IRIS

Integrated and Replicable Solutions for Co-Creation in Sustainable Cities

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Deliverable 2.3

Recommendations for KPIs based on CITYKEYS and SCIS

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Authors

Surname	First Name	Beneficiary
Sacco	Francesco	RISE
Schade	Jutta	RISE
Tsarchopoulos	Panagiotis	CERTH

In case you want any additional information or you want to consult with the authors of this document, please send your inquiries to: irissmartcities@gmail.com.

Reviewers

Surname	First Name	Beneficiary
Broock Hijar	Diego	CCS
Tsarchopoulos	Panagiotis	CERTH

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0.1		First Draft
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1.0	14/02/2023	Draft version send for internal review
2.0	20/02/2023	Second draft sent for external review
3.0	24/02/2023	Third and final draft

Disclaimer

Executive Summary

This deliverable was aimed at providing recommendation for the Key Performance Indicators (KPIs) based on the smart city platforms CITYkeys and SICS. This having already being done in WP1 and WP9, it was decided together with the WP2 management, to bring together the "loose ends" of WP2, by providing 1) a concise summary of the work that has been done for the establishment of a KPI framework, to be seen as a guide for future projects and 2) gathering the feedback from the LH cities and relevant parallel smart cities initiatives to derive some lessons learned when applying the framework in practice in the demo sites.

The procedure for the establishment of a successful KPI framework was gathered from the work done in the following deliverables:

- D 1.1 *Report on the list of KPIs for each transition track* – where the procedure for assessing the KPI repository list is underlined, as well as stakeholder identification and domain categorization (= KPI aggregation)
- D 9.2 *Report on monitoring and evaluation schemes for integrated solutions, D 9.5 Report on monitoring framework in LH cities and established baseline, D 9.6 Intermediate report after one year of measurement* – for the description of the KPI evaluation, monitoring and follow-up plans.

The aim is to report the result of work with several iterative processes involving the LH cities and their partners during the IRIS project, putting together the defined procedures with the lessons learned from the practical implementation in the demo sites.

The feedback from the LH stakeholders was collected in form of questionnaires, where a set of open questions were asked on the subject of the KPI framework and monitoring process, and more in general about the IRIS project as a whole. The aim was to identify some lessons learned that could be useful for the implementation of future smart city projects. Even though every project is different, there are some similarities, and the analysis of which can lead of an easier project set up, by knowing in advance the possible barriers and bottlenecks connected to the implementation of a KPI framework.

Additionally, the lessons learned from other lighthouse projects and similar initiatives (Smart City Information System – SCIS, Smart City Guidance Package – EIP-SCC, Scalable Cities) were included to give a broader perspective from the governance and policy point of view when it comes to the introduction of a KPI framework in smart city projects.

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List of Abbreviations and Acronyms

Abbreviation	Definition
BMS	Building Management System
CIP	City Innovation Platform
CITYkeys	Smart City performance measurement system (Project funded by the European Union HORIZON 2020)
DR	Demand Response
D	Deliverable
DHCN	Daily Host Configuration Network
EIP-SCC	European Innovation Partnership on Smart Cities and Communities
ESCO	Energy Service Company
EU	European Union
EV	Electric Vehicle
FC	Follower City
ICT	Information and Communication Technologies
IS	Integrated Solution
KPI	Key Performance Indicator
LCA	Life Cycle Assessment
LH	Lighthouse
PV	Photovoltaic
RES	Renewable Energy Sources
RISE	Research Institutes of Sweden
SECAP	Sustainable Energy and Climate Action Plan
SCIS	Smart Cities Information System (Project funded by the European Union HORIZON 2020)
TG	Task Group
TT	Transition Track
V2G	Vehicle to Grid
WP	Work Package

1 Introduction

1.1 Scope and objectives of the deliverable

The IRIS project aims to use the full ability of existing urban platforms and ICT systems in the Lighthouse (LH) cities to provide better services, innovative business models and implementation of new ways to reach and engage citizens in sustainable, smart city solutions. The overall aim is to build a secure local energy system that is both cheaper for the citizens and local authorities and contributes to reduced environmental impact by reduction of transport-based CO_2 emissions, sustainable electricity production and heating at district level.

The IRIS project is part of a common European effort for the transition to smarter, more inclusive and efficient cities, and the work package on cooperation with ongoing projects (WP2) capitalized on the already available body of information from similar initiatives. The WP focused its activities on the Action Clusters of the European Innovation Partnership on Smart Cities and Communities (EIP-SCC), and on the H2020-SCC ESPRESSO project for smart city standards, the H202-SCC CITYKEYS project for smart city indicators and the EU Smart City Innovation System (SCIS).

