CITYkeys

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

Deliverable 2.4 Report on the case studies

Revision 0

Preparation date 2017-01-20 (m24)

Due date 2016-10-31 (m21)

Lead contractor ..... VTT

Authors:

Aapo Huovila ..... VTT

Miimu Airaksinen ..... VTT

Henri Biström ..... VTT

Topi Penttinen ..... VTT

Kalevi Piira ..... VTT

Hans-Martin Neumann ..... AIT

Peter Bosch ..... TNO

Sophie Jongeneel ..... TNO

Nikolaos Kontinakis ..... EUR

Elli Kotakorpi ..... TAM

Lilli-Nora Siikasmaa ..... TAM

Roland van der Heijden ..... ROT

Quirijn Oudshoorn ..... ROT

Eva Pangerl ..... VIE

Ana Jimenez ..... ZGZ

Daniel Sarasa ..... ZGZ

Marko Kucan ..... ZAG

Sanja Malnar Neralic ..... ZAG

Dissemination level		
PU	Public	X
PP	Restricted to other programme participants (including the Commission Services)	
RE	Restricted to a group specified by the consortium (including the Commission Services)	
CO	Confidential, only for members of the consortium (including the Commission Services)	

Deliverable administration										
No & name	**D2.4 Report on the case studies**									
Status	Draft / Working / Released	**Due**	m21	**Date**	2016-10-31					
Author(s)	Aapo Huovila, Miimu Airaksinen, Henri Biström, Topi Penttinen, Kalevi Piira (VTT), Hans-Martin Neumann (AIT), Peter Bosch, Sophie Jongeneel (TNO), Nikolaos Kontinakis (EUR), Elli Kotakorpi (TAM), Roland van der Heijden, Quirijn Oudshoorn (ROT), Eva Pangerl (VIE), Ana Jimenez, Daniel Sarasa (ZGZ), Marko Kucan, Sanja Malnar Neralic (ZAG)									
Description of the related task and the deliverable in the DoW	**T2.4 Testing** This task will focus on implementing and verifying the functionality of the application. The research partners and cities design and co-create the user interface. In this task the demo version of the user interface which was developed in T2.3 will be tested in the five partner cities and based on feedback from cities the interface will be further improved. The work will first, in parallel with T2.1 and T2.2 evaluate existing data platforms in the cities involved. Testing the tool, with a selected KPIs sample, by the partner cities will allow analyzing the functionality (including usability) of the demo tool. Performing the impact assessment in the case cities also enables analysing the validity of the framework as the replication and suitability for different types of cities (different geographics, economics, scale, place on the smart city innovation curve etc.) will be tested. The ITU L.1440 ICT in Cities methodology will be piloted by some partner cities (as the ones in Green Digital Charter) and feedback provided in terms of workability and how it relates to other assessment methodologies. This will be reported in a specific deliverable (d2.5) with assigned resources and lead by partner 3 (TNO). **D2.4 Report on the case studies** A report on the testing of the tool functionality and usability in the case cities.									

Planned resources PM	VTT	AIT	TNO	EUR	TAM	ROT	VIE	ZGZ	ZAG	Total
	2	2,7	2,8	1	1	1	1	1	1	13,50
Comments										

V	Date	Authors	Description
0	2016-10-28	AH, VTT	First draft combining partnersô contributions
0	2016-12-13	AH, VTT	Second draft with updated contributions
0	2017-01-20	AH, VTT	Final draft for internal review
0			
1	2017-XX-XX		

Table of contents

PUBLISHABLE EXECUTIVE SUMMARY

This report describes the results from testing the CITYkeys performance measurement framework and the different prototypes of the associated tool in citiesô case studies. The concrete case studies in the five CITYkeys consortium cities, and 13 additional voluntary cities / other organisations, have served in validating the indicator framework earlier developed in CITYkeys. In consequence recommendations have been made also on the use of the framework and for refinements of some KPI descriptions. By providing feedback and suggestions on the usability and functionality of early prototypes of the KPI tool cities have participated in the co-design of the user interface at all stages of the process. Since the tool co-development and testing were parallel activities, this report also shortly describes the properties of the online tool developed within Task 2.3 (ñImplementation of the performance measurement systemò).

The main target groups of this report are cities and policy makers who could use the KPI framework and associated tool in future. In addition the smart city project consortia (particularly lighthouse projects) are expected to use the CITYkeys framework in evaluating their projectsô impact. This would be especially important to combine the still often typical input/output assessment (of e.g. number apps of sensors implemented in a project) that donôt tell anything of the true impact achieved in those projects. Some lighthouse project consortia have already implemented or engaged in CITYkeys assessment in their projects but it is not yet the case for all of them (at least at the moment of writing this report).

The main results from the wide testing in practice can be summarised as follows:

- Cities active involvement at all stages of development (of both KPI framework and tool) has been crucial for the quality and usefulness of the results.
- The KPI tool developed has been successfully tested and well received. In addition to the user interface testing also automatic data reading functionality has been validated. Cities can also by themselves connect their own datasets to the tool though the tool APIs. Also future development possibilities for the tool are presented in this report.
- Most of the project and city KPIs have been tested in some of the case studies that each had a different aim and focus. The data availability and successful implementation of most of the project KPIs (73/101 = 72%) and city KPIs (59/76=78%) have been validated. The average KPI data availability rates in a European city are expected to be over 70% (around 25% as open data) for quantitative city KPIs and close to 100% for all the qualitative ones.
- Several improvements in KPIs have been suggested and, to the extent they will be agreed as sound, they will be reported in the CITYkeys D4.6 User handbook along with recommendations on the use of CITYkeys main results.
- The framework structure and KPIs correspond well to the key objectives of citiesô smart city projects, and along with the well-received balance of qualitative and quantitative KPIs, the assessment methodology has been validated as useful in practice for smart city (project) assessment.
- The flexible approach in applying the KPI framework based on particular aims and priorities have been found to be good approach when applying the KPIs/framework. That allows selecting only the most relevant KPIs for assessment while a comprehensive and holistic assessment is still encouraged.
- For completing the CITYkeys project and city indicators a broad knowledge base is necessary with sometimes needs for external experts.

- The main barrier in data collection, however, is not the data availability or lack of expertise but the localisation and accessibility of the needed data. The localisation of the data within or outside the often scatted city organisation dealing with the wide topic of a smart city has proved to be often so burdensome task that it leads in many giving up the whole KPI evaluation process due to the time needed (many phone calls and emails). The development of centralised data management, storing and publishing practices would help a lot in the localisation and exploitation of the currently vast amount of available city data. As a later step the standardisation of (open) data set formats would further improve the data exploitation possibilities. In addition these steps would greatly improve the efficiency of city processes including management, coordination and reporting.

1. INTRODUCTION

1.1 Purpose and target group

The purpose of this report is to describe the results from testing in citiesô case studies the CITYkeys performance measurement framework (developed in D1.4) and the early prototypes of the associated tool (developed in T2.3). The concrete case studies have served in testing the validity of the framework. In consequence recommendations have been made also on the use of the framework. By providing feedback and suggestions on the usability and functionality of early prototypes of the KPI tool cities have participated in the co-design of the user interface.

The main target groups of this report are cities and policy makers who could use the KPI framework and associated tool in future. The specific potential end-users within a city organisation were analysed more in detail by each of the five cities during the case studies and the results are presented in this report. In addition, the results are useful for consortia of smart city projects (particularly lighthouse projects) that want to evaluate the impacts of their projects.

1.2 Contributions of partners

Partner cities (ROT, TAM, VIE, ZAG, ZGZ) have had a major role in this task as they have carried out the case studies and commented on the tool interface which form the basis of this report. They have been supported by the other partners (TNO, AIT, EUR) under the coordination of the task leader VTT.

In addition to CITYkeys partner organisations, both the KPI framework and tool prototype have been presented to an extended network of cities, projects and companies through webinars, workshops and other events. The following additional cities, projects and organisations have been involved in the testing phase and provided feedback on the KPI framework and/or prototype tool:

- AREBS (Belgium)
- City of Aachen (Germany)
- City of Bottrop (Germany)
- City of Brno (Czech Republic)
- City of Brussels (Belgium)
- City of Maringá (Brazil)
- City of Milan (Italy)
- City of Newcastle (UK)
- City of Prague (Czech Republic)
- REMOURBAN lighthouse project
- Sharing Cities lighthouse project
- University of Tsinghua (China)
- UrbanDNA (UK)

In addition, the following have expressed their interest in using the KPI framework and/or KPI tool and are in process or planning to use those in their cities/projects: city of Amadora (Portugal), city of Espoo, city of Helsinki, city of Jyväskylä (Finland), city of Chemnitz, city of Magdeburg, city of Rostock (Germany), New Taipei city (Taiwan), city of Reykjavík (Iceland), National university of Singapore (Singapore), SBEnrc (Australia) and the

lighthouse projects mySMARTLife, REPLICATE, TRIANGULUM and SmartEnergyCity. The remaining lighthouse projects are also expected to use CITYkeys KPIs as applicable in their projects.

The CITYkeys consortium gratefully acknowledges all the previously mentioned organisations for their valuable inputs.

1.3 Relations to other activities

The main activities of this task focused on testing 1) the KPI tool developed in T2.3, and 2) the KPI framework defined in D1.4. The experiences from co-designing the tool interface together with cities are reported in this deliverable. Based on the testing results presented in this report possible updates to the KPI framework and KPI definitions will be reported in D4.6 City handbook including guidelines for implementation of smart city performance measurement framework, and a summary of the main project recommendations.

2. KPI TOOL DEVELOPMENT, FEATURES AND TESTING

This chapter presents the tool development process with cities, the main tool properties and feedback received.

The KPI tool can be accessed at https://ba.vtt.fi/keystone/kpitool/. The access is restricted to registered users behind authentication to private accounts. The functionalities of the tool can be tested with user name ñdemoò and password ñdemoò. A private account can be obtained by contacting VTT. The main features of the KPI tool user interface are presented in section 2.2 with user guidance while short technical specifications of the functionalities are presented in Appendix 1.

2.1 Tool development process

The process started by cities specifying their needs regarding the prototype KPI tool. They answered the following types of questions:

- Who will be the target end-users of the tool? What types of needs do they have from the tool?
- What types of internal or open databases do cities have, can those be used in data collection?
- To whom will the overall assessment results be communicated and for which purpose?
- In which format should the assessment results be communicated to them, do they have specific needs on how the assessment results should be visualised?

After that the first prototype of the tool was implemented using citiesô wishes and the specifications defined in D2.2. The first prototype was then released to cities for testing and cities made comments and suggestions on the user interface. During the testing phase major issues in the tool were solved and in September all the feedback was summarised and decisions on the final changes were made together. Thus, all the feedback was used to implement the final prototype of the KPI tool. Regular teleconferences and meetings have been used during the whole process to showcase the tool functionalities and to discuss the changes to be made.

2.2 Main features and user guidance for CITYkeys KPI tool client

The main features and related graphical end user interfaces of the CITYkeys KPI tool client are described here. The tool is web browser based and it can be started form the URL https://ba.vtt.fi/keystone/kpitool/. The login procedure is shown in Figure 1.

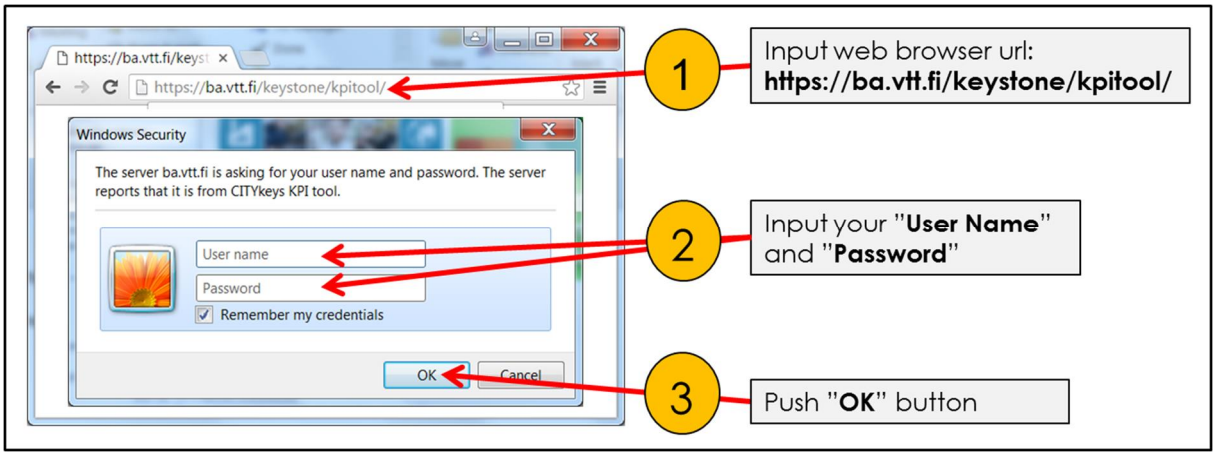

Figure 1. CITYkeys KPI tool login procedure

If the CITYkeys main page is in the web browser cache next authentication related error message is possible (Figure 2). To continue press Ctrl + F5 or Shift + F5 to reload the page from the CITYkeys server.

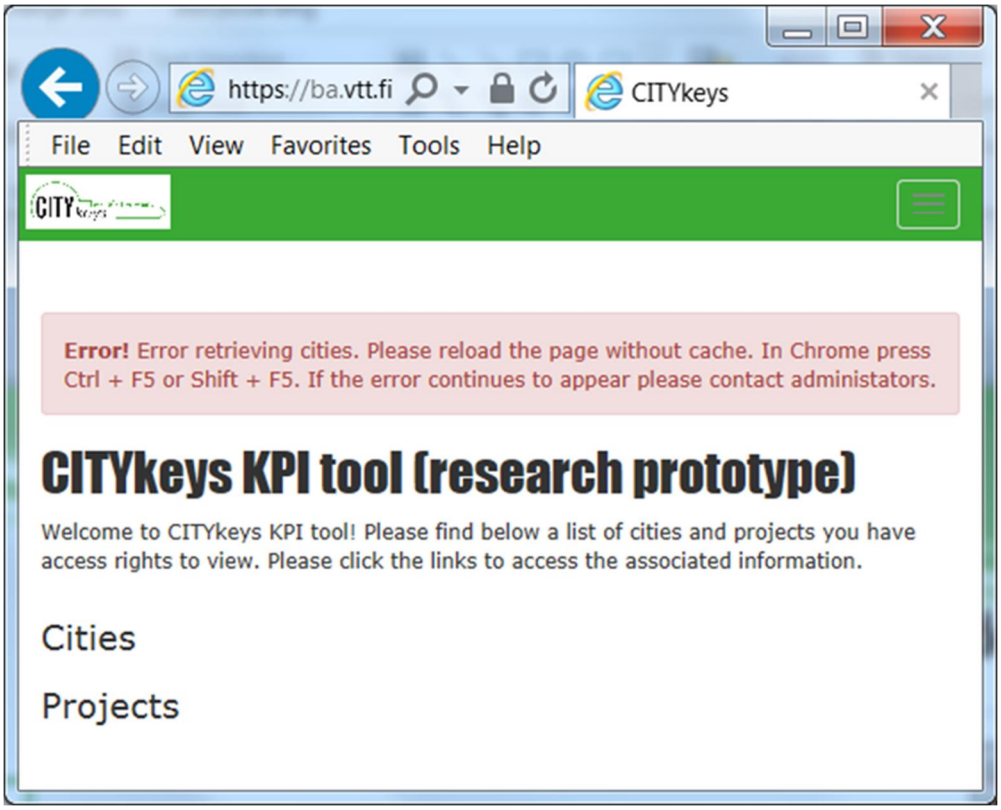

Figure 2. Possible authentication error when logging in if web browser cache is in use

The main page of the tool is show in Figure 3.

