furthermore, two projects are not comparable as such with the above defined indices (see section 5.1) if their indices are based on scores of very different amounts of assessed KPIs. Someone could even misuse the indices by calculating them deliberately for a small number of KPIs in which a project is performing particularly well.

In order to indicate how well a smart city project addresses and integrates the various aspects of a smart city, and to improve the transparency of assessments, an additional score "KPI coverage" could be calculated and communicated along with the indices presented in 5.1. The KPI coverage is defined as the percentage [%] of all CITYkeys project KPIs assessed. Similarly KPI coverages can be indicated for each main theme (People, Planet, Prosperity, Governance, Propagation) helping in communicating how balanced the project or assessment is with regard to the main aspects of a smart city project. The use of these KPI coverage scores could encourage cities to improve their data collection processes and to communicate more transparently their smart city project targets and achievements with help of the calculation of the wide range of available CITYkeys KPIs.

In order to illustrate KPI coverage score calculation with a practical example we can again consider the fictive project assessment example presented in Figure 10. Table 2 then presents the resulting overall KPI coverage score as well as the KPI coverage scores related to each CITYkeys main theme (People, Planet, Prosperity, Governance, Propagation). In this fictive example the number of KPIs is very low, but in the case studies carried out in CITYkeys partner cities within CITYkeys T2.4 "Testing", the KPI coverage scores varied between 22% and 50% and were 38% on average. The KPI coverage scores can, of course, be calculated as well for city assessments as for project assessments.

[5] See D1.2 Neumann, Hans Martin, et al, 2015. Overview of the Current State of Art. CITYkeys report.

Table 2. KPI coverage score calculations for the fictive example of Figure 10

	Nb of KPIs assessed	Nb of KPIs available	KPI coverage score
CITYkeys (whole project framework)	11	101	11%
Main themes:			
People	3	27	11%
Planet	2	25	8%
Prosperity	3	18	17%
Governance	2	13	15%
Propagation	1	18	6%

5.4 Impact of smart city projects on city scale

Another important factor to consider when evaluating various smart city projects is what impacts they have on the scale of the city. The CITYkeys framework has been developed to be as harmonised as possible for both project and city scales but differences in KPIs and their definitions are clear. It has also been noted already during the earlier phases of the project that the link between project and city scales is not straightforward with the indicators. The Appendix 3 of CITYkeys D1.4 "Smart city (project) KPIs and related methodology" makes the link between project KPIs and the most well corresponding city KPIs.

Testing[6] has confirmed that with only a few indicators, such as Final energy consumption, Renewable energy generated and emissions of air pollutants, etc. it is possible to quantitatively link the results on project level to the city level indicator.

[6] See D2.4 Aapo Huovala et al, 2016. Report on the case studies. CityKeys report.

6. TOWARDS A CITY INDEX?

6.1 City opinions on city indices

From a discussion between the partner cities on this topic it appears that cities do not see many advantages in comparisons and rankings with other cities. Differences in geographic location, history, economic structure, institutional arrangements, etc. make each city unique and incomparable to others.

Although the publication of a certain city index may get some attention in the press, it is quickly forgotten and seldom leads to any policy reaction. At best some questions are asked in the Council, that requires capacity of the civil servants to answer, but there are no examples of the use of a city index in actual city policy making.

Cities are well aware that quite a number of city indices are published by companies, such as Siemens and Arcadis which are suspected for using the indices to create market for their services.

6.2 Issues in applying indices

One of the big disadvantages of several of the existing indices is the relative ranking. For the city at the top there is no incentive (and no guidance) to improve further. For all ranked cities it is unclear what their absolute position is. In a sustainability index it could be possible that many of the cities are clearly unsustainable, without the index indicating such a status.

When an absolute ranking is made, the methodological issues noted in Section 2.5.1 remain important. Implicit weighting in normalization and explicit weighting are issues that cannot be decided by the indicator developer alone and it will be difficult to get city agreement on weights given the variability in cities.

6.3 Conclusion

It is possible to design a smart city index, based on a selection of the CITYkeys city level indicators. Testing of the city indicators has revealed that for many of the city indicators data will be available[6]. However, its use for cities would be limited and hence the idea is not elaborated further here.

On the other hand, as companies like Siemens, Arcadis, Ericsson, 2thinknow seem to have identified a business model in providing some kind of city ranking and selling follow-up services to cities, there might be a commercial interest in providing a smart city index and smart city ranking. As “smart cities” is still a fluid concept, with cities experimenting various applications, it is, however, difficult to imagine what an index would add to the ongoing initiatives to make European cities smarter.

7. CONCLUSIONS AND RECOMMENDATIONS

7.1 Summary of achievements

The overview of existing city sustainability indices and their aggregation methods, combined with the discussion with the partner cities in the consortium leads to the following insights:

- A variety of (sustainable, innovation, etc) city indices have been developed to compare cities
- As cities consider themselves unique, they do not see many advantages in being compared with other cities
- Actual use of city indices in city governance seems to be very limited
- Many of the existing indices have the disadvantage that they rank cities relative to each other, not providing much incentive to the top-3 to improve, neither to solve unsustainable conditions.
- It is hence of little use to propose a CITYkeys smart city index for use by the cities
- However, as companies like Siemens, Arcadis, Ericsson, 2thinknow seem to have identified a business model in providing some kind of city ranking by selling follow-up services, there might be a commercial interest in providing a smart city index and city ranking.
- For aggregating the CITYkeys project indicator scores for the moment an equal weighting of themes and indicators can be used (see sections 5.1-5.2).
- A KPI coverage score as described in Section 5.3 is a good additional indicator to express the quality of the project assessment for the wide variety of smart city projects. Together with an index calculated based on average KPI scores (see section 5.1) it would increase the transparency of the assessment results, and add information both on the comparability of different project/city assessments and on how balanced and integrated the assessed project/city is.

7.2 Relation to continued developments

In the CITYkeys project most attention has been given to developing and testing the KPI framework. Further efforts are needed to develop an attractive aggregation and presentation of the project assessment results.

It is expected that all of the Horizon2020 “lighthouse projects” will be using the CITYkeys indicators for evaluating the impacts of their lighthouse projects. This provides the framework for further development of presentations of aggregated indicator outcomes and to continue the discussion about weighting themes and indicators.

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