The original purpose of Deliverable D2.3, namely, to provide recommendations for a complete and meaningful set of KPIs for WP9, drawing from the experience of CITYKEYS and SCIS projects, has been already done in WP9. It was therefore decided, in agreement with the Project Manager and the Work Package Leader, to use this deliverable to present a set of lessons learnt in the implementation of a KPI structure, drawing both from the experiences of IRIS projects' LH cities and other smart city projects, especially those involved in the Task Group Replication (SCC1 Collaborative Framework).

The main objective of this deliverable is to bring together the "loose ends" from WP2, to find and summarize the valuable lessons that have been learned throughout the project, from a KPI point of view.

The specific objectives are listed below:

- Objective 1: describe the process of identifying the KPIs for the right situations, measuring and following up, by giving concrete recommendations but on a higher level, integrating what has been learned in WP9;
- Objective 2: present the overall lessons learned, main challenges and findings from application of the KPI framework in the LH cities of Gothenburg, Nice and Utrecht;
- Objective 3: present the overall lessons learned, main challenges and findings from application of other KPI frameworks in the fellow Smart City projects of the SCC1;

1.2 Contributions of partners

Deliverable D2.3 has been authored by Research Institutes of Sweden (RISE) and Centre of Research & Technology (CHERT) reviewed by Diego Broock Hijar (Cluster Construcción Sostenible).

The partners of the LH cities of Gothenburg, Nice and Utrecht have collaborated by filling in the questionnaires for KPI framework evaluation. The questionnaires were filled by the partners that worked with the collection of the KPIs and / or were involved in the creation process.

1.3 Relation to other activities and project planning for monitoring and evaluation activities

Deliverable D2.3 is part of WP2 EU wide cooperation with ongoing projects, initiatives, communities and builds on the results and experiences of WP9.

This deliverable is also based on input from D1.1 Report on the list of selected KPIs for each transition track, D9.2 Report on monitoring and evaluation schemes for integrating solutions, D9.5 Report on monitoring framework in LH cities and established baseline, D9.6 Intermediate report after one year of measurement.

The following table presents the deliverables of WP2 and WP9 that are related to D2.3

Table 1. Deliverables related to D2.3

Number	Title
D1.1	Report on the list of selected KPIs for each Transition Track
D9.2	Report on monitoring and evaluation schemes for integrated solution
D9.5	Report on monitoring framework in LH cities and established baseline
D9.6	Intermediate report after one year of measurements
D9.7	Report on evaluation and impact analysis for integrated solution

1.4 Structure of the deliverable

- **Chapter 2** describes what methods used to obtain the results presented in this report.
- **Chapter 3** presents the procedure followed in the IRIS project for the KPI identification, measurement/evaluation and follow up, reporting it in a concise and easy-to-follow way for replication in other smart city projects.
- **Chapter 4** reports the lessons learned from the project partners of the three LH cities involved in the application of the KPI framework in the demo sites.
- **Chapter 5** summarizes the lessons learned and insights from other European projects and related initiatives.
- **Chapter 6** sums up the conclusions on how a project can successfully implement a KPI evaluation framework.

2 Methodology

In order to produce this Deliverable, the following methodology was adapted:

- The KPI process was summarized for an easy lookup by condensing the information from: D1.1 Report on the list of selected KPIs for each Transition Track, D9.2 Report on monitoring and evaluation schemes for integrated solution, D9.5 Report on monitoring framework in LH cities and established baseline and D9.6 Intermediate report after one year of measurements
- A questionnaire was created to evaluate the implementation of the KPI framework in the LH cities, and then distributed to the partners and affiliates that worked with the KPI definition / collection / measurement themselves
- The questionnaires were analysed, their responses recorded, and the most relevant findings and results integrated in the conclusions chapter
- The lessons learned from the experts of the WP2 and WP9 lead, as well as from the following cities were added as well to give the deliverable a greater relevance and broader scope.

3 KPI identification, measurement and follow up

KPIs are the mean of objectively assessing the degree of success of either a research innovation project or even a commercial one. All interested stakeholders can just take a look at the KPI values and acquire a good understanding of the progress that is made. Moreover, KPIs can be used as a mean for presenting the project results to a political audience and influence decision making.

This chapter describes the method that was designed and implemented in the IRIS project for the successful adoption of the KPI framework. It presents the best practice identified in the project, and explains the different stages, namely:

- Identification
- Measurement and Evaluation
- Calculation process
- Measure narrative generation

It is intended as a to do list, for a practical replication of the process that was followed within the IRIS project.