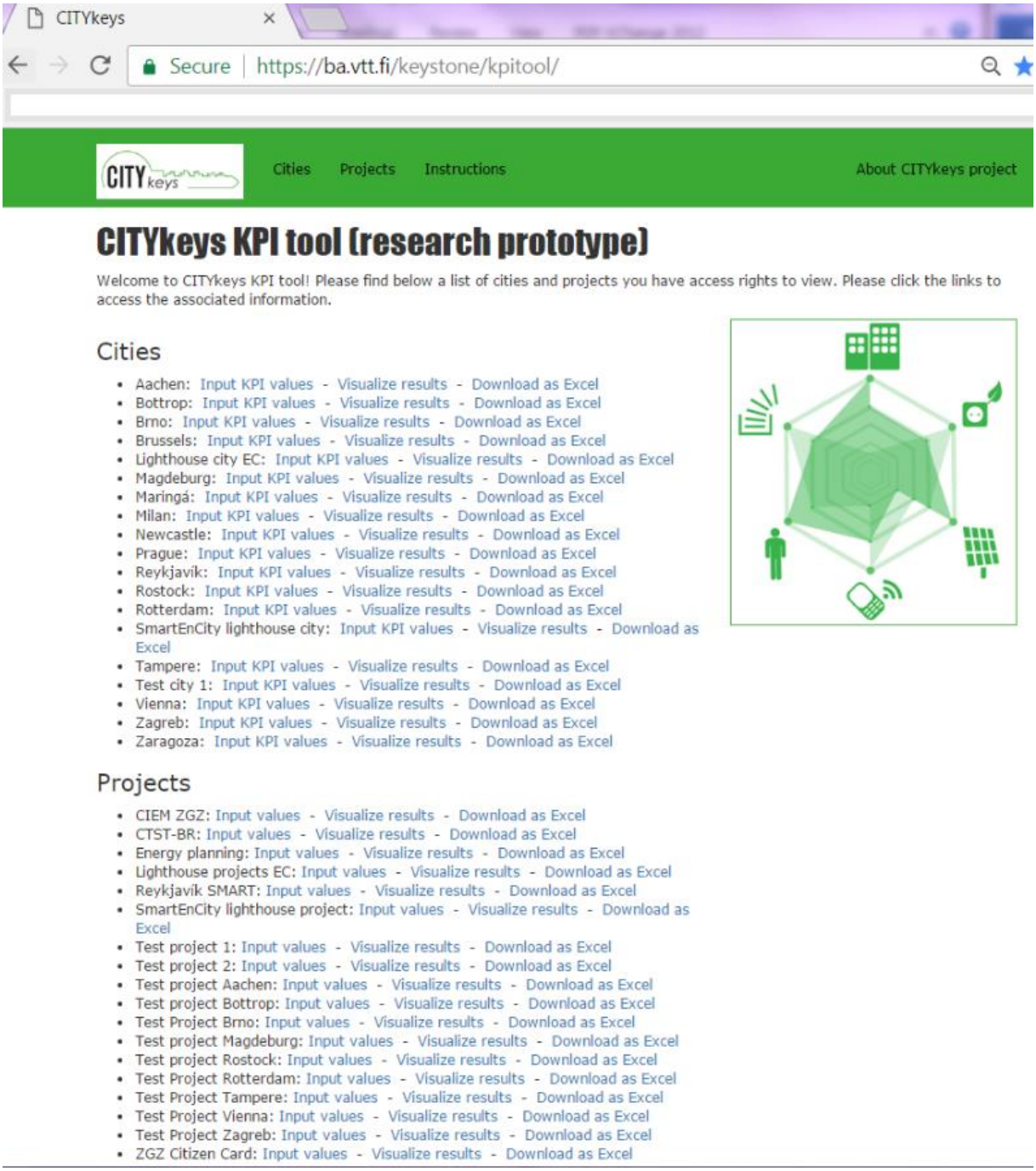

Figure 3. The main page of the CITYkeys KPI tool

All the cities and projects to which the user has access rights are listed in the main page of the tool. Related functions are ñinput city KPI valuesò, ñvisualize city KPI valuesò, ñdownload city KPI values as Excelò, ñinput project KPI valuesò, ñvisualize project KPI valuesò and ñdownload project KPI values as Excelò.

Tool related user interface for selection of the city indicator for inputting related value is shown in Figure 4.

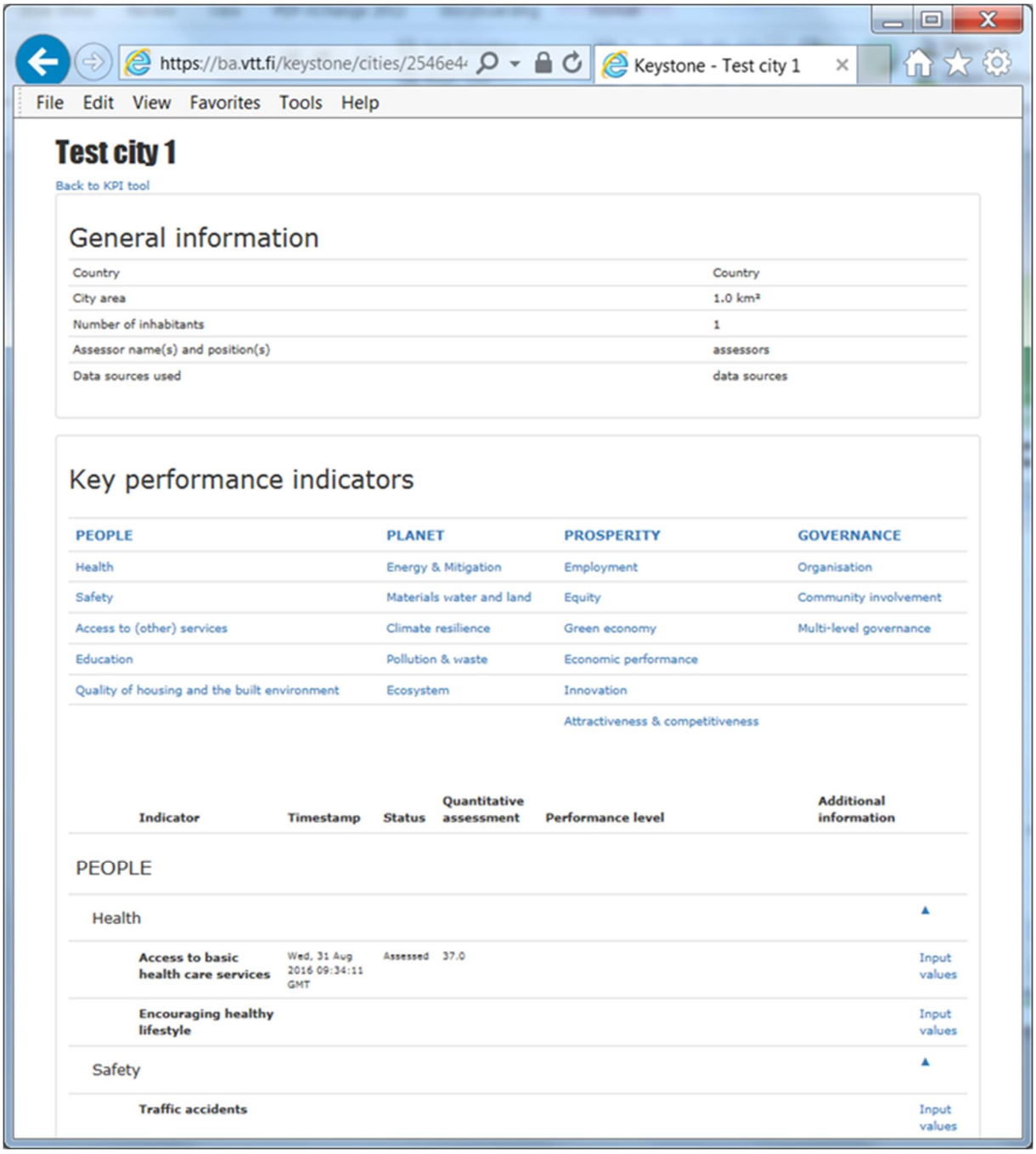

Figure 4. CITYkeys KPI tool related user interface for selection of the city indicator for inputting related value

The indicator selection related user interface includes general information of the studied city, CITYkeys framework for navigation between indicator subcategories and list of all CITYkeys city indicators including related values and the selection for inputting the indicator value.

The CITYkeys KPI tool related user interface for inputting and deleting city indicator value is shown in Figure 5.

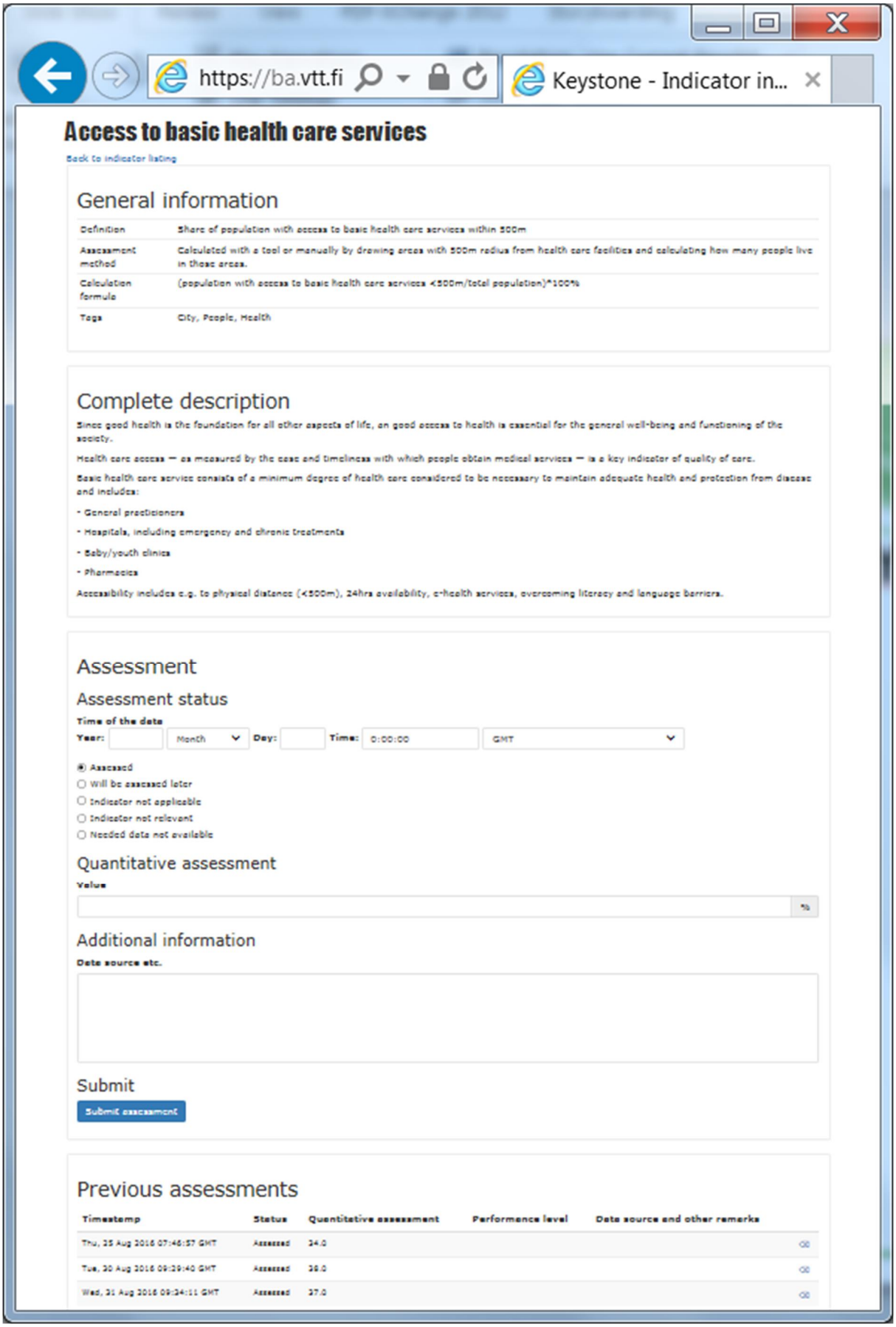

Figure 5. The CITYkeys KPI tool related user interface for inputting and deleting city indicator value

The user interface includes general information about the assessed project/city, complete description of each studied project/city indicator and possibility to input indicator assessment time of the data, assessment value, indicator performance level on 1-5 scale (only for project KPIs and Likert scale city indicators) and additional information like data sources, comments etc. In addition it is also possible to delete assessment (see more detailed information from the user instructions available at CITYkeys KPI tool web site).

The CITYkeys KPI tool includes two different types indicator visualization, the ñspiderò diagram based visualisation for KPIs assessed on a uniform performance 1-5 scale to illustrate the overall assessment results (Figure 6) and the trend graph based visualization for individual KPIs analysis (Figure 7).

The spider visualization supports the selection of the indicators which will be visualized. Only relevant selection tags (CITYkeys framework subcategories) are shown. The selection of multiple tags can be done by holding down the Ctrl key and left-click mouse button.

The tool supports also the visualization of the indicators by assessment dates (last value before the given date will be used (red coloured òspiderò diagram in Figure 6) and comparing the indicator values by assessment dates (grey coloured òspiderò diagram in Figure 6). This makes it possible e.g. to compare indicator values between the year 2015 and 2017 or project indicator values at the beginning of the project, in the middle of the project and at the end of the project. See more detailed information on how to compare indicator values from the user instructions available at CITYkeys KPI tool web site.

The trend graph based visualization is suitable for both quantitative and qualitative Likert indicators. It is most relevant for automatic reading based indicators and all those indicators which have many timestamped values (e.g. air quality index and energy or water consumption related indicators).

The visualization results can be saved or copied by clicking right mouse button over the figure and select òSave Image Asé ò to save the figure into the file or òCopy Imageò to copy the image to the clipboard (Figure 8).