3.1 KPI identification and framework

The first step is to determine the appropriate list of KPIs for the technology solutions proposed in the project. This could sound as an intimidating task, but the recommended procedure is to check first the already existing lists of KPIs for the evaluation of systems and technologies demonstrated in smart city projects. A good place to start is the SCIS and CITYkeys initiatives, which are repositories which bring together project developers, cities, institutions, industry and experts from across Europe to exchange data, experience and know-how and to collaborate on the creation of smart cities and an energy-efficient urban environment.

Those KPI lists can then be updated to fit well to the requirements of the specific solutions, by modifying or introducing new KPIs, in order to assess more accurately the success level of each technology or methodology tested by the demonstrators. The following paragraphs summarize the most practical info from D 1.1.

3.1.1 Stakeholder identification

First, a working group with relevant stakeholders must be identified. The stakeholders' perspective is crucial to the understanding of the KPIs. They will not just participate in the solutions evaluation, but also contribute to the decision-making as they know better the needs and the other parameters of a problem than the people affected by and affecting it. The decision analysts by themselves cannot be aware of a problem to the level of detail and awareness that a relevant stakeholder can.

For smart city projects, a sensible stakeholder categorization can include the following group of them, so that most of the stakeholders can be actively participating / represented in the evaluation of the solutions (from a first level) and of the city (to a final level).

The proposed groups of stakeholders include:

A. **Distribution System Operators (DSOs)**
B. **Consumers (End-users)**
C. **Technology and Services Providers**
D. **Decision-Making Bodies**
E. **Executive and Legislative Bodies**
F. **Citizens**
G. **Representative Citizen Groups**
H. **Citizen Ambassadors**

After having determined the stakeholder groups, the identification of the objectives for each stakeholder group should be named, followed, by each stakeholder group of interests and the main strategy envisioned to be followed, towards the overall project evaluation in terms of advancements and new expertise gained during its course. The eight stakeholders referred, try to represent all the stakeholder points of view concerning the development of smart grids and solutions.

3.1.2 Domain categorization

A domain categorization must then be defined, for a better understanding of the whole KPI structure at a project level and how the stakeholders are connected to it. Once the KPIs are identified (and we will see that the list is, by no means, set in stone at this initial stage), they have to be grouped in different domains reflecting the structure of the project. For instance, in the IRIS project, the KPIs were subdivided in the following categories:

- **KPIs measuring Technical Performance**, such as the energy consumption, the RES generation ratio, the peak load reduction etc.
- **KPIs measuring Economic Performance**, such as the average cost of energy consumption, the average estimation of cost savings etc.
- **KPIs of Environmental Performance**, such as CO_2 emissions reduction
- **KPIs of Social Performance** such as the degree of users' satisfaction.
- **KPIs concerning the Performance of ICT** such as people following the advice of the Urban Pulse app, apps which enable the residents to monitor and analyse their energy and water consumptions, home energy management systems etc.
- **KPIs of Legal Performance**, such as the level of adaptation of electricity/heat integration in the legal framework, the legal barriers for usage of biofuels for energy exploitation purposes etc.

The current proposed domain categorization is not the only one that can be defined. There are other domain frameworks too, either close to the one presented (e.g. SCIS), or quite different (e.g. CITYKeys). IRIS proposes the one presented as a more holistic in studies for systems operation characterized by a medium to high Technology Readiness Level (TRL). The domain presentation is therefore dependent on the specific project TRL.

These six domains (or dimensions) are complementing each other and facilitate the holistic evaluation of the specific technical characteristics of a technology, its impact on the social and environmental

surroundings, its feasibility from an economic point of view, its smart automation and interaction through an ICT platform and its availability concerning the legal infrastructure. Since all smart cities projects deal directly or indirectly with those issues, the categorization will be done more or less along the aforementioned domains.

The following picture summarizes the KPI framework definition for the IRIS project.

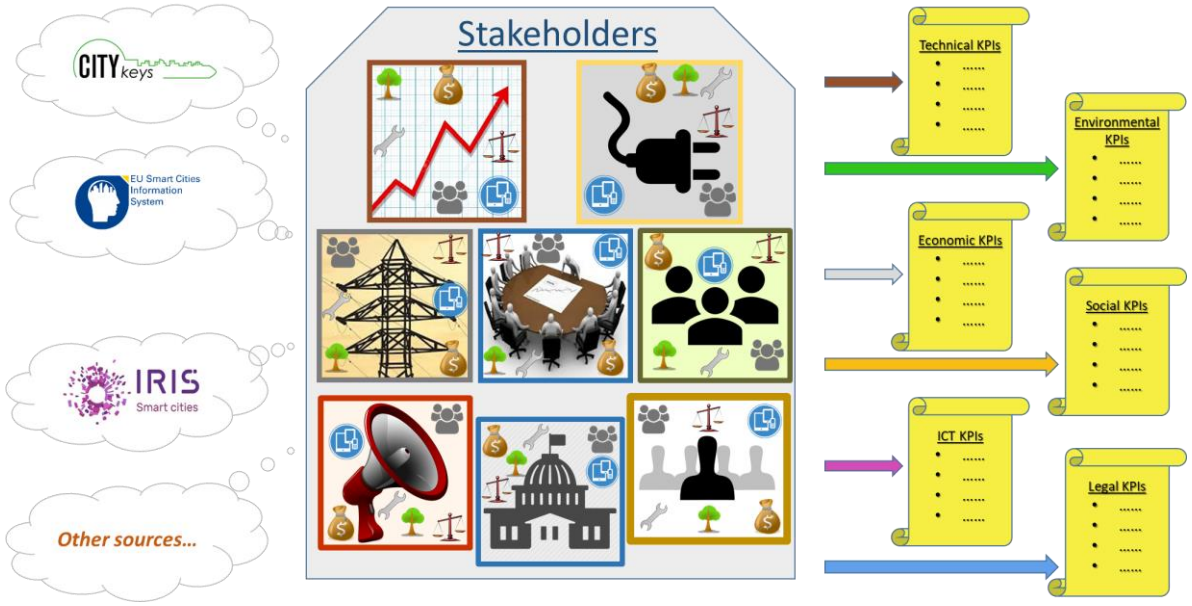

Figure 1. KPI framework definition in IRIS (from D1.1)

3.1.3 Definition of KPI repository

Each KPI is presented in a detailed table (KPI card) that contains all the required information for its calculation. The KPI cards are then collected in a repository. The use of quantitative indicators is valuable not only to describe/assess as accurately as possible individual characteristics of a technology, but also to evaluate them, in a simple and on a fair basis way, against other solutions of the same characteristics serving the same role. Such an approach facilitates the direct comparison of available technologies, designed for the same scope (in many aspects, as it will be evident subsequently from the text document).

Each card should contain:

- description (including justification)
- calculation formula
- unit of measurement
- measurement procedure
- object(s) of assessment
- involved stakeholders
- responsible project partner for data collection.

In general, indicators (and even more so KPIs) should express as precisely as possible to what extent an aim, a goal or a standard has been reached or even surpassed.

See an example of a KPI card in Appendix 2.

3.1.4 Threshold definition

After the final definition of the KPI repository, threshold definition is an important and sometimes difficult task, since it sets the quantified objectives of the project. Each KPI will finally acquire a value calculated throughout the monitoring of the project. The actual evaluation of the presented technology solution has to be done with the comparison of the KPI final value with a threshold that separates success to failure. This separation line can have the form of:

- **Baseline**: Baseline is a measurement taken in the beginning of the project. If the threshold is the baseline, then the scope is to check the difference in the actual result because of the implementation of the proposed technology solution.
- **Business as Usual (BaU)**: BaU is a more complex thresholds since it takes into consideration the change in the value of the KPI throughout the time period of the project, without the implementation of the tested technology solution. It takes into account the general tendency of the change in the KPI value. The BaU threshold comprises a more realistic view on the tested technology impact on its environment but is more difficult to be estimated.
- **Other threshold**: A threshold value could be defined by the evaluator, without it being either a baseline or a BaU. This could apply to KPIs that are not estimated in the past such as the legal KPIs or some social that are measured with the Likert Scale.

3.2 KPI evaluation plan and monitoring program

Once that the KPIs are defined as described in the previous paragraph, it is necessary to set up an evaluation plan and a monitoring program, which can be summed up as follows:

- The **evaluation plan** is developed for assessing the performance of the cities' interventions from a holistic point-of-view, addressing such issues as energy and economic performance, social acceptance, urban mobility and integrated infrastructures actions. The evaluation plan describes how the project will be evaluated on several different levels from the solution level up to city level and project level.
- The **monitoring program** is defined based on the evaluation plan. Necessary requirements such as the systems for monitoring, metering and data acquisition including appropriate time resolutions and aggregation levels are considered. The data requirements are specified in city-specific **monitoring protocols** based on the selected KPIs and their definitions. The monitoring protocols also consider the data needed to create a baseline for the evaluation.