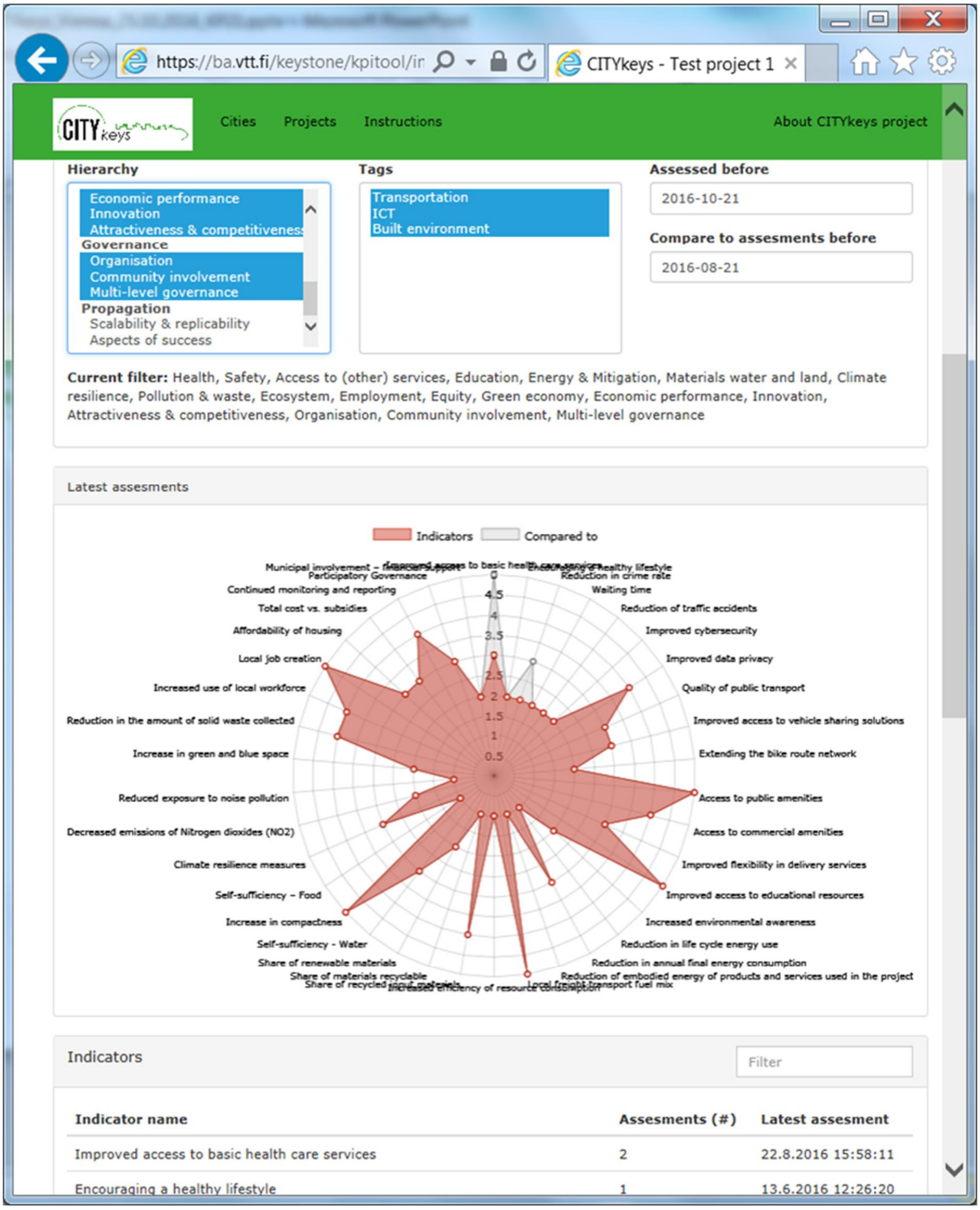

Figure 6. CITYkeys KPI tool: visualising overall assessment results

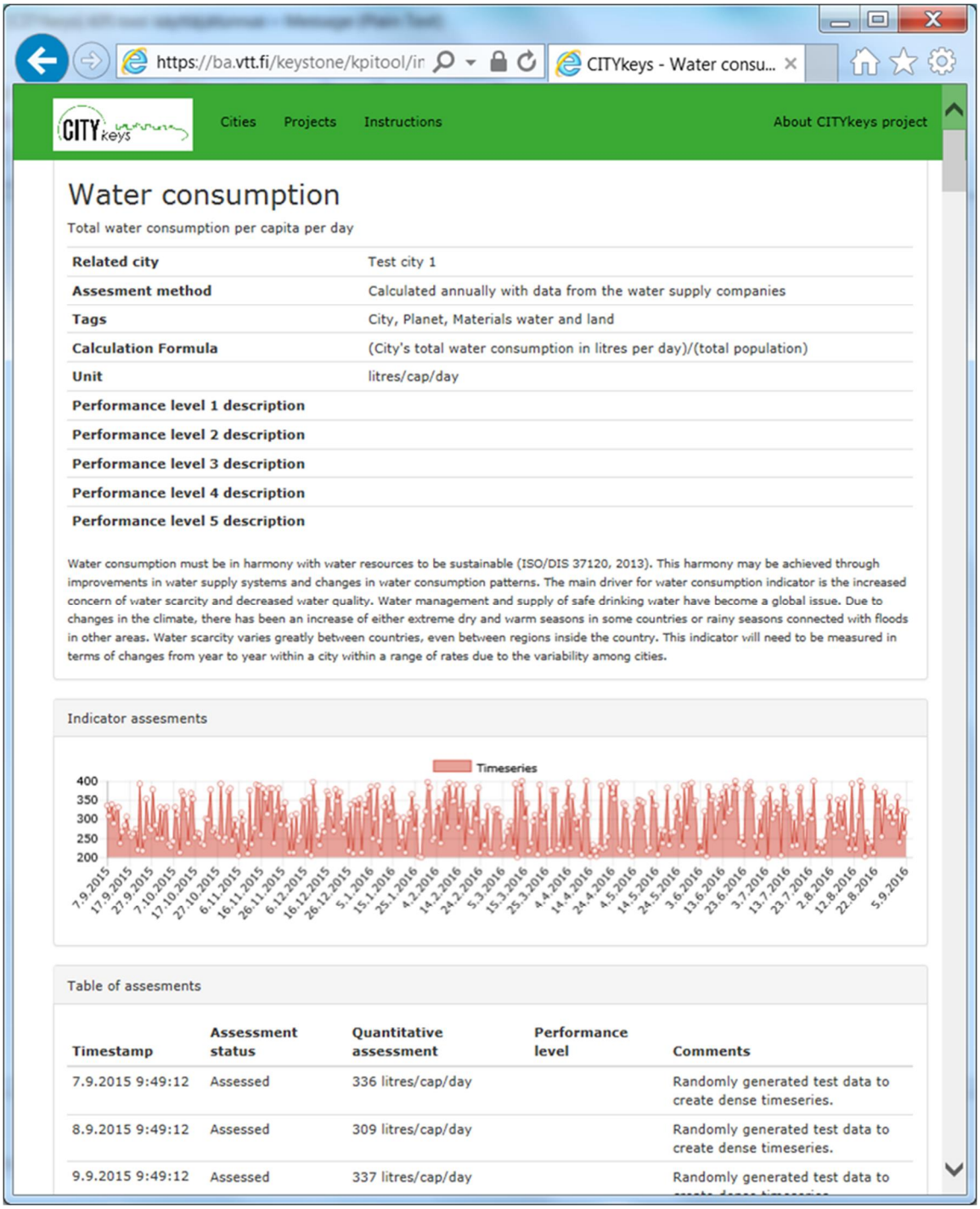

Figure 7. CITYkeys KPI tool: trend graph visualisation of individual indicators

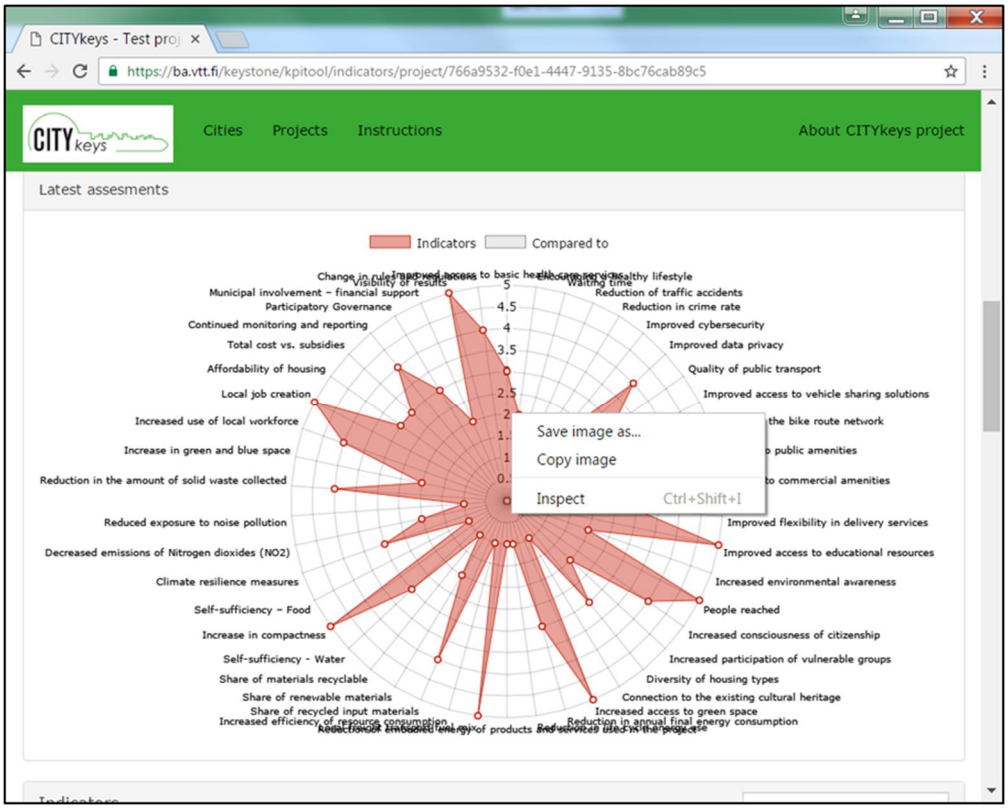

Figure 8. CITYkeys KPI tool: saving visualization results as bitmap image

In addition the indicatorôs exact values can be seen by moving cursor upper the related data point (Figure 9).

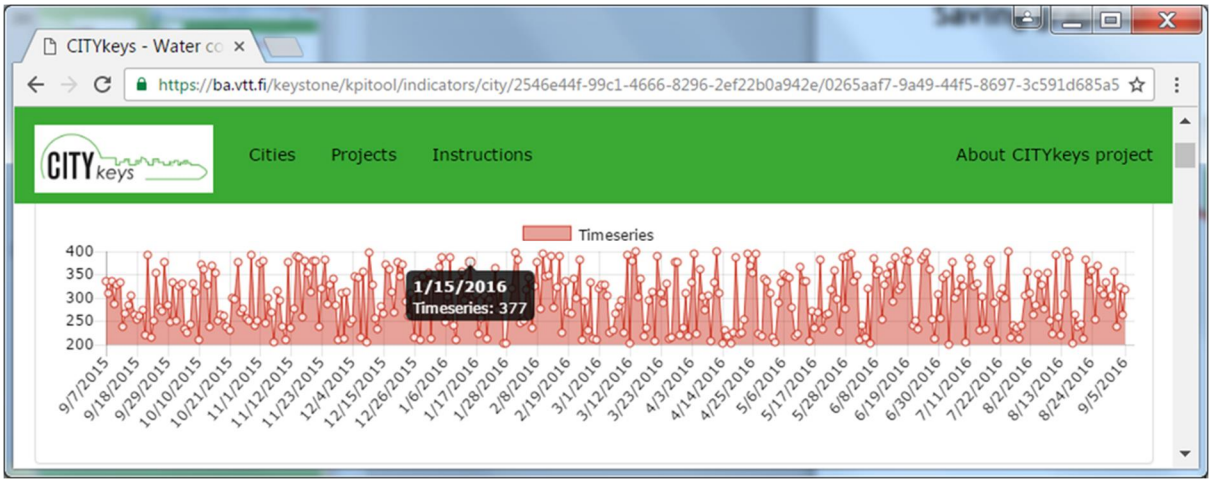

Figure 9. CITYkeys KPI tool: studying exact values of indicator related data point

CITYkeys KPI tool user interface and its functions for project assessment are analogue to the city assessment. The only difference is that the descriptions and definitions are different. In addition, it is important to note that a uniform scoring method on a 5-level scale is available for all the project KPIs (making it possible to show the overall assessment result with all KPIs on a uniform 5-level scale spider) while at city level those are available only for those KPIs that are assessed on Likert scale. This is due to the fact that it did not make sense to define generic target values for all cities for quantitative city KPIs (e.g. energy consumption) because of major differences between cities (stemming from e.g. climatic conditions).

To validate the automatic reading feature (further described in Appendix 1) it was implemented in the five CITYkeys partner cities for selected indicators as follows:

- Air quality index (Rotterdam, Tampere)
- Length of bike route network (Tampere, Zagreb, Zaragoza)
- Urban heat island (Tampere)
- Access to public free Wi-Fi (Vienna)
- Renewable energy generated within the city (Vienna)

The automatic reading functionality allows reading and updating automatically KPIs from citiesô own databases. This is useful when cities update regularly the raw datasets and the tool automatically updates the related KPI values in CITYkeys tool. The implementation was done by hardcoding the KPI related raw dataset URLs.

2.3 Cities' input

2.3.1 Test scoping and definition of targeted end-users

Rotterdam:

Rotterdam is mainly interested in assessing projectsô performance and evaluating the impact of projects on area and city level. Within the city the target users of the tool and evaluations made with it are the cityôs smart city manager, research and area development departments, project and programme managers and civil servants and experts working on a project or project development and policy-makers. Project and programme managers need the tool to set targets for their own projects/programmes and follow how those are met. Policy-makers (for example planners) need to assess also what impacts the projects have on area and city scale. Policy-makers also want to see how the city scores in comparison to other cities.

Tampere:

In the case of Tampere the main interest is in city level evaluations. The tool and its assessments are targeting different management levels (strategic and operational) and politicians, more specifically: city managers, operative level managers and politicians. Politicians mean hear the mayor, vice mayors and municipal councillors. The results are communicated to these politicians and different boards of directors. Thereby the tool is also related to the discussion on the cityôs strategy.

Vienna:

For Vienna the main interest is in project level meaning hear area developments of building blocks, quartiers and neighbourhoods. Consequently the main target groups are planners and project managers/coordinators. In addition, depending on the case, the tool and its assessment results are communicated to all the actors that are involved in those development projects including non-experts.

Zagreb:

In Zagreb the main interest is in project level but city level is relevant as well. The targeted end-users of the tool are experts working within the city. Depending on the themes addressed those are working at different city offices but the main users are from the Office of energy, environment and sustainable development. The testing project focuses on public buildings and in that case the target group is composed of the building managers and people responsible for the monitoring of those buildings.

Zaragoza:

In Zaragoza, the focus is on both project and city levels, although the project level has gained more relevance as CITYkeys has evolved. On the project level, the main interest is to foster a culture of indicators in project management. In this sense, CITYkeys is helping the Smart City Department to advance towards a project management dashboard. On the city level, Zaragoza is interested in providing data to guide policy decision making and to identify gaps and opportunities in areas related to the smart city.

The target end-users (to which the results are also communicated) are the Mayorôs office, the metropolitan observatory, the cityôs smart city department and, indirectly, citizens and businesses that participate in co-creation sessions. They mostly cover the following topics: low-energy buildings, start-up incubators, digital services (Zaragoza Citizen Card) and smart mobility.

2.3.2 Functionalities of the tool user interface

During the whole process of the tool implementation cities were involved in testing the intermediate versions of the tool user interface. This has been of course very useful to identify bugs in the tool but especially it has made it possible to ensure that the user interface is easy to understand and use by the cities and to be able to take into account citiesô needs since early phases. The implementation of those needs would have been much more difficult, if not impossible, at later stages of the implementation. The case studies have been carried out in parallel with the tool implementation and thereby useful feedback has been collected also about the applicability in concrete cases and daily situations.

Citiesô suggestions that have been simple to implement and have seemed necessary have been implemented immediately. For the rest of the feedback and suggestions there have been two rounds during which citiesô suggestions have been collected and summarised and then a decision has been made about their possible implementation. Those have been then discussed with the partners and a decision on final implementation has been agreed together. The decision on the implementation has taken into account how important certain functionalities have been for the five cities and from CITYkeys project point of view and how much resources they have required. In some cases some wishes have been also contradictory and a compromise has been agreed together.

The following list provides examples of citiesô suggestions that have been implemented:

- Data timestamp of KPI assessments has been changed in a format that is easier to understand and specifically requests selection of day, month and year. Simple guidelines on its use have been added.
- Possibility to delete assessments has been added.
- Excel download functionality has been added for the initial data entries.
- Visualisation download functionality has been added.
- A visualisation functionality to compare the overall assessment results of different time periods in spider diagrams has been developed.
- The input section of the tool has been made easier to understand and navigate with the following properties/functionalities:
    - The framework structure has been added on top of the page with links enabling direct navigation to different sections.
    - The different hierarchy levels of the framework have been made easier to distinguish from the list by using more clear and different formats and by changing their places in the list.
    - Back buttons have been added to move from individual KPI assessment to the same place in the framework on the main page or on top of the main page.

    - Links have been added after each KPI on the main page to move on top of the page where the framework picture with links is situated.
- An interface has been provided for cities to code and connect their own databases or data sets to the tool for automatic reading.

Overall the final the tool is seen as self-explaining and it is easy to navigate through. The functions ñinsert dataò and ñvisualize resultsò are seen as very useful and are expected to greatly support the management of the data.

2.4 Future development needs

The following opportunities have been identified to further develop the KPI tool (not yet implemented due to either the limited implementation resources or the project scope):

- Features to support citiesô voluntary publication and comparison, if they wish, of their assessment results. (Such feature was not yet implemented, since early in the process some cities set as basic requirement that all data should be kept completely private, which guided then the tool design and at the end of the process, when this opportunity was identified, there were no more time and resources left in the project to implement this feature.)
- Adding creation of own KPIs on top of CITYkeys frame. During the testing experience some cities have found out that it would be useful for cities to be able to define new ñlocalò KPIs intended for internal use. They found that CITYkeys has triggered some interesting positive effects in the way to manage both test projects internally, arising new KPIs that are meaningful mostly internally. If they could use CITYkeys tool as a single point of entry for both types of KPIs they feel that they would be more likely to use the tool once the project is over. If found widely important, as it seems, this would require from the current KPI tool further development to allow the use of own KPIs together with CITYkeys KPIs.
- Further exploitation of geo-data features to allow cities geographical e.g. district performance comparisons
- Linked data based support for linking "automatic data reading" with open data
- Allow users more independency in creating new projects and cities in their accounts and modifying existing ones
- Further support for target setting functionalities and visualizations
- More possibilities for users not only to set the KPI value but also if the KPI is for example about % of something, to also have to the option to set in addition the numerator and denominator as well. Or for a project KPI demanding the improvement during the project, to store also the values before and after separately and not only the improvement.
- Further develop search functionalities

3. RESULTS OF TESTING THE KPI FRAMEWORK IN CITIES' CASE STUDIES

Citiesô case studies were used to test the feasibility and applicability of the smart city performance assessment framework and KPIs in real cases. The aim was to get answers to the following types of questions:

- Is the framework appropriate to assess smart city/project performance in real cases?
- Are KPI definitions and assessment methodologies feasible, make sense?
- Is the required data available? In appropriate format/unit? Can it be collected in reasonable time/resources?
- Differences in the applicability and usefulness of KPIs in different cities/contexts (different geographic, economics, scale etc.)?

Each cityôs case study had different focus and scope corresponding to their respective priorities.

3.1 Rotterdam

Rotterdam case study focused on assessing one projectôs performance with all KPIs relevant to that project as well as its impact on city scale with those associated city KPIs that were relevant.

3.1.1 Case study description

The project used in the case study is called ñBoosting e-mobilityò which aimed to stimulate the development of electric transport in the Randstad region by placing chargers and by promoting electric vehicles.

The testing project is described in the following table.

Table 1. Rotterdam case study description

City	Rotterdam
Project name	E-mobility 3 cities NL - Boosting electro-mobility Amsterdam - Rotterdam - Utrecht
Start and end *date of the project*	Start: Q3 2012 End: Q1 2016
General description	Electric transportation is necessary for improving the air quality in cities and allows for the use of renewable energy in transport. The market for charging infrastructure is not fully developed. The business case for further investments in charging infrastructure can be bolstered by preparing the electrical grid to meet increasing demand. The Boosting Electromobility project stimulates the development of electric transport in the Randstad region by expanding the public charging infrastructure with strategically placed chargers and by promoting the use of electric vehicles. The four

	partners aim to increase the share of electric transport within the Randstad region. This region is an industrial and metropolitan area in west-central Netherlands including the cities of Amsterdam, Rotterdam, Utrecht and the Hague. The Randstad is one of the most important economic areas in Europe. The regionôs dense population and extensive economic activity make it suitable for electric transport. Actions include: 1. Prepare innovative and shared procurement of charging infrastructure 2. Install and manage chargers and fast-chargers 3. Initiate stakeholder-platforms 4. Promote electric transportation 5. Monitor and share knowledge
Stakeholders *involved in the project including funding body*	The project is a cooperation between the metropolitan area of Amsterdam, the cities of Rotterdam and Utrecht and the Royal Dutch Touring Club ANWB. The project is funded by the European Commission under the LIFE+ program.
Definition of the boundaries of the project *(geographical or other), please define the scope of the project (what is included and what is excluded)*	City level
List of CITYkeys data sets relevant for the project*. You can make the selection with some colour in the excel list of project data sets*	Preliminary selection presented in D2.1 Definition of data sets Appendix 4
Project data collection*.* *If the project has ended or is ongoing please describe your methodology for data collection, storing, etc.* *If the project is starting now please describe your planned methodologies, databases, etc. (see next row for non-quantitative data)*	Project nearly finished. Relevant data should be available.
Non-quantitative data: *please indicate your ideas how to evaluate the non-quantitative indicators for your project*	Interview with project manager
Additional information*, e.g. link to project web-page*	http://ec.europa.eu/environment/life/project/Projects/index.cfm?fuseaction=search.dspPage&n_proj_id=4407 http://www.boostingelectromobility.eu/ http://www.rotterdam.nl/elektrischrijden http://www.rotterdam.nl/rotterdamelektrischineuro

	peseprojecten

The following table shows the KPIs for which the project-to-city evaluation was tested.

Table 2. KPIs selected for testing project-to-city evaluation

Theme	**Project KPI**	**Associated city KPI**
Planet	Reduction in annual final energy consumption	Annual final energy consumption
	Decreased emissions of NO_2	NO_2 emissions
	Decreased emissions of $PM_{2,5}$	$PM_{2,5}$ emissions
Prosperity	Fuel poverty	Fuel poverty

3.1.2 Results and feedback

Project level testing:

In the project case study assessment, around half (45) of the available CITYkeys project KPIs were assessed. The other available KPIs were either not relevant (32) or applicable (16) in the project or the data was not available (5).

Data was not available for the following project KPIs: ñReduction in life cycle energy useò, ñReduction in lifecycle CO2 emissionsò, and ñLocal job creationò. As the project was a fully subsidised government project, almost all economic performance indicators were deemed not relevant.

Feedback on specific KPIs:

- ñPeople reachedò: the scoring scale seems too demanding since a lot of efforts were put to reach the target group in the project which translated only to the lowest score of 1. Therefore it is suggested to revise the assessment scale. The current KPI description also doesnôt take into account how well the target group has been involved.
- ñLifetime extensionò: a revision of the Likert scale is suggested since the current wording doesnôt take into account the case of this project in which durability was a design requirement but still only the score of 2 was achieved.
- ñCertified companies involved in the projectò: a revision of the Likert scale is suggested.
- ñGreen public procurementò: a specific definition of the meaning of the concept is missing from the definition.
- ñDiffusion to other actorsò: consider broadening the scope beyond only commercial parties
- ñChange in public procurementò: there is no difference between scoring levels 2 and 3

For the most part the framework was found appropriate for the case assessment and the KPIs matched well with the project goals. The framework was found especially useful for a qualitative assessment. The experience with the Likert scale KPIs was positive and those were found useful because the results of smart city projects are often not easy to catch in numbers. The KPIs were found relevant and applicable for comparison of smart city projects by experts while the KPIs were found too detailed for politicians. In future the framework is seen useful to make smart city projects better comparable at EU level and make them more visible. It took around six hours to collect the needed and relevant data.

Some indicators were assessed as not relevant as they were out of the scope of the project. It was noted that for some indicators the selection of a KPI as relevant/not relevant can be judged in a very matter-of-fact way. As an example ñkm of bike lanesò are not relevant for a transportation project that has nothing to do with cycling, while in other cases it can be argued to be a missed opportunity for the project. Another example is ñenvironmental educationò that should be relevant for all projects, even if the project itself has not considered it. Even with the extensive manual of D1.4 it is open for a range of dilemmas and shades of grey. If the more ñaspirational indicatorsò are always judged as not relevant, then their value is not properly taken into account and they will never become mainstream. However if they are fully taken into account but no project ever complies with them, the assessment would be overly harsh.

City level testing:

For the city level 23 KPIs were assessed. For one planned KPI (ñGreen jobsò) the data was not available. The KPI ñAir quality indexò was calculated using the automatic dataset reading functionality so its value is updated in the tool automatically.

At city level the work required to collect the needed data and calculate the KPIs was around 50 hours. One aim of Rotterdam is to be able to compare results between cities. On city scale assessment there was a clear preference for quantitative KPIs since the assessment made with qualitative KPIs was not found objective enough for this type of comparisons. Rotterdam would like the framework to support better the connections between different scales of assessment: project scale, neighbourhood scale and city scale.

Remarks on specific KPIs:

- ñAccess to commercial amenitiesò: in Rotterdam the limit distance used to calculate % of available commercial amenities for daily use is 275m (which is a mean distance in Rotterdam) and the KPI was calculated with that number (instead of the 500m limit of the CITYkeys KPI definition).

For the indicator ñReduction in direct (operational) CO_2 emissionsò it was possible to relate the project indicator with the city indicator, showing how much the project has contributed to reducing the cityôs emissions. With some more data mining this probably would have been possible too for: ñReduction in NO_2 emissionsò and ñReduction in $PM_{2.5}$ emissionsò.

3.2 Tampere

3.2.1 Case study description

The case study in Tampere focussed on testing the city scale assessment as widely as possible. In the long term the case study was expected to support the following aims of the city:

- Improve and develop the measurement of KPIôs mainly on sustainable urban development and innovation
- Further develop the cityôs knowledge management system and the ecosystem for data collection
- Exploiting the results when the new city strategy will be planned (after the municipal election in 2017)

3.2.2 Results and feedback

The testing focused on carrying out a city scale assessment as comprehensively as possible. Most of the data needed for quantitative KPIs was available and 39 KPIs were calculated. The KPIs ñLength of bike route networkò and ñAir quality indexò were calculated using automatic dataset reading. In the beginning of the testing phase, the plan was to calculate also the KPI ñwater consumptionò by using automatic dataset reading. There was an initial agreement with Tampere Water Utility to cooperate on this, but in the end they didnôt have enough resources to make it happen.

The qualitative KPIôs evaluated through interviews were assessed by interviewing one expert per indicator. It would be interesting to assess further, if this is enough to get a reliable result.

The needed data was not available (or the effort for the data collection was too high) for the following KPIs:

- Digital literacy
- Local freight transport fuel mix
- Domestic material consumption
- Grey and rain water use
- Water exploitation index
- Local food production
- Native species
- Green jobs
- Congestion

It is to be noted that there are varying reasons for data not being available. Sometimes it is because of lack of resources, but sometimes it is because lack of understanding how the indicator should be assessed. This was the case for ñdigital literacyò or ñgreen jobsò.

KPI specific remarks:

- GDP: the data is about the wider region of city of Tampere

The time needed to collect the data and calculate the KPIs was between 15min and one hour for each KPI. However, for many of the indicators, it took some time to find out the right data source and it took even two weeks to get the data. From that time, the amount of ñactive workò was one hour, and the rest consisted of waiting for responses from different city departments or other organisations.

3.3 Vienna

Viennaôs testing focused on project assessment.

3.3.1 Case study description

The testing project used was SMARTER TOGETHER lighthouse project that started in February 2016. Since the implementation and monitoring phase of the project hadnôt started yet during the testing phase, only an assessment of expected impacts was conducted.

The project is described in the following table.

Table 3. Vienna case study project description

City	Vienna
Project name	SMARTER TOGETHER H2020-SCC1 lighthouse project
***Start and end** date of the project*	01.02.2016 ï 31.01.2019 (implementation) /

	31.01.2021 (monitoring)
General description	Viennaôs testing project is the SMARTER TOGETHER Lighthouse Project. The project area of Smarter Together: Large social housing estates mainly built between 1945 and 1985 and owned by the City of Vienna ï Wiener Wohnen or Non-Profit Housing Cooperatives (i.e. BWSG) need to be refurbished in the upcoming years. This refurbishment shall be conducted by a holistic approach: mobility concepts for the area, installation of local renewable energy (to be used locally and to be fed into the district heating grid), participation etc.
Stakeholders *involved in the project including funding body*	European commission, City of Vienna, BWSG (housing company), Wiener Stadtwerke (Utility company), Kelag Wärme GmbH (district heating operator), Siemens Austria, Sycube, Austrian Post, AIT, University of St. Gallen, local citizens and SMEs
Definition of the boundaries of the project *(geographical or other), please define the scope of the project (what is included and what is excluded)*	Viennaôs smart city lighthouse area is part of Simmering, the 11th and one of the outer districts in the South-East of Vienna. Simmering is a traditional workersô district. The area selected for SMARTER TOGETHER is located in its North-West. It is an area ñin betweenò vast redevelopment sites (Vienna main station, Mautner-Markhof Areal), but not directly connected to them, and is as a whole a refurbishment area. The area covers about 1.5 km^2 with some 21,300 inhabitants, hosts 12,000 jobs and is characterized by important social housing from between WW1 and WW2. With 14,200 inhabitants per km^2 it is a rather dense area, way above the average in the district or the city as a whole.
List of CITYkeys data sets relevant for the project*. You can make the selection with some colour in the excel list of project data sets*	Preliminary selection presented in D2.1 Definition of data sets Appendix 4
Project data collection*.* *If the project has ended or is ongoing please describe your methodology for data collection, storing, etc.* *If the project is starting now please describe your planned methodologies, databases, etc.*	Assess the status quo (t=0) to check the availability of data and the quality of the data sets. Additionally estimated data on the impact of the project and at the expected end state (t=1) of the project is collected to the extent possible. Potentially, this desired end state could be compared later with the "real" end state at the end of the Smarter Together

(see next row for non-quantitative data)	project. The Smarter Together project proposal was the main source for the data collection.
Non-quantitative data: *please indicate your ideas how to evaluate the non-quantitative indicators for your project*	Interviewing the project leader of the testing project.

3.3.2 Results and feedback

In Vienna the following city KPIs were calculated using automatic dataset reading: ñAccess to public free Wi-Fi accessò and ñRenewable energy generated within the cityò. Otherwise the testing focused on project scale.

On project scale in total 22 project KPIs were calculated.

Data was not available (or the effort for the data collection was too high) for the following of the selected KPIs:

- Reduction in lifecycle CO_2 emissions
- Maximum Hourly Deficit
- Decreased emissions of Nitrogen dioxides (NO_2)
- Decreased emissions of Particulate matter ($PM_{2,5}$)
- Increased use of local workforce
- Fuel poverty
- Costs of housing
- Certified companies involved in the project
- Net present value
- Internal rate of return

KPI specific comments:

- Improved access to vehicle sharing solutions: What does access mean here? Is it related to ICT (apps, or to hardware / vehicles)?
- Increased environmental awareness: remove the term ñsomewhatò from the description of level 5.
- Increased participation of vulnerable groups: Better refer to "socio-demographically vulnerable groups" instead of "not well represented" groups. Hard facts (income, handicaps) are more important here than representation issues.
- Design for a sense of place: Should also include public spaces, not just buildings. To which extent are the criteria applicable to refurbishment projects?
- Increased use of local workforce: We can only estimate the number of jobs directly or indirectly created by the project based on investment, but not specifically for local jobs.
- Green public procurement: Green procuring is very important for the City of Vienna. Private project partners consider it to a limited extent.
- Stimulating an innovative environment: What does stimulate the environment mean? Better refer to the triple helix here.
- Improved interoperability: The headline should be better called: "Improved interoperability of community infrastructure".
- Continued monitoring and reporting: Level 3: Why are the well-defined smarty goals mentioned here, and only here?
- Bottom-up or top-down initiative: The headline does not fit to the question.

Feedback on quantitative KPIs:

Since the testing project is still at a very early stage, the main data source for the quantitative KPIs was the Smarter Together project proposal. Therefore the data collection process was rather fast and easy. The collection of the data, the calculation of the KPIs and the insertion of the results into the tool took approximately 10 min for most of the KPIs.

However, the data collection for data not stated in the project proposal was very challenging. It was very hard to identify the sources and to collect the data. In most cases it would have required too much time and effort to identify whether the data would be available or not (e.g. asking various departments for data availability, etc.). Thus almost no additional data besides the one stated in the project proposal were collected.

In general the main difficulty in the project level assessment was the definition of the project scope and boundaries which naturally also have a significant impact on the KPI values. Depending on KPIs different scopes were chosen and therefore the overall consistency was lacking. Some examples of these difficulties are listed here:

- Indicator ñPeople reachedò: the project area in which the project takes place can be drawn in various ways. You can either choose the number of inhabitants living in the houses that get renovated or of all inhabitants in the project area → the %value changes accordingly and so the number is not conclusive. (% is bigger or smaller ï doesnôt give information about the people actually reached)

People reached	% of people	Percentage of people in the target group that have been reached and/or are activated by the project	number of people reached/total number of people considered as the total target group of the project) * 100%

- Indicator ñIncrease in local renewable energy productionò: It can be based on all the houses where refurbishment takes place or on the entire project area. Depending on the scope the result differs and therefore the value is not very conclusive.
  - Other problem: what is local? Produced in the project area or in the city of Vienna?
  - Other problem: If there was zero renewable energy production before the project, *any* increase of renewable energy due to the project means +100% (or error) → value not very conclusive

Increase in local renewable energy production	% in kWh	Percentage increase in the share of local renewable energy due to the project	[(Energy production after the project - Energy production before the project) / (Energy production before the project)] *100%

Feedback on qualitative KPIs:

The qualitative Likert scale KPIs were assessed by the project leader of the testing project and were generally well perceived, in particular due to the clear description of the qualitative indicators. By verifying the scores by two additional people it seemed that objectivity was reached for the KPI scores. 15 Likert Scale KPIs were tested which took approximately two hours.

The testing has shown that the main challenges for implementing the CITYkeys framework in the future would be data availability (or the effort and time for the data collection), the definition of the project scope/boundaries and the integration of the framework into the processes of a city.

3.4 Zagreb

Zagreb case study focused on assessing one case project and some city KPIs.

The aims were as follows:

1. Improve and develop the measurement of KPIôs
   - At the city level KPIôs related to sustainable urban development and innovation
   - At the project level: Solutions for refurbishment buildings (Energy efficient urban revitalization)
   - Model for replication (public buildings, private buildings, city district etc.)
2. Further develop the knowledge on management system, financial solutions and data collection
3. Exploring the results in current and future city strategic plan: ZAGREBPLAN 2020+

3.4.1 Case study description

The testing project is described in the following table.

Table 4. Zagreb's case study project description

City	City of Zagreb
Project name	ZagEE ï Zagreb energy efficient city
Start and end *date of the project*	2015 - 2018
General description	The ZagEE - Zagreb energy efficient city represents an initiative for encouraging and realizing significant energy savings by implementing economically viable and energy efficient technologies and measures on buildings of different purposes owned by the City of Zagreb as on the public lighting system. The project is implemented as part of the IEE program for technical assistance 2012 - Mobilizing Local Energy Investment (MLEI) which is used to finance technical assistance and production of the necessary technical documentation for the application of measures of energy efficiency and renewable energy sources on objects included in the ZagEE project. The implementation of the project ZagEE began on April 1st, 2013 and it shall last for three years. The project value is 1.813.464 EUR. Energy refurbishment of public buildings includes the implementation of standard energy efficiency measures (restoration of facades, roofs, external joinery, internal lighting, change of energy sourcesé), as well as the application of renewable energy

	systems (solar collectors and photovoltaic systems) on the said buildings. The modernization of a part of public lighting will be the first project of such size in Croatia which will feature LED lamps with regulation during late night hours. The ambitious plan of renovating 87 public buildings and the replacement of a part of energy inefficient public lighting through the ZagEE project with an estimated investment of 29.379.114 EUR will result in high energy savings and a reduction of CO_2 emissions. The implementation of energy refurbishment investments, the local economy will gain a significant initial incentive through creating new business opportunities, new workplaces as well as contribute to positive economic shifts and boost economic development as a whole. The ZagEE project is the first project of this size and complexity in Croatia and wider region and the experience gained through its implementation can serve as an example and guidance to other public, local and regional self-governments that wish to implement energy refurbishment on their territory.
Stakeholders *involved in the project including funding body*	Co-funded by the IEE (Intelligent Energy Europe) programme of the EU (as part of the IEE program for technical assistance 2012 - Mobilizing Local Energy Investment (MLEI)) Stakeholders involved (see Figure 9 for the project core team)
Definition of the boundaries of the project *(geographical or other), please define the scope of the project (what is included and what is excluded)*	The City of Zagreb.
List of CITYkeys data sets relevant for the project*. You can make the selection with some colour in the excel list of project data sets*	Preliminary selection presented in D2.1 Definition of data sets Appendix 4
Project data collection*.* *If the project has ended or is ongoing please describe your methodology for data collection, storing, etc.* *If the project is starting now please describe*	Collection of the data of energy consumption by smart metering (electricity, heating, water, weather forecast) for technical analysis. Collection of bills of energy consumption for economic analysis. Investments initiated by energy refurbishment of the public buildings

your planned methodologies, databases, etc. (see next row for non-quantitative data)	and modernisation of the public lighting. Capacity building in energy refurbishment of public buildings: trainings, number of workshop for the building managers and workshops for the city administration.
***Non-quantitative data:** please indicate your ideas how to evaluate the non-quantitative indicators for your project*	Interviewing project stakeholders.
***Additional information**, e.g. link to project web-page*	http://zagee.hr/?lang=en

The organisation of staff and data within the project are illustrated in Figure 10.