As for defining the KPIs, the evaluation and monitoring process should not necessarily be done from scratch, but by taking advance of existing smart city evaluation frameworks such as SCIS and CITYKeys. The different performance evaluation frameworks can be tailored and adjusted to the needs of the actual project, adopting the categories of interest and creating others that might be needed. It is also recommended to check a list of other European frameworks, standards and neighbourhood certification schemes to get inspiration and evaluation / monitoring routines. The Grant Agreement is also a source of targets that have to be met and therefore influences the KPI monitoring program.

Prior to the creation of the above-mentioned plans, it is necessary to organize workshops with the key partners organization to assess:

- What to measure
- How to measure

The following paragraphs describe each plan in more detail.

3.2.1 Evaluation plan (D9.2)

The evaluation plan is based on a set of KPIs selected to evaluate the effectiveness and impact of the cities' proposed integrated solutions and compares the measures between the cities and for possible replication at different time horizons. Every solution has an individual table with KPIs selected for that solution, organised as follows:

KPI	Unit of measurement	Definition	Source	Target
Name, e.g. "CO2 emission reduction"	e.g. %, absolute value, etc.	Explanation of what the KPI is about	Framework / project	Target value for the project (if in the GA)

The evaluation can then follow the KPI aggregation structure created when defining the KPIs. This allows an evaluation on different levels, following a bottom-up approach from the individual solution, up to the specific domain (called Transition Track in IRIS), and finally to the city and project level. This allows for comparisons on the desired level (for instance, evaluation at project level makes it possible to evaluate the project in comparison to other smart city projects).

For a better understanding, the different levels of aggregation (and therefore evaluation) for the IRIS project are shown in the figure below.

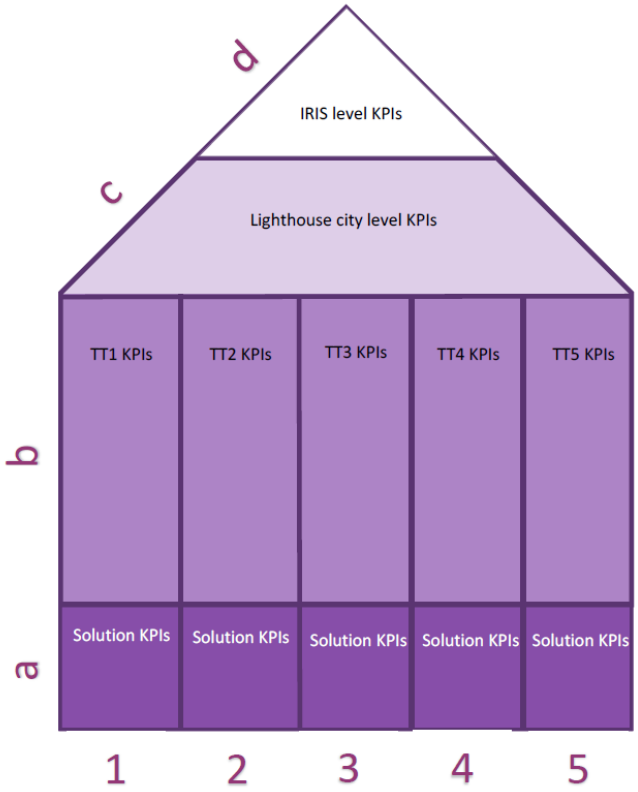

Figure 2. KPI House and Transition Tracks (from D 1.1)

Each LH city has its own KPI house; the top level of the house containing the IRIS level KPIs is however the same for all cities. On the solution level, the KPIs may vary between the cities since different solutions are implemented in each city and the cities have different objectives. Still, in many cases, the same KPIs can be found in all cities, thus allowing comparison between the Transition Tracks of the cities. For some Transition Tracks the evaluation of integrated solutions cannot be separated, and the KPIs are hence calculated at the Transition Track level.

3.2.2 Monitoring protocols

The KPIs selected for each solution in the LH cities have been translated into monitoring protocols for each Transition Track that list the data needed to calculate the selected KPIs. Each protocol contains the name of the data sets required, the expected source of the data, the solutions concerned and what KPIs the data will be used for. Monitoring needs a baseline to build the comparison on, and often a target, in case the specific solution will have to reach a certain goal, quantified at the beginning or during the project. The information contained in this and the following paragraph is a summary from D 9.2.

Monitoring protocols have been established for the three LH cities and their transition tracks. For each LH city and transition track, the protocols are organised by data point, i.e. the input data needed for the related Key Performance Indicators to be evaluated. Responsible partner(s) to collect the data is mentioned under the source followed by the related solution(s). The protocols also indicate if a baseline will be established for the measure.