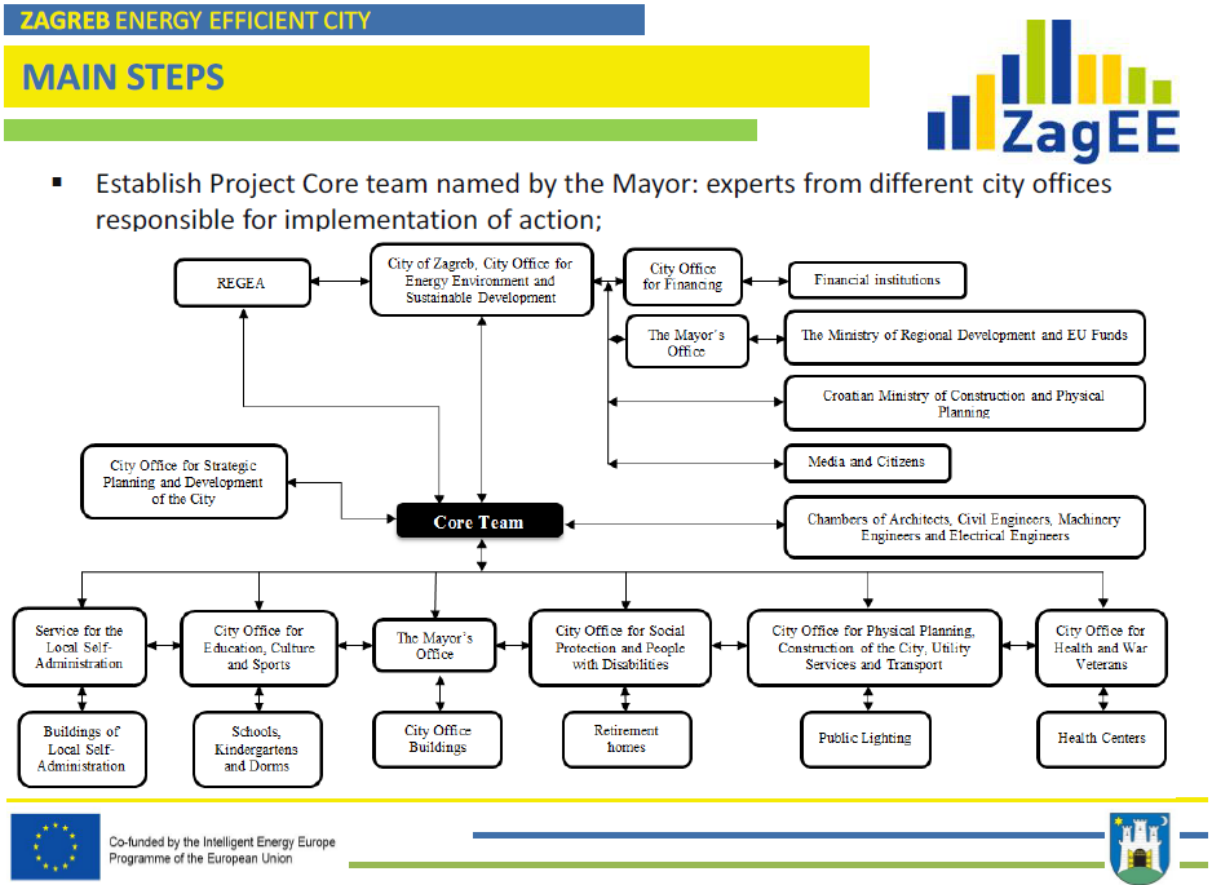

Figure 10. Parties involved in the case study project within Zagreb

3.4.2 Results and feedback

The assessed project is on-going and will end in 2018. The assessment done during CITYkeys testing therefore considered the situation in 2016. The results will change once the project will be completed. The data availability and usefulness of the assessment results are expected to be better after the end of the project.

The KPI ñLength of bike route networkò was used to test the automatic data set reading functionality. That dataset (provided through Zagrebôs open data portal) however lacked some of the cityôs bike routes and was therefore used only to test the technical feasibility of the tool functionality.

For the project scale 24 KPIs were assessed. Three KPIs were out of the project scope and were therefore judged as ñnot relevantò. The needed data is not available to evaluate the KPI

ñReduction of embodied energy of products and services used in the projectò. Many KPIs were considered as relevant but were not assessed since the project is on-going and all the data was not available yet.

The main challenge in data collection was related to the first step of identifying whether data is available or not, and if yes, where that data is located within the city of Zagreb. This is due to the fact that, as can be seen in Figure 9, there are many different city offices involved in the project and the data needed by different KPIs of the holistic CITYkeys framework are collected by many different city offices in Zagreb. Similarly to many other cities the lack of centralised city databases makes it difficult for city personnel to know where certain data is located and stored. Even if the data would be available, it often requires significant resources (many phone calls and emails) to be aware of it and to localise it. Due to this fact the main focus in Zagrebôs testing was on testing the aspects of the CITYkeys framework for which data was available in the office coordinating the project, i.e. the City Office for Energy, Environment and Sustainable development. For these areas, the data was available and easy to find. Especially for the social and economic KPIs in the CITYkeys categories ñPeopleò and ñProsperityò the identification of the data availability and its localisation was too time-consuming and was done only for a couple of KPIs.

The CITYkeys framework was considered appropriate and useful to assess the testing project of Zagreb since the KPIs address the key objectives of the project. Also the framework structure People-Planet-Prosperity-Governance-Propagation was very well received. The users of the KPIs considered having enough expertise to calculate the KPIs, the main challenge remaining in the localisation of the data. Also it was noted that sometimes the KPIs require collecting data from private companies. For example the KPI ñImproved access to vehicle sharing solutionsò requires information from car sharing companies and is not straightforward to obtain.

Qualitative KPIs were assessed and considered to be easy to evaluate on the Likert scale. Among the users there was, however, a preference on quantitative KPIs (being more objective). It was, however, noted that technical experts typically prefer numbers while qualitative KPIs could be more informative in social domains.

3.5 Zaragoza

In Zaragoza the case study consisted of testing both project and city scales. The project scale was tested by assessing two projects: CIEM Start-up incubator and Zaragoza Citizen Card.

The main goals of the testing were as follows:

1. At the project level

- Showcase two practical examples of Zaragoza's vision towards a Smart City (openness, transversatility, innovation)
- Improve the decision making process (better informed decisions)
- Generate new open (aggregated) data sets

2. At the city level

- Raise political awareness on the smart city subject and identify gaps and opportunities for new services with businesses and citizens
- Improve city's branding
- Provide new (automated) tools to the metropolitan data observatory

3.5.1 Case study description

The two projects used in Zaragozaôs testing are described in the following tables 5-6.

Table 5. Description of Zaragoza's case study project CIEM

City	Zaragoza
Project name	CIEM (Centro de Incubación Empresarial de la Milla Digital)
Start and end *date of the project*	Start construction: 2010, project on-going
General description	zero-emissions building holding a start-up incubator (so testing can be applied both to energy performance and innovation)
Stakeholders *involved in the project including funding body*	Zaragoza City Council, Init services (start-up incubation services), Zeroaplus (CIEM Data Lab project / energy data collection and exploitation)
Definition of the boundaries of the project *(geographical or other), please define the scope of the project (what is included and what is excluded)*	The project consisted of the construction of a Zero Emissions Building (CIEM) to serve as start-up incubation facilities.
List of CITYkeys KPIs relevant for the project*. You can make the selection with some colour in the excel list of KPIs*	Preliminary selection presented in D2.1 Definition of data sets Appendix 4
Project data collection*.* *If the project has ended or is ongoing please describe your methodology for data collection, storing, etc.* *If the project is starting now please describe your planned methodologies, databases, etc. (see next row for non-quantitative data)*	Data collection about the economic / innovation part (start-up incubation services) is done through the ñAnnual CIEM's Wealth generation reportò http://www.ciemzaragoza.es/2014/04/el-informe-de-generacion-de-riqueza-%C2%A1ya-esta-en-ingles-wealth-generation-report/ Data collection about the energy consumption in process of being collected and published.
Non-quantitative data: *please indicate your ideas how to evaluate the non-quantitative indicators for your project*	Internal surveys with non-quantitative data about the services provided to entrepreneurs and their overall satisfaction with the project.
Additional information*, e.g. link to project web-page*	www.ciemzaragoza.es

Table 6. Description of Zaragoza's case study project Zaragoza Citizen Card

City	Zaragoza
Project name	Zaragoza Citizen Card
Start and end *date of the project*	March 2010
General description	A unified all-in-one city card for public services
Stakeholders *involved in the project including funding body*	City Council, transport operators, banks...

Definition of the boundaries of the project *(geographical or other), please define the scope of the project (what is included and what is excluded)*	Geographical boundaries is the city, and those elements where citizens interact with public services: parking meters, kiosks (for recharge), transport validation machines...
List of CITYkeys KPIs relevant for the project*.*	People / people reached, # of citizens considered stakeholders in the project, project costs spent on local suppliers, contractors and service providers, number of green jobs created by project, Number of jobs created by project, Project's initial total investments, Project's annual total cash inflow, Project's annual total cash outflow, Average delay per vehicle kilometre (before and after project)
Project data collection*.* *If the project has ended or is ongoing please describe your methodology for data collection, storage, etc.* *If the project is starting now please describe your planned methodologies, databases, etc. (see next row for non-quantitative data)*	Methodologies: – mobility surveys, activity surveys – meetings (minutes of meetings) – design of ñmobility spidersò (pedestrian route optimization)
Non-quantitative data: *please indicate your ideas how to evaluate the non-quantitative indicators for your project*	– activity surveys (to measure the level of satisfaction) – meeting minutes
Additional information*, e.g. link to project web-page*	https://www.zaragoza.es/ciudad/sectores/tarjetaciudadana/

3.5.2 Results and feedback

In Zaragoza the KPI ñLength of bike route networkò was assessed with automatic dataset reading.

At city level 42 KPIs were assessed. For the following KPIs the needed data was not available: ñPublic outdoor recreation spaceò, ñDigital literacyò, ñAffordability of housingò, ñShare of green public procurementò, ñGreen jobsò, ñOpen public participationò, ñExpenditures by the municipality for a transition towards a Smart Cityò.

Concerning the testing project ñCIEMò 50 KPIs were assessed. The other available KPIs were not applicable or relevant for the project except ñIncrease in compactnessò for which data was not available.

For the project ñCitizen cardò 42 KPIs were relevant and were calculated. For the following ones data was not available: ñQuality of public transportò, ñCO_2 reduction cost efficiencyò and ñDecreased travel timeò.

KPI specific remarks for project level:

- Increased consciousness of citizenship: KPI description is not clear enough.
- When it comes to measuring or assessing ñnon-physicalò projects (such as Zaragozaôs digital citizen card) some KPIs lose their relevance or they are just not applicable.

KPI specific remarks for city level:

- Access to public amenities: regarding the definition public fountains and rest rooms are not seen in the same package as community centres
- Access to educational resources: Education is under the responsibility of the regional Government
- Renewable energy generated within the city: data is only available at regional level (region of Aragon)
- Energy consumption and CO_2 emissions: data is available in tons of oil equivalent and needs to be converted to the unit used in CITYkeys (MWh)
- Share of certified companies: suggest to include in the KPI definition instead of the total number of companies only those from relevant sectors (construction, industry and related services)

There were some situations where data available in the city for a particular KPI does not fit, either the formula, or the units. For instance, data for NO2 emissions, or energy consumption (we have the unit ñTons equivalent of oilò instead of MWh), or even water consumption, where only the domestic consumption was available. It is unrealistic to think that KPIs, even the most simple or common ones, will match exactly throughout cities with the definition, formulas or units provided by the tool.

Based on the testing experience Zaragoza found that it would be useful for cities to be able to define new ñlocalò KPIs intended for internal use. They found that CITYkeys has triggered some interesting positive effects in the way to manage both test projects internally, arising new KPIs that are meaningful mostly internally. If they could use CITYkeys tool as a single point of entry for both types of KPIs they would be more likely to use this tool once the project is over.

During the testing experience Zaragoza has found out that CITYkeys KPIs serve as a suitable engagement method for citizens to be aware of what is going on in the city, and that such engagement can be fruitfully used by policy makers to shape new projects through co-creation dynamics.

3.6 Feedback from additional testing cities and projects

The five CITYkeys partner cities have actively participated in all stages of the indicator framework and tool development and therefore have also agreed on their final versions. This section summarizes some of the important remarks collected from additional voluntary KPI and tool testers (outside the project consortium) that for majority are European cities but also contain stakeholders from other contexts (e.g. companies or cities/universities outside Europe).

Importance of certain topics outside Europe:

- Resilience is an important aspect of a smart city that is almost completely non-addressed by the framework (Note: received from China)
- In our case and context cyber-security would be the most important of the KPIs. It's difficult to start a Smart City project without a specific cyber security project. People don´t know even know yet what is cyber security which further poses problems. (Note: received from Brazil)

Framework structure and approach:

- The D1.4 manual with complete KPI descriptions is too long document and not easily/quickly accessible for most cities, a simpler guidance is needed. (Note: The KPI tool contains all necessary information for KPI assessment in shorter and more

accessible format. Also easily readable short guides have been published in CITYkays especially to answer this need, notably D3.1 CITYkeys experience: recommendations from cities to cities and 4.6 User handbook accessible through CITYkeys website http://citykeys-project.eu/)

- The structure under People-Planet-Prosperity-Governance-Propagation was well received by all as well as the thinking behind it.
- The division to project and city levels is also seen as a good approach.
- Spread and coverage ï notably including governance, and particularly including propagation (that is unique as regards indicator sets I am familiar with ï and very necessary to support demand aggregation).

Indicators:

- The indicator list includes a large number of source references to Eurbanlab (which I am not familiar with); compared to for instance references to ISO 37120 (which I would anticipate). I did however notice ISO37120 referenced substantially in the detailed metrics appendices.
- In terms of making CITYkeys most relevant to EU cities (and potentially beyond EU ï if that is a desire?), my expectations is that EU cities will pay increasing attention to ISO as it is the ώberô standards body.
- A suggestion might be to provide a simple summary chart up front that makes more reference to the major sources of indicators. That would help cities build confidence in using CITYkeys.
- There appears to be a fair reliance on judgement (Likert scale) ï first impression is around half of them? That makes things relatively easy and swift (good); however introduces human influence (manageable at city / project level; less robust for cross-city comparison)
- The SCC01 programmes may require greater reliance on numerical measures. What has been the initial feedback from discussions with them?

Investment Readiness

- I wonder to what extent you have considered the funders side of the measurement framework ï both their view of a city from financial strength, and project from the standpoint of making it the most investable. The traditional economic project measurement is certainly included. Some of the other factors that influence investability of a project (or viability and attractiveness of a city) are also critical to smart city adoption

KPI tool:

- Overall well received, easy to use and answers the need within various city organizations. Direct application in practice is foreseen
- Need a score and simple overall visualization (spider) from overall city assessment result to show at management within city where the city is performing well on one simple graph

3.7 Summary of results

The testing phase has been crucial in CITYkeys for the validation of the indicator framework. The framework structure has been well received by all. The results show that the KPIs also correspond well to the key objectives of citiesô smart city projects, and thus the structure of the framework and KPIs selected have been well designed and can be validated as useful in practice.

Almost all of the project and city KPIs have been tested successfully in at least some city. The main challenge for application is related to data collection ï particularly to find where the data is. Even if the data is most of the time available somewhere it is difficult to localise and access. Another mentioned challenge is the definition of project scope and boundaries that have a significant impact on the assessment results.

The data availability and successful implementation have been validated though testing for most of the project KPIs (73/101 = 72%) and city KPIs (59/76=78%). This however doesnôt allow concluding on the true data availability rates in each city since each city focussed on addressing a different selection of KPIs in testing. As the CITYkeys framework has been designed for evaluating a wide variety of smart city projects, it is also logical that our small sample of testing projects did not cover all indicators. A number of indicators suited for evaluating transport projects for example were not tested in a project dealing with buildinsô energy refurbishment. The data availability rates presented in D2.1 ñDefinition of data setsò showing an average 70% overall data availability rate and 25% open data availability for the quantitative city KPIs still seem to remain more or less valid. For the qualitative Likert scale KPIs that represent over a half of the project KPIs and under a half of the city KPIs the data availability should in principle be close to 100% since their assessment mainly depend on the assessorôs willingness and time available.

It has to be noted also that there can be varying reasons for data being judged as ñnot availableò during testing. Sometimes it is because of lack of resources, and the data actually might be available if enough time could be spent on localising it. Sometimes it is also because lack of understanding on how the indicator should be assessed. This was the case for example for the KPIs ñdigital literacyò or ñgreen jobsò.

Some KPIs also have true data availability issues. This is typically the case of KPIs for which there is not regular data collection in place, such as ñchange in the number of native speciesò or ñdomestic material consumptionò.

Based on the testing, several refinements to KPI descriptions or assessment methods have been suggested (as detailed in Appendix 2). The KPI specific testing conclusions (mainly already presented within this chapter) are summarised in detail in Appendix 2. Those will lead to minor improvements in KPI definitions that will be documented in CITYkeys D4.6 City handbook including also guidelines for implementation of smart city performance measurement framework, and a summary of the main project recommendations. The improvements needed, mainly relate to ambiguous KPI descriptions leaving room for various types of interpretations, as presented in Appendix 2.

The project-to-city assessment was found most difficult and was explored with success only for a small number of KPIs.

Wider lessons learned are presented in the following chapter 4.

4. LESSONS LEARNED

4.1 Importance of cities' involvement in all stages of the development

CITYkeys testing phase (as the whole project) has shown that citiesô involvement in smart city KPI & tool development is crucial. Without engaging the end-users at all stages of the development the results wouldnôt probably be used at the end. Such developerī end-user collaboration must include from the end-users at least the following: 1) requirement setting in the beginning, 2) commenting various intermediate versions, and 3) validation of the final version ensuring the proper communication format.