The requirement of monitoring is data collection. It should be noted that smart city projects are heterogeneous in nature, implying that data sources and means of data collection and storage might differ. In some cases, data will be provided by systems that include smart meters, which automatically collect data and upload it to a repository. In other cases, they reside in another system's repository and simply needs to be moved or copied. Data can be also collected by other methods such as questionnaires, interviews, direct observations, etc. and their results are registered in forms (electronic or paper). In some cases, data transformation is required so that the information can be used in analysis and evaluation. For example, instant data about electrical consumption provided by a smart meter might not be easy to interpret but the electrical energy consumed by a building during one month is relevant. This second value can be calculated from the information of several smart meters like the first one providing information during a whole month.

A dedicated IRIS KPI tool was created by CERTH for more manageable data collection, KPI calculation and visualisation. Data collection can either be manual or automatic, and the process is shown in the figure below. The CIP is the City Innovation Platform, a data repository for the LH cities.

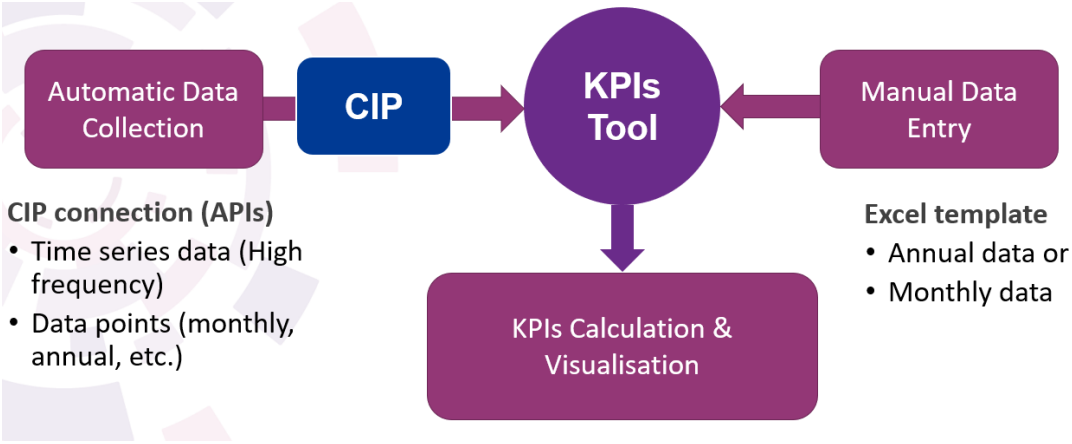

Figure 3. The monitoring process - from data to KPIs (from IRIS presentation at SCC1)

3.2.3 Baseline

The monitoring of each solution as well as the KPIs on Transition Track, Lighthouse and IRIS level will in most cases require a baseline for comparison. Depending on the solutions and the KPIs to be calculated the baseline can be either a real measured baseline of the situation before implementation or a theoretical baseline based on e.g. national standards or average production, consumption and emissions.

3.2.4 Targets

In the Grant Agreement impact section as well as in the task descriptions for each LH city, targets have been set for many but not all solutions in the project. KPIs lacking a target can be assigned a target at a later stage of the project when necessary. For some of the KPIs it will be difficult to set a target because it is challenging to predict the impact of the measures on the KPI in advance. This especially concerns some of the KPIs on social aspects. The comparison of these KPIs before and after implementation will however serve a purpose as input to the Work Packages dealing with the replication of the solutions.

It should be noted that each city can add some specific targets they are interested in pursuing.

3.3 KPI calculation process

This section follows the process of interpreting and applying the KPIs to the demonstrators, going from theory to practice. This paragraph summarizes the information reported in D 9.5. The "interpretation" process is iterative and has to be followed carefully to ensure that:

- KPIs are defined and calculated such that only one way of interpretation is possible. This way results from different projects and cities are homogenized.
- It is well understood what result the measurement of a KPI leads to.

A guideline to support the partners who implement the demonstrators in setting up their projects was developed so that:

- KPIs that are being measured are well understood
- KPIs give a meaningful result
- The right data is being measured to calculate the required KPIs during the implementation of the measures.

The guideline developed within the IRIS project is reported below

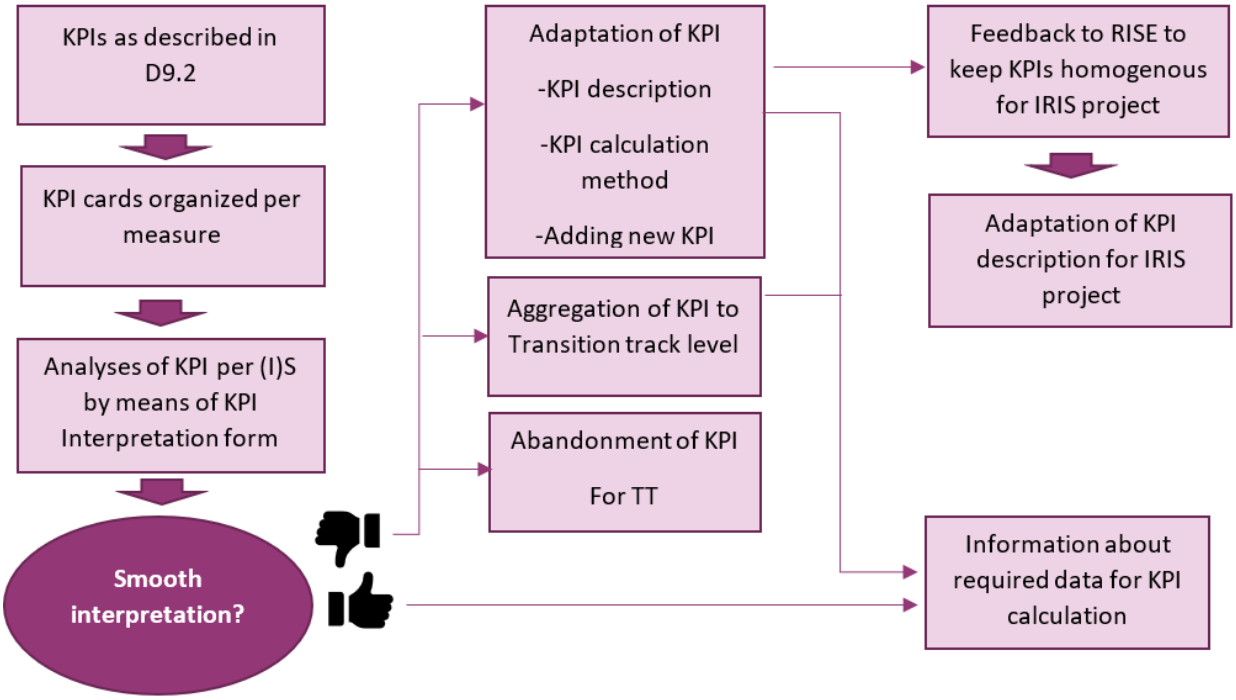

Figure 4. KPI following and implementation process (from D 9.5).

It can happen that a procedure or a KPI that were defined in theory do not suit well the application in practice. When interpretation does not happen smoothly, different options are possible:

- **Adaptation of the KPI**: This could either mean that the KPI description or the KPI calculation method will be changed. Adjustment of the KPI will happen in close contact with RISE to make sure that KPIs remain homogenous for each city throughout the IRIS project. Alternatively, a new KPI could be added to the database.
- **Aggregation of the KPI to transition track (TT) level**: In some cases, integrated solutions are so much integrated into a transition track that it's impossible or meaningless to distinguish the effect of the solutions separately. In this case, the KPI will be calculated for more solutions combined, at transition track level.
- **Abandonment of KPI**: In case a KPI cannot be measured neither at solution or TT level, or measurement is possible but gives a meaningless result.Abandoning the KPI will be requested.

When the KPI is updated, the follow-up process is repeated to ensure that the interpretation runs smoothly.

3.4 Generate measure narratives

KPIs are used in smart city project for evaluating the project impacts through monitoring and evaluating different measures. Furthermore, the KPI results of the measure can be compared to each other and aggregated on different project levels. The risk of missing the measurement narrative by using KPIs is that KPIs, by their nature, are focused on specific and quantifiable outcomes and may not fully capture the broader narrative and context of the measurement. To generate measure narratives, it is important to consider additional information beyond the KPIs and the numerical values of the measures. Creating narratives around technical KPIs in a project, stakeholders need to be involved in a collaborative and iterative process.

Workshops been hold in the IRIS project to increase the awareness of the Project partners that the KPIs results may not explain each measure's outcome and that additional information is needed. Relevant data for the measure has been gathered, like the target of the measurement, results of the KPIs and additional information related to the KPI. Reviewing the data related to the KPIs with the project partners encouraged them to ask questions for additional information to develop a shared understanding of the measure's results.

The workshop showed that telling the measure narratives by using the KPIs and additional information in a short version are very difficult. Some changes in the demonstration and measures need a wider explanation, as the more complex and technical measures can be difficult to present to non-experts.

Moreover, the workshops showed that this is an iterative process to encourage project partners to be involved in the storytelling process and to provide additional information on the measure result. To continue this process, regular meetings with the LHC, responsible partners and the monitoring and evaluation team have been held. These meetings have been used to discuss how the measure narratives could be enhanced by adding specific information to ensure a more holistic picture of the results.

4 Feedback from the Lighthouse cities

4.1 Utrecht

4.1.1 KPI Framework and monitoring

The problems experienced in collecting data for the KPIs can be recapped as follows

- It was **difficult to get relevant information from citizens**.
- **Most of the KPIs for TT#2 and TT#3 were easy to calculate**. There was an exception though, namely "peak load reduction" for which a separate research trajectory has been set up in order to calculate the KPI and, at the same time, produce other relevant research results. More specifically, in TT1, as it was needed to install smart thermostats and **get the consent of the tenants**. It took time and afterwards also led to gaps in datasets because tenants switched the data connection of the smart thermostat.
- It was **necessary to convince the industrial parties (companies) of the actual usefulness and effectiveness of the KPI before they were willing to supply any detailed data**.

Concerning the relevance of the chosen KPIs, there is some mixed feedback as well:

- **The updated KPIs were deemed to be relevant, but not all the initial KPIs**.
- The KPIs were considered useful, also because the KPI list for the Utrecht demo was curated in the first years of IRIS. **A local interpretation of the KPIs with a self-developed form** was done to get a good connection between the KPIs and the demo activities. It had a positive side-effect because it also led to a shared responsibility for the KPI work.
- The actual usefulness differs per KPI – **most KPIs seem more useful for reporting to the EC than for the actual demonstrations because they do not convey the lessons learned.**

The process of implementing the IRIS project KPI framework was not deemed as very effective:

- **It took a long time to align all the KPIs** of the different parties.
- The process was not deemed effective, as **it was a struggle from the beginning with the IRIS KPI House. It was not clear how the aggregation would work in the KPI House**. This was also a remark during the first EC Review after 12 months. As demo-lead Utrecht it was introduced the KPI interpretation form to guide the discussion with the Utrecht partners. That led to clarity and an approach to further detail the KPIs to monitoring requirements. But after that **it was still not easy to implement the right monitoring approach**. By setting regular meetings between demo Utrecht and WP9 ,Utrecht got a rhythm to help the implementation of the KPIs.
- **The process was lengthy and somewhat difficult, but in the end effective** because it led to a set of mostly easily measured and relatively sensible KPIs.
- In the process, it was long unclear to what degree the KPIs would influence the evaluation of the project itself – would not meeting a target have any impact on the subsidy? This complicated the discussions.

- At first, there was a tendency to over-design the KPI monitoring (asking for detailed data where for instance, yearly figures were more sensible), but this was adapted during the definition process – in that sense, the process was very effective.

Concerning whether some of the KPIs could have been measured in a different way (and in that case, how):

- It was thought that the KPI measurement process was OK.
- It was thought that **the interpretation of KPIs was needed to get clarity on how to monitor the demo activities and feed them into the KPI calculations**. It was very helpful to have local support, since UU took a lot of work on its plate to structure the data gathering for the Utrecht KPIs
- Because of the above process, the final set of KPIs was well thought out with respect to data monitoring and evaluation.

The specific challenges related to the demo site and the hardest part of the demonstration to implement were indicated as follows:

- The hardest challenge, by far, in our demo site in Utrecht was to **convince the tenants of our apartment buildings to support the renovation plan**.
- The hardest part to implement was the **citizen engagement**, due to COVID-19 but also due to a hard-to-reach target group. And in relation to that, we had to cope with the delay in the retrofitting schedule. And that cascaded into mitigation measures to get enough monitoring data.
- The Peak Load Reduction KPI was the hardest to implement because the peak load was going to increase due to the electrification of heating functions and the addition of EV chargers. As mentioned above: a specific research trajectory has been set up to evaluate that KPI.

4.1.2 About the IRIS Project

If the project were to start again, this is what the partners would like to do differently:

- Create an **Impact Assessment Framework** in the first 6-9 months of the project **and Monitoring Guidelines** in 6-12th months of the project.
- **Create space in the project for an iterative process where deviations from the initial plan are possible**. It's tough and even impossible to make a plan in advance, in which a lot of developments take place and insights are gathered.
- Try to clarify the work plan as much as possible with respect to actual work distribution and expectations of partners.

The partners expressed satisfaction concerning the communication from the project management side. Whenever problems arose due to unclarities (KPIs as described above, project amendment procedures, financial rules), they were mostly sorted out well.

4.2 Nice

4.2.1 KPI Framework and monitoring

The problems experienced in collecting data