The previous stages were already strongly incorporated earlier in the development of the CITYkeys indicator framework. The testing phase served to validate the framework and refinements to the indicators are reported in the D4.6 City handbook.

The KPI tool co-design experience in CITYkeys led to the following insights:

- When tool developers and practitioners from cities (with completely complementary expertise) join forces they firstly learn from each other and finally add contributions that are crucial for the end result. The complementarity of backgrounds and expertise might be challenge for efficient collaboration in the beginning but itôs worth the effort. Citiesô engagement is particularly crucial for ensuring the easy and intuitive usability of the tool interface.
- In some cases researchers think to know best how certain things should be implemented but the result is not satisfying the end-users. In our case this often related to the communication format of the information asked in the tool interface (e.g. the format of time stamp of an assessment). Such things might seem minor for developers but have at the end an important impact on the easiness of using the user interface which is crucial for practitioners.
- All information communicated and requested in the tool interface must be in the clearest and simplest form possible. City practitioners are often so busy that they wonôt use a tool if there is any extra difficulty in understanding how to use it or where to find the needed information.
- End-usersô testing of the intermediate versions is off course also very useful to identify bugs that sometimes otherwise might get unnoticed.
- Active involvement of end-users in early stages of the development makes it possible to still change some functionalities that, if noticed at later stages, might be too burdensome to implement.

4.2 Flexible approach in applying the CITYkeys framework

While the aim of CITYkeys was the development of a common European framework, it has to be acknowledged that each city is unique and has its own priorities and aims. The key differences between cities that have an effect on relevant indicators include the following:

- Size and population density
- Geographical location, culture and climatic conditions
- Economic level and technology maturity

Also the wide variety of smart city projects was taken into account in the development of the KPI framework. This led to a framework that has a long list of almost 100 KPIs available. While earlier in CITYkeys project it seemed wise to require cities to assess all of those that are relevant in the assessed project (in order to ensure that the assessment integrates all key aspects of a smart city) the testing experience has shown that it might be too much asked.

Based on testing even the evaluation of all those KPIs that are applicable for the assessed project sometimes requires too many resources from cities, at least with the limited resources for one projectôs assessment. Citiesô case studies also showed that due to the specific aims and priorities in a project/city it is often reasonable to focus only on assessing certain of the available and most relevant KPIs.

These observations have led to a situation where a flexible approach in applying CITYkeys framework is allowed and often recommended.

That being said a comprehensive and holistic assessment is still encouraged always when resources are available since it would lead to a holistic assessment of all the key aspects of a smart city.

Probably partly due to different backgrounds many of the testers have had a clear preference, and good justification behind, for either qualitative or quantitative KPIs. For some quantitative KPIs are seen more valid and objective than the information got from a qualitative assessment. On the other hand, those preferring qualitative KPIs have found them indeed quite objective (after testing with independent evaluators). The qualitative KPIs seem especially useful for evaluating smart city projects at early stages when hard facts are often lacking and they might still help to incorporate important aspects in the project. All in all the balance of both types of KPIs offered by CITYkeys framework has been well justified and seems a sound approach to combine the advantages of both types of assessments. Thus it is highly recommended to use both types of KPIs since they often help to achieve an as comprehensive and rich assessment result as possible, containing most information for further analysis. Of course, hear as well, the selection of either type of KPIs is always allowed depending on the case and objectives of the assessment.

When applying for own purposes without need to compare indicator results to other cities the flexible approach is also allowed for interpretation of KPI definitions. For example the limit distance used for accessibility related KPIs is 500m but in a city with higher population density a lower distance might be more reasonable (for example 275m in Rotterdam). Also for example the method suggested for the assessment of ñdiversity of housing typesò is Simpson diversity index, for which the data has been found to be difficult to obtain and some cities use easier proxies such as % of social housing that are allowable.

4.3 Recommendations for the use of the framework

4.3.1 Resources needed to apply the KPIs

For completing the CITYkeys project and city indicators a broad knowledge base is necessary. The testing cities generally felt that they had the needed expertise available. From the results it can be noted, however, for instance that respondents mixed up ñemissions of air pollutantsò with ñconcentrations of air pollutantsò and did not know how to recalculate energy in Joules to kWh. The CITYkeys indicator framework needs (like many other frameworks) to be used in an expert based assessment. Also the indicators requesting a qualitative governance or process evaluation presuppose that ideally an external expert needs to be involved. A basic requirement for applying the holistic CITYkeys framework is the collaboration and integration of various experts from different city departments.

4.3.2 Definition of project boundaries is an important but not always evident task

For some cities the main difficulty in the project level assessment was the definition of the project scope and boundaries which naturally also have a significant impact on the KPI values. Depending on KPIs different scopes were sometimes chosen and therefore the overall consistency was lacking. Therefore this very important first step of a project assessment needs to be carried out very carefully and considering different aspects. This would be the case for example when assessing a project about a transport app for the whole city or a refurbishment project where only some buildings of an area are refurbished.

4.3.3 Possible uses of the KPI framework

The following summarizes some identified possible uses of the CITYkeys framework:

- Project management
  - Users: e.g. project managers, urban planners, civil engineers
  - Evaluating a project before, during and after the project
  - Assessing individual projects or a project portfolio
- City management
  - Users: e.g. mayor's office, Smart city department, Metropolitan observatory, Environmental planners, politicians
  - Assessment for cityôs strategic level, operative level or policy decision making
  - Setting targets for city and monitoring progress
  - Deciding on new projects, steering existing ones and assessing the performance of past ones
  - Set quantitative targets for cityôs smart city strategy and monitoring those

In addition, some cities have found out that CITYkeys KPIs serve as a suitable engagement method for citizens to be aware of what is going on in the city, and that such engagement can be fruitfully used by policy makers to shape new projects through co-creation dynamics.

4.3.4 Recommendation for evaluating the impacts of lighthouse or other projects

Some smart city projects, including certain lighthouse projects, have been steered by using input-output indicators such as numbers of smart meters installed, new apps applied or meetings held. While such types of KPIs can be useful to monitor how effectively a project is implementing its objectives they donôt tell anything of the impact achieved with those meters, apps and meetings. Therefore lighthouse and other projects are highly recommended to CITYkeys framework for evaluating their true impacts targeted and achieved. The need for applying such a holistic impact based assessment methodology has been widely acknowledged during the testing period by both those lighthouse projects already involved in testing and other stakeholders dealing with lighthouse projects. This statement naturally is valid for other applications as well.

4.4 Data collection issues: need for coordinating SC activities and developing centralised databases and standardised open datasets

Data availability as such was not an issue in testing cities for applying the CITYkeys KPIs and the KPIs are quick to calculate. The data collection process was however found burdensome. This partly stems from the fact that the smart city topic (and the holistic CITYkeys framework) is so wide that it integrates various different topics that traditionally

are handled by many different city departments that are not regularly collaborating. Only a small share of cities yet have a smart city department that would coordinate the associated activities including data management. On the other hand, some CITYkeys KPIs even need to collect the data from sources outside the city organization (e.g. regional or national sources or private companies). There is a significant need for improvement in both coordinating these activities within the city and especially improving the data management practices in order to improve the efficiency of the data collection process and to better exploit of the big amount of the data available. The lack of centralised city databases makes it difficult for city personnel to know where certain data is located and stored. Even if the data would be available, it often requires significant resources (many phone calls and emails) to be aware of it and to localise it. Often the data is in someoneôs personal excel file without many being aware of it while it would be useful for many.

Therefore the main challenge in data collection during testing was related to the first step of identifying whether data is available or not, and if yes, where that data is located within the city. This was an important barrier in several cases for cities to exploit the various relevant and important aspects of the framework as the localisation of the data was so burdensome for the persons involved in the assessment that they contented themselves to assessing only those KPIs that related to topics they were familiar with.

From data management perspective the first very important and needed step is the development of citiesô centralised databases where all city data is stored. There is a lot of work on this domain needed but it would greatly improve the efficiency of all data collection, management and exploitation in cities. To further improve the exploitation potential of all the vast amount of the data currently collected next steps would be requirements for useful data formats and processes for defining whether a dataset can be published as open/publicly available or not and to make these datasets easily accessible from the databases.

From automatic reading point of view it is very important that the open datasets needed for indicator calculations are standardized. It is important because the implementation of the calculation routines is almost impossible if every city is using different types of raw dataset and different methods for publishing this data.

In addition RESTful APIs are good and easy way to open CITYkeys data for other developers. In future, linked data would probably be a good way to integrate different types of open datasets in different URLs but because of limited implementation resources that was not tested in CITYkeys.

4.5 Discussion

4.5.1 How to select the relevant KPIs for an assessment?

Some indicators were assessed as not relevant as they were out of the scope of the assessed project. It was noted, however, that for some indicators the selection of a KPI as relevant/not relevant can be judged in a very matter-of-fact way. As an example ñkm of bike lanesò are not relevant for a transportation project that has nothing to do with cycling, while in other cases it can be argued to be a missed opportunity for the project. Another example is ñenvironmental educationò that should be relevant for all projects, even if the project itself has not considered it. Even with the extensive manual of CITYkeys D1.4 it is open for a range of dilemmas and shades of grey. If the more ñaspirational indicatorsò are always judged as non-relevant, and thus not applied, then their value is not properly taken into account and they will never become mainstream. However if they are fully taken into account but no project ever complies with them, the assessment would be overly harsh.

4.5.2 Role of public funding in cities' smart city projects

A majority of the smart city projects cases proposed by the cities for evaluation appeared to be partly publicly funded. While the rather small sample doesnôt allow drawing wider conclusions it still suggests that public funding (still) plays an important stimulating role for current smart city projects. Many of these projects, however, incorporate very solid and promising business components which hopefully will be soon capitalized in new jobs and economic growth to return the public investment.

4.5.3 Future development possibilities and needs

Since the beginning of CITYkeys the involved cities have set as main objective the development of a framework that would be useful for them to set targets for their development and to monitor their own progress. This has been called as ñself-benchmarkingò and has been expected to help the cities to improve their projects and smart city processes and activities in general. This has led to the development of a framework that is not best applicable for traditional benchmarking purposes.

Later in the testing phase some cities have, however, expressed also the interest for comparing to other cities. Since these havenôt been the original aim set by the participating cities both the KPI framework and also the current KPI tool design donôt easily support such use purposes and would need some further development to support inter-city comparisons. For project KPIs a uniform five-level scoring scale has been developed allowing the comparisons of different projects. However, on city scale it seemed not reasonable to develop generic target values for all cities for the quantitative KPIs. This is mainly due to the differences between cities. Due to for example the different climates in the South and North the same requirements for energy consumption wouldnôt be fair. Therefore cities cannot be easily numerically compared with CITYkeys city assessment. Instead cities have been encouraged to develop their own target values to be implemented in the KPI tool which would at least allow the spider visualisations of all city KPIs in addition to the project assessments. There hasnôt been yet however no interest (or knowledge) to perform that task which therefore remains an unexplored future opportunity. The possibilities for developing a smart city index for citiesô ranking are further explored in CITYkeys D3.3. ñRecommendations for a smart city indexò.

On the other hand, some potentially useful new future features of the KPI tool have been identified but not yet implemented due to limited implementation resources in CITYkeys. Those include for example:

- Tool features to support citiesô voluntary publication, visualisation and comparison, if they wish, of their assessment results.
- Features to enable the incorporation of citiesô own local KPIs (or from other sources) in the KPI tool

5. CONCLUSIONS

5.1 Summary of achievements

The testing phase has been crucial in CITYkeys for validation of the indicator framework and the associated tool through feasibility testing in citiesô case studies. The results show that the framework and KPIs are useful in evaluating smart city (projects) in daily practice. Especially the framework structure (People-Planet-Prosperity-Governance-Propagation), the relevance of the KPIs and the balance between quantitative and qualitative indicators have been well received. According to many, the important holistic impact assessment approach is still lacking from many smart city project evaluations.

The main results from the indicator testing can be summarised as follows:

- Most of the project and city KPIs have been tested in at least some of the case studies that each had a different aim and focus. The data availability and successful implementation of most of the project KPIs (73/101 = 72%) and city KPIs (59/76=78%) have been validated. The average KPI data availability rates in a European city are expected to be over 70% (around 25% as open data) for quantitative city KPIs and close to 100% for all the qualitative ones. The few non-tested examples refer to items without regular data collection, such as ñchange in the number of native speciesò and ñdomestic material consumptionò.
- Several improvements in KPIs have been suggested and, to the extent they will be agreed as sound, they will be reported in the CITYkeys D4.6 User handbook along with recommendations on the use of CITYkeys main results.

By setting the requirements and providing, at all stages, feedback and suggestions on the usability and functionality of early prototypes of the KPI tool cities have participated in the co-design of the user interface at all stages of the process. Therefore the usability and exploitation of the developed KPI tool are expected to be high in future. In addition to the user interface testing an automatic data reading functionality has been validated in all the five cities involved. Cities can also by themselves connect their own datasets to the tool though the tool APIs. Future development opportunities for the tool have been identified to further improve the tool adaptability for various use purposes.

5.2 Conclusions and lessons learned

The following insights arise from the testing experience:

- A European indicator framework is always a compromise due to the different practices and conditions in each country. In addition each city is unique with its own existing data formats etc. The KPI framework application therefore requires certain local adaption including at least some data conversions but sometimes also the selection of the locally relevant KPIs for assessment. In consequence, and due to the various use purposes of the framework, a flexible approach has been supported. Such approach would probably make the use of the KPI framework most useful while holistic and comprehensive assessments are still highly recommended when the needed resources are available.
- As validated through testing the developed framework seems currently most useful for citiesô ñself-benchmarkingò, for setting targets and monitoring those for projects/ the city and for comparing different projectsô performances. As it hasnôt been its purpose

the framework wonôt be well adapted at least in its each current form for city rankings/comparisons. Future opportunities for such are however explored in D3.3 ñRecommendations of a smart city indexò.

- A wide network of European cities and lighthouse projects have been actively engaged in CITYkeys framework implementation and use of the associated tool now or in near future. The testing phase has also allowed engaging some additional projects, research organisations and companies, even sometimes from other continents (South America, Asia, Australia), thus to a small extent allowing to compare the continental differences and priorities.
- Some of the lighthouse projects have been engaged during the testing phase or already earlier in using the CITYkeys framework in assessing holistically their projectsô true impacts. The remaining are expected and highly recommended to join as well to further explore and ensure CITYkeys frameworkôs best usefulness in their projects.
- For completing the CITYkeys project and city indicators a broad knowledge base is necessary with sometimes needs for external experts.
- The main barrier in data collection, however, is not the data availability or expertise but the localisation and accessibility of the possibly available data. The localisation of the data within or outside the often scatted city organisation dealing with the wide topic of a smart city has proved to be often so burdensome task that it leads to many giving up the KPI evaluation process due to the time needed (many phone calls and emails). The development of centralised data management, storing and publishing practices would help a lot in the localisation and exploitation of the currently vast amount of available city data. As a later step the standardisation of (open) data set formats would further improve the data exploitation possibilities. In addition these steps would greatly improve the efficiency of city processes including management, coordination and reporting or smart city related activities.

6. REFERENCES

Bosch et al. 2016. D2.1 Definition of needed datasets. Available at http://citykeys-project.eu/
Bosch et al. 2017. D3.3 Recommendations for a smart city index. Available at http://citykeys-project.eu/
Kontinakis et al. 2017. D4.6 User handbook. Available at http://citykeys-project.eu/

APPENDIX 1: TECHNICAL SPECIFICATIONS OF CITYKEYS KPI TOOL

An overview of the implemented CITYkeys KPI tool concept is shown in Figure 1.

The most important parts of the tool are

- CITYkeys backend including support for the CITYkeys framework and storing of city and project level projects and related indicator values.
- CITYkeys RESTful APIs including e.g. support for querying, inserting and deleting city and project indicator values.
- CITYkeys KPI tool client including support for inputting, visualizing and downloading KPI values.
- CITYkeys automatic data reading including support for automatic reading of supported open datasets, calculating related KPIs and saving calculated values to the CITYkeys backend.

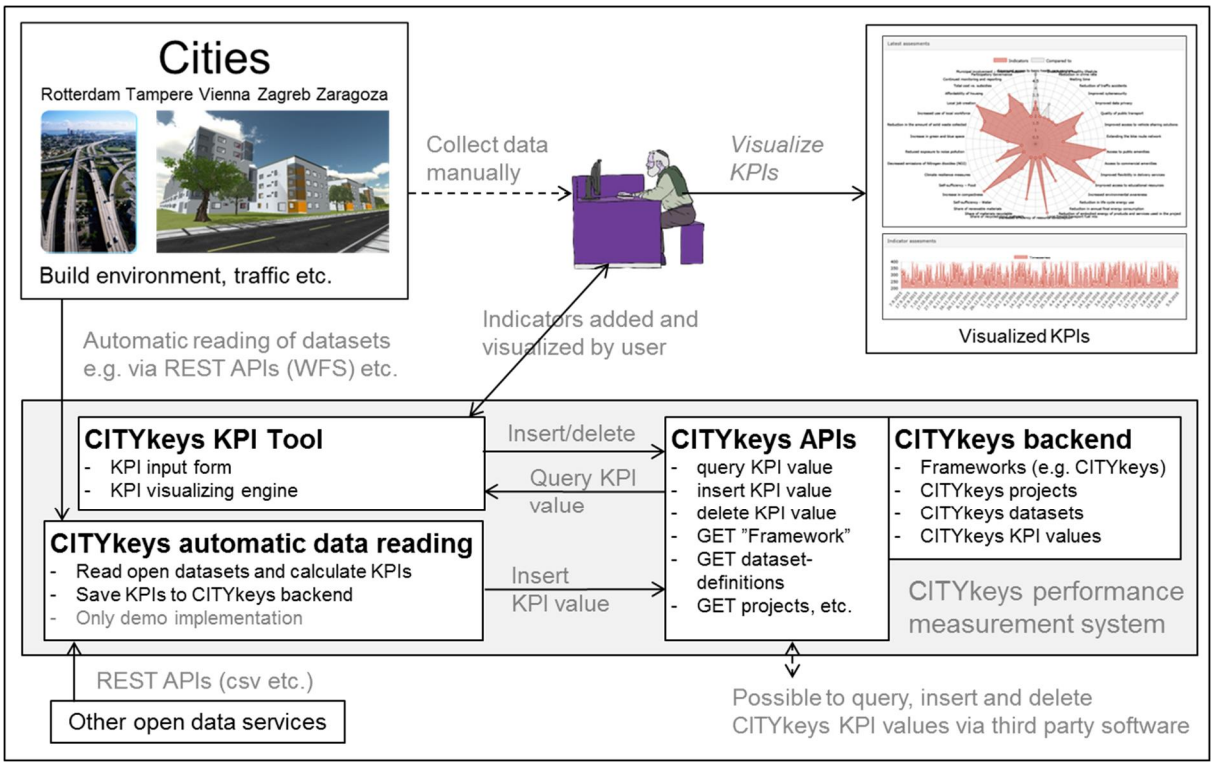

Figure 1. Overview of the CITYkeys KPI tool concept

CITYkeys RESTful APIs

CITYkeys RESTful APIs make it possible to integrate CITYkeys backend to third party software if the authentication is accepted. In other words this makes it possible for cities to utilise CITYkeys information by their own software tools or link the CITYkeys platform with other city platforms.

CITYkeys query API is described in Figure 2. This API makes it possible for third party software to read CITYkeys KPI values from CITYkeys database.

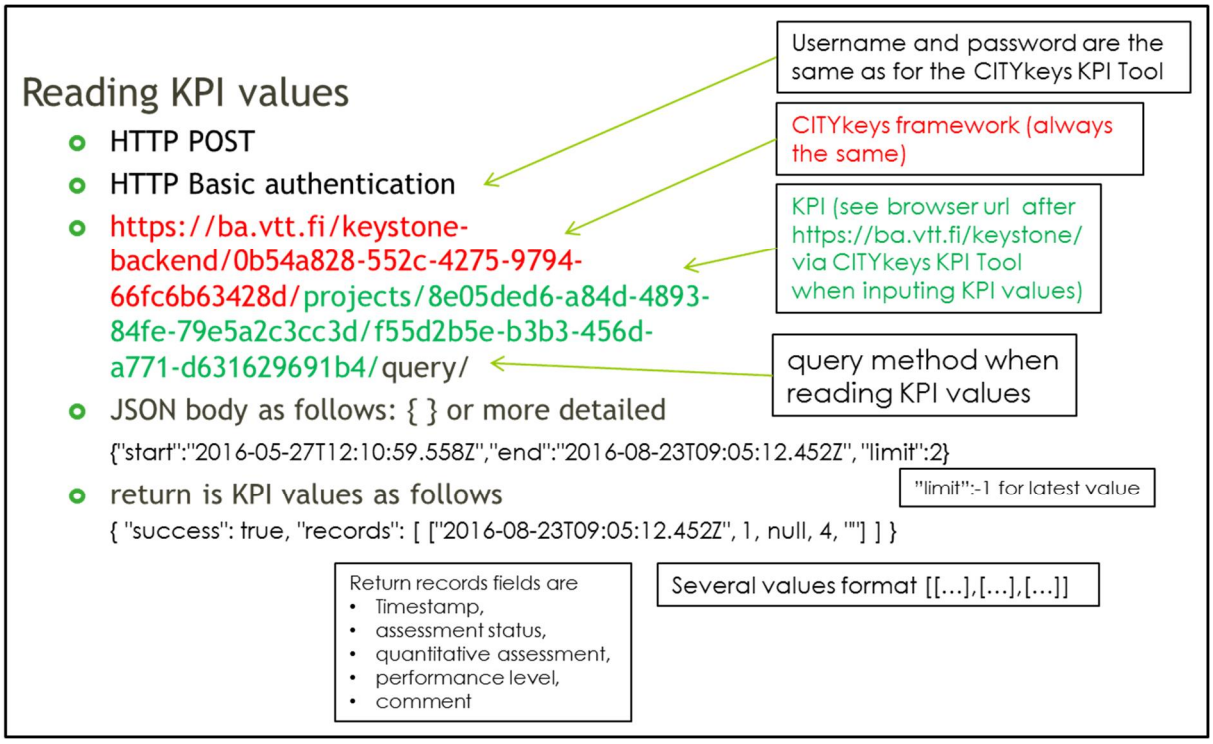

Figure 2. CITYkeys query KPI value API

CITYkeys query API is described in Figure 3. This API makes it possible for third party software to insert new CITYkeys KPI values to CITYkeys database.

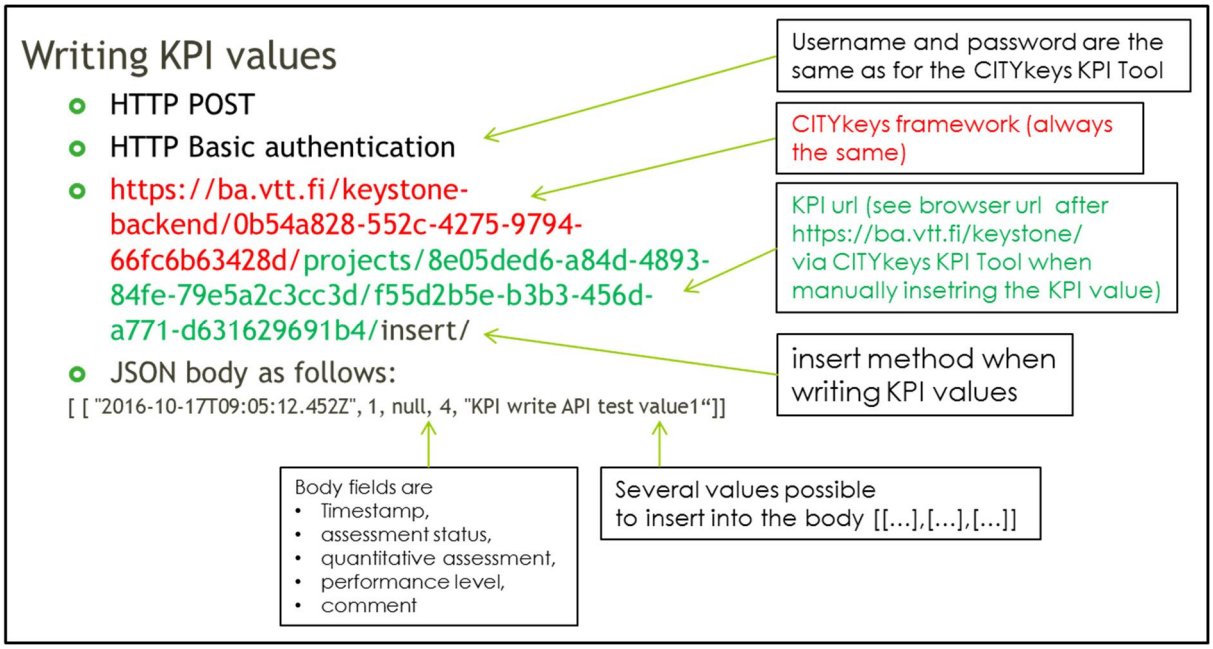

Figure 3. CITYkeys insert KPI value API

CITYkeys query API is described in Figure 4. This API makes it possible for third party software to delete CITYkeys KPI values from CITYkeys database.

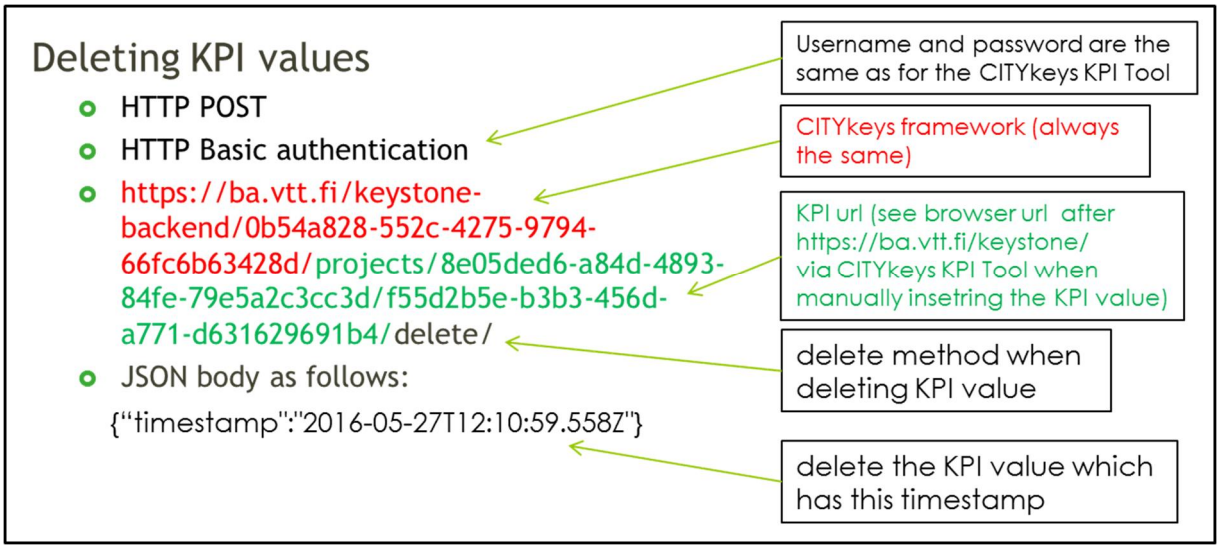

Figure 4. CITYkeys delete KPI value API

CITYkeys KPI tool's end user client

CITYkeys KPI tool client is described in Appendix 1. An example of CITYkeys KPI tool input form is shown in Figure 5 and related visualization in Figure 6.

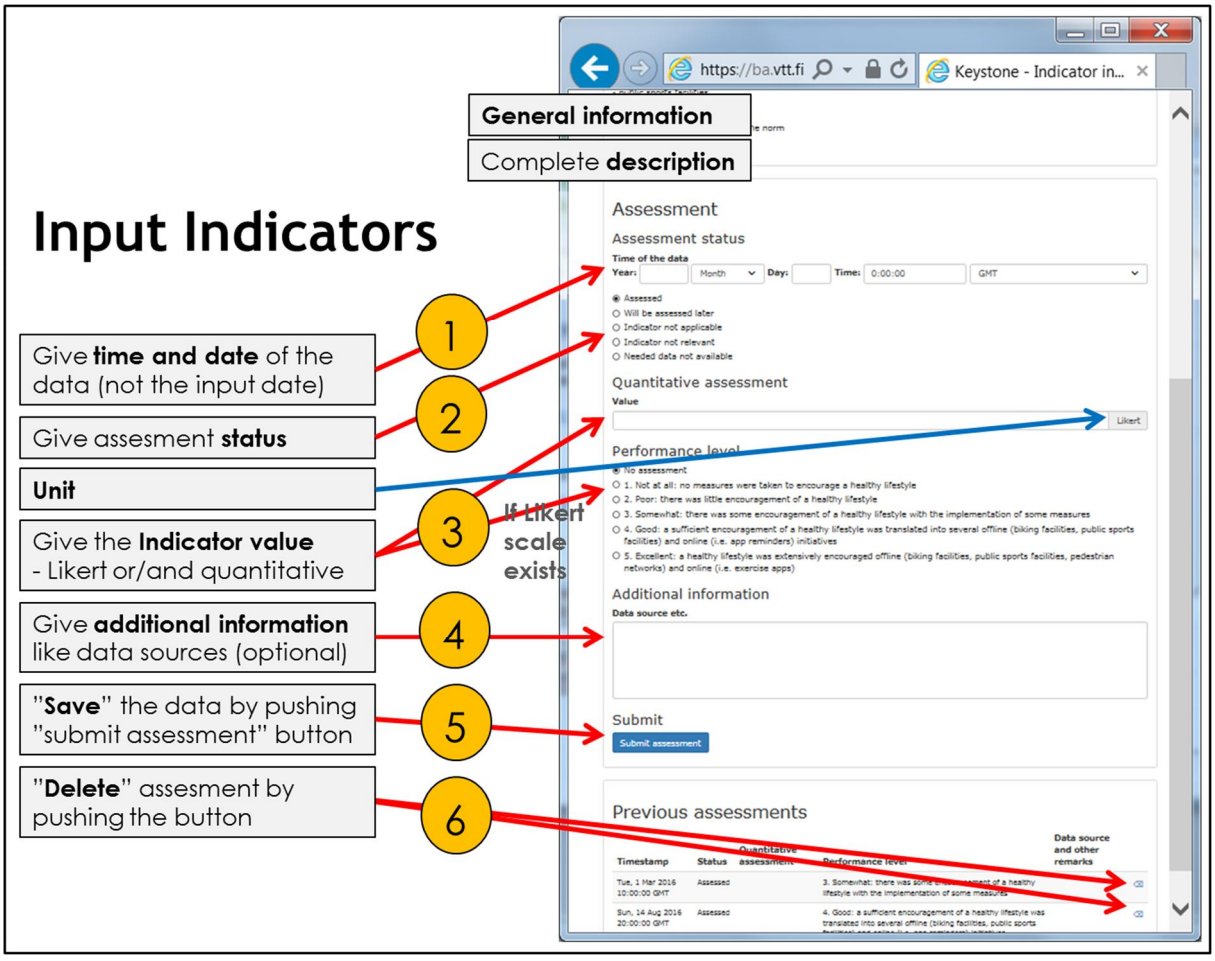

Figure 5. CITYkeys KPI tool input form

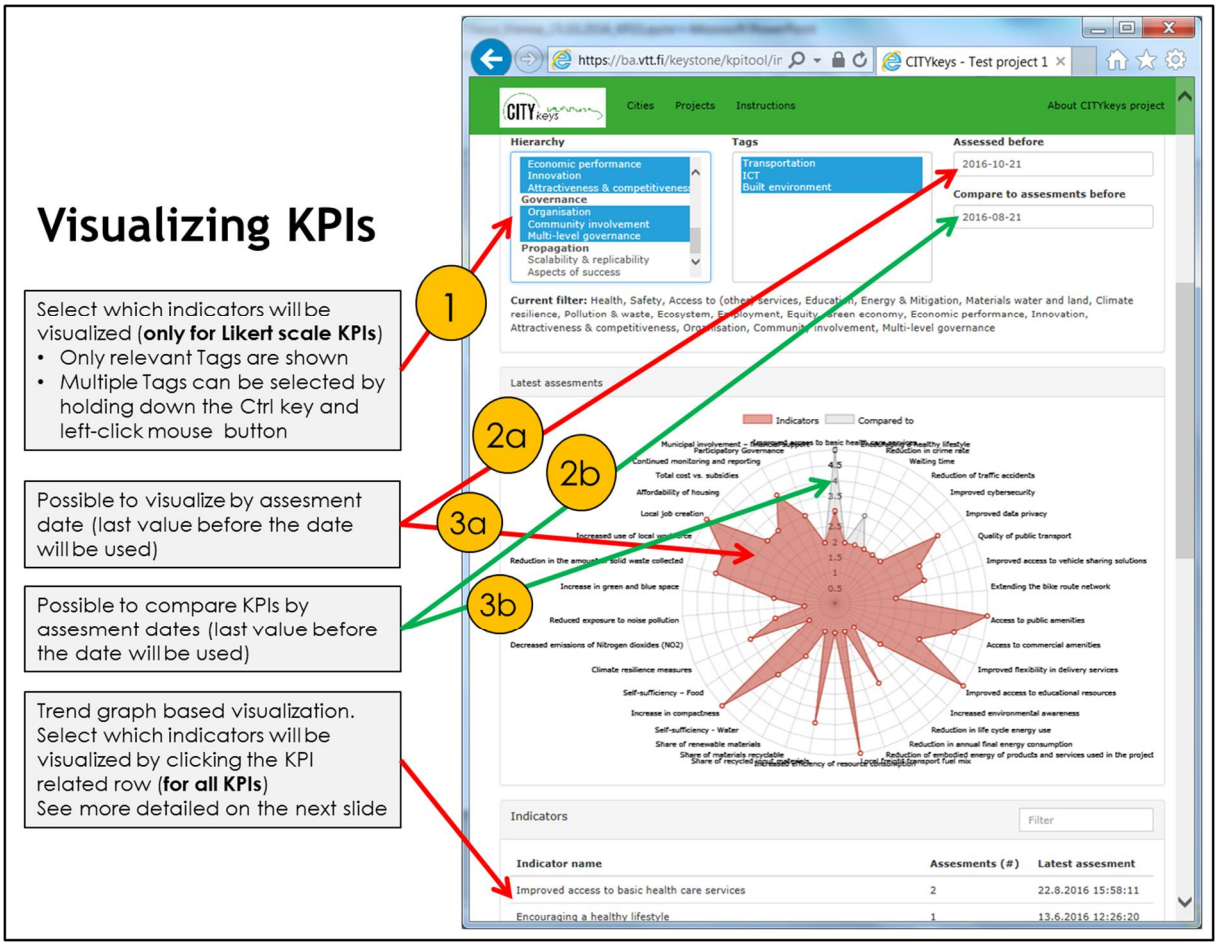

Figure 6. Example of CITYkeys KPI tool visualization features

CITYkeys visualization features support comparisons of indicator values from different times. The indicators that are not on the uniform five-level Likert scale (i.e. quantitative city KPIs) cannot be visualized via ñspiderò diagram, instead trend based visualization is supported (Figure 7).

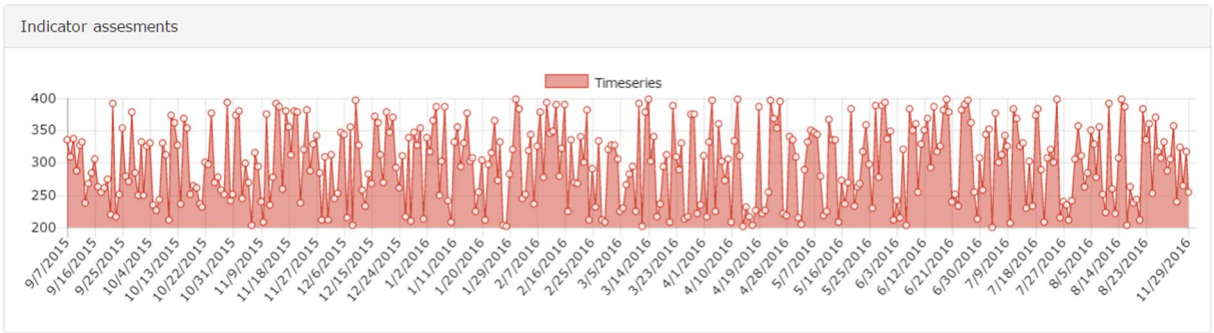

Figure 7. Example of CITYkeys KPI tool visualization features – case quantitative indicators

Automatic data reading

The main concept of the automatic data reading is described in Figure 8.

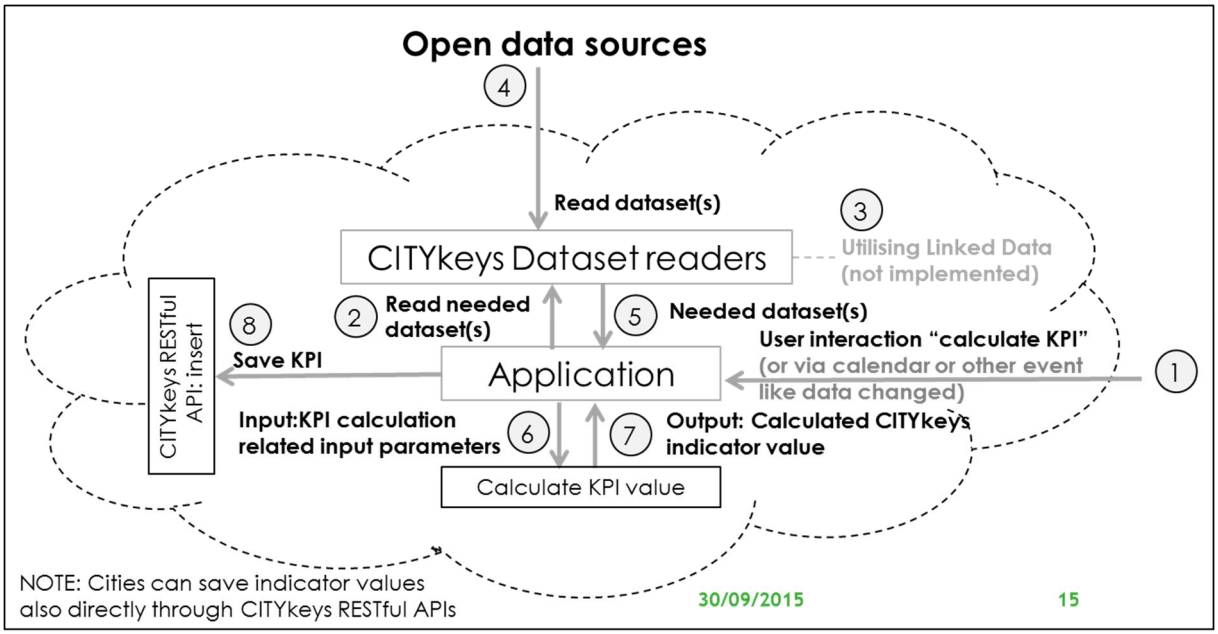

Figure 8. Main concept of the CITYkeys automatic data reading.

The CITYkeys automatic data reading and indicators calculating service was implemented as follows:

1) End user interaction (or calendar) starts the CITYkeys calculation process, e.g. calculate KPI ñAir quality indexò.
2) CITYkeys automatic data reading application reads ñair quality indexò related raw datasets from the given URLs.
3) CITYkeys automatic data reading application calculates the ñair quality indexò based on related raw datasets.
4) CITYkeys application save automatic the ñair quality indexò to the CITYkeys backend via CITYkeys ñinsertò API
5) CITYkeys application can now e.g. visualize the calculated CITYkeys indicator value.

APPENDIX 2: SUMMARY OF KPI SPECIFIC TESTING AND CONCLUDING REMARKS

Table 1. Summary of KPI specific testing at project level (x = has been tested; NA = Not available; NR = Not relevant; NT = Not tested)

KPI	ROT	VIE	ZAG	ZGZ	Remarks
PEOPLE					
Health					
Improved access to basic health care services	NR			NR	NT
Encouraging a healthy lifestyle	NR			x	OK
Waiting time	NR			NR	NT
Safety					
Reduction of traffic accidents	NR			NR	NT
Reduction in crime rate	NR			NR	NT
Improved cybersecurity	NR			xx	OK
Improved data privacy	NR			xx	OK
Access to (other) services					
Access to public transport	NR			x	OK
Quality of public transport	NR			NR	NT
Improved access to vehicle sharing solutions	x	x		x	Consider adding guidance to definition What does access mean here? Is it related to ICT (apps, or to hardware / vehicles?) Please elaborate.
Extending the bike route network	NR			NR	NT
Access to public amenities	NR			x	OK
Access to commercial amenities	NR			x	OK
Increase in online government services	NR			x	OK
Improved flexibility in delivery services	NR			NR	NT

Education					
Improved access to educational resources	NR			x	OK
Increased environmental awareness	x	x	x	x	Minor improvement suggested Delete "somewhat" in level 5.
Improved digital literacy	NR			x	OK
Diversity & social cohesion					
People reached	x	x	x	xx	Consider changing the Likert scale Likert scale seems overly harsh at least for lowest levels 1-2
Increased consciousness of citizenship	x			x	Consider clarifying definition Indicator description is somewhat confusing.
Increased participation of vulnerable groups	NR	x		xx	Consider improvement of description Better refer to "socio-demographically vulnerable groups" instead of "not well represented" groups. Hard facts (income, handicaps) are more important here than representation issues.
Quality of housing and the built environment					
Diversity of housing types	NR			NR	NT
Connection to the existing cultural heritage	NR			x	OK
Design for a sense of place	NR	x		x	Consider minor improvement Should also include public spaces, not just buildings. To which extent are the criteria applicable to refurbishment projects?
Increased use of ground floors	NR	NR		NR	NT
Increased access to public outdoor recreation space	NR	NR		x	OK

Increased access to green space	NR	NR		x	OK
PLANET					
Energy & Mitigation					
Reduction in annual final energy consumption	x		x	NR	OK
Reduction in life cycle energy use	NA			NR	Seems difficult Too burdensome unless a key objective of the project
Reduction of embodied energy of products and services used in the project	x		NA	NR	OK
Increase in local renewable energy generation	x		x	x	Consider adding further guidance and clarifications for calculation formula What is considered as ñlocalò? What if 0 renewable in the beginning? The calculation formula would require to divide by 0 resulting in error
Carbon dioxide emission reduction	x		x	NR	OK
Reduction in lifecycle CO2 emissions	NA			NR	Seems difficult Too burdensome unless a key objective of the project
Maximum Hourly Deficit	NR			NR	NT
Local freight transport fuel mix	NR		NR	NR	NT
Materials water and land					
Increased efficiency of resource consumption	NR			NR	NT
Share of recycled input materials	NR			NR	NT
Share of renewable materials	NR			NR	NT
Share of materials recyclable	NR			NR	NT
Life time extension	x			x	OK
Reduction in water consumption	NR		x	NR	OK
Increase in water re-	NR			NR	NT

used					
Self-sufficiency - Water	NR			NR	NT
Increase in compactness	NR	x		NA	OK
Self-sufficiency ï Food	NR			NR	NT
Climate resilience					
Climate resilience measures	NR			x	OK
Pollution & waste					
Decreased emissions of Nitrogen dioxides (NO2)	x			NR	OK
Decreased emissions of Particulate matter (PM2,5)	x			NR	OK
Reduced exposure to noise pollution	NA		x	NR	OK
Reduction in the amount of solid waste collected	NR			NR	NT
Ecosystem					
Increase in green and blue space	NR			NR	NT
Increased ecosystem quality and biodiversity	NR			x	OK
PROSPERITY **Employment**					
Increased use of local workforce	x	NA	x	xx	OK (Can only estimate the number of jobs directly or indirectly created by the project based on investment, but not the amount spent for local suppliers.)
Local job creation	NA			xx	OK
Equity					
Fuel poverty	NR			NR	NT
Affordability of housing	NR			NR	NT
Green economy					
Certified companies involved in the project	NA			xx	Consider rephrasing as a Likert scale Would take a lot of work to collect data.

Green public procurement	x	x		xx	Consider clarification for definition Needs clarification on what is meant by GPP
CO2 reduction cost efficiency	NA			NA	Seems difficult Burdensome to get data Difficult to define/calculate to which extent the reduction in CO2 emissions are due to the project
Economic performance					
Financial benefit for the end user	NR	x		xx	OK Sometimes difficult to quantify
Net Present Value	NR			NR/NA	NT
Internal rate of return (IRR)	NR			NR	NT
Payback period	NR	x		x	OK
Total cost vs. subsidies	x		x	xx	OK
Innovation					
Involvement of extraordinary professionals	x			xx	OK
Stimulating an innovative environment	NR	x	x	xx	Consider minor remark for description What does stimulate the environment mean? Better refer to the triple helix here.
Quality of open data	NR			x	OK
New startups	x			xx	OK
Improved interoperability	x	x		xx	OK for most, but also clarification and changes requested The description of improved interoperability raises more questions than it answers. The headline should be better called: "Improved interoperability of community infrastructure".
Attractiveness & competitiveness					
Decreased travel time	NR			NA	Consider change Difficult to assess ï

					consider Likert scale
GOVERNANCE					
Organisation					
Leadership	x		x	xx	OK
Balanced project team	x	x	x	xx	OK
Involvement of city administration	x	x	x	xx	OK
Clear division of responsibility	x	x	x	xx	OK
Continued monitoring and reporting	x	x	x	xx	Consider minor remark Level 3: Why are the well-defined smarty goals mentioned here, and only here?
Market orientation	x			xx	OK
Community involvement					
Professional stakeholder involvement	x		x	xx	OK
Bottom-up or top-down initiative	x	x	x	-	Consider clarification The headline does not fit to the question.
Local community involvement in the planning phase	x		x	xx	OK
Local community involvement in the implementation phase	x	x	x	x	OK
Participatory Governance	NR			-	NT
Multi-level governance					
Smart City Policy	x	x		xx	OK
Municipal involvement ï financial support	x		x	xx	OK
PROPAGATION					
Scalability & replicability					
Social compatibility	x			xx	OK
Technical compatibility	x			xx	OK
Ease of use for end users of the solution	x			xx	OK
Ease of use for professional stakeholders	x			xx	OK

Trialability	x			x	OK
Advantages for end-users	x		x	x	OK
Advantages for stakeholders	x		x	x	OK
Visibility of results	x			x	OK
Solution(s) to development needs	x			xx	OK
Market demand	x			x	OK Sometimes difficult to evaluate market demand outside the city
Aspects of success					
Changing professional norms	x		x	xx	OK
Changing societal norms	x		x	x	OK
Diffusion to other locations	x			xx	OK
Diffusion to other actors	NR			xx	Consider change in definition Consider broadening beyond just commercial parties
Change in rules and regulations	x			xx	OK
Change in public procurement	x	x		xx	OK 2 and 3 level descriptions are the same, to be distinguished
New forms of financing	NR	x	x	xx	OK
Smart City project visitors	x			NA/NR	OK

Table 2. Summary of KPI specific testing at city level (x = has been tested; NA = Not available; NR = Not relevant; NT = Not tested)

KPI	ROT	TAM	VIE	ZAG	ZGZ	Remarks
PEOPLE						
Health						
Access to basic health care services	x	NA			x	OK But it might be difficult to obtain the data on number of persons in each building to strictly apply the calculation method

Encouraging a healthy lifestyle		x			x	OK
Safety						
Traffic accidents	x	x			x	OK
Crime rate	x	x			x	OK
Cybersecurity		x			x	OK
Data privacy		x			x	OK
Access to (other) services						
Access to public transport	x	NA			x	OK But it might be difficult to obtain the data on number of persons in each building to strictly apply the calculation method
Access to vehicle sharing solutions for city travel		x			x	OK
Length of bike route network		x automatic data reading implemented		x automatic data reading implemented (but the open dataset used was no exactly through as it lacked some bike routes)	x	OK
Access to public amenities		NA			NR	It is difficult to obtain the data on number of persons in each building
Access to commercial amenities	x	NA				Consider reformulation It is difficult to obtain the data on number of persons in each building Can be assessed only as % of dwellings having the services within the given distance within 275 meter (= mean distance in Rotterdam) for ROT instead of 500m
Access to high speed internet						NT

Access to public free Wi-Fi access		x	x automatic data reading implemented		x	OK
Flexibility in delivery services					NR	NT
Education						
Access to educational resources		x			NR	OK
Environmental education		x				OK
Digital literacy		NA			NA	Difficult to assess
Quality of housing and the built environment						
Diversity of housing types	x	NA			NR	OK but consider reformulation Very difficult to get the needed data In ROT the proxy ñ% of social housing would make senseò and be easily assessable
Preservation of cultural heritage		x			x	OK
Ground floor usage		NA				Very difficult to get the needed data
Public outdoor recreation space					NA	Consider adding clarification How to define outdoor recreation space?
Green space					x	OK
PLANET						
Energy & Mitigation						
Annual final energy consumption	x	x			x	OK
Renewable energy generated within the city			x automatic data reading implemented		x	OK
CO2 emissions		x			x	OK
Local freight transport fuel mix		NA				NA/NT
Materials water and land						

Domestic material consumption		NA				NA
Water consumption	x				x	OK
Grey and rain water use		NA				NA
Water exploitation index		NA				NA
Water losses		x				OK
Population density	x	x			x	OK
Local food production		NA				NA
Brownfield use		x				OK
Climate resilience						
Climate resilience strategy		x				OK
Urban heat island		x				OK
Pollution & waste						
Nitrogen dioxides (NO2)	x	NA			x	OK But data availability issues in some cities
Fine particulate matter emissions (PM2,5)	x	NA			x	OK But data availability issues in some cities Available often only in microgram/m3
Air quality index	x automatic data reading implemented	x automatic data reading implemented			x	OK
Noise pollution	x	x				OK
Recycling rate		x			x	OK
Municipal solid waste		x				OK
Ecosystem						
Share of green and water spaces						NT
Native species		NA				Difficult to find needed data
PROSPERITY						
Employment						
Unemployment rate	x	x			x	OK
Youth unemployment rate		x			x	OK
Equity						

Fuel poverty	x				x	OK
Affordability of housing	x				NA	OK
Green economy						
Share of certified companies		x			x	OK
Share of Green Public Procurement		x			NA	OK
Green jobs	NA	NA			NA	Difficult Consideration adding clarifications and guidance Considered as an important KPI if possible to assess
Freight movement						NT
Economic performance						
Gross domestic product		x				OK
New business registered	x	x				OK
Median disposable income	x				x	OK
Innovation						
Creative industry	x					OK
Innovation hubs in the city		x			x	OK
Accessibility of open data sets		x				OK
Research intensity		x				OK
Open data	x	x	x	x	x	OK
Attractiveness & competitiveness						
Congestion		NA			x	OK But in some cities very difficult to find the needed data
Public transport use		x			x	OK
Net migration	x	x			x	OK
Population dependency ratio	x				x	OK
International events held		x			x	OK
Tourism intensity	x	x			x	OK No data for initiatives

						like Airbnb.
GOVERNANCE **Organisation**						
Cross-departmental integration		x			x	OK
Establishment in the administration		x			x	OK
Monitoring and evaluation		x			x	OK
Availability of government data					x	OK
Community involvement						
Citizen participation					x	OK But data collection can be burdensome
Open public participation					NA	NA
Voter participation	x	x			x	OK
Multi-level governance						
Smart city policy		x			x	OK
Expenditures by the municipality for a transition towards a Smart City		NA			NA	Difficult to assess / get data / define data boundaries
Multilevel government		x			x	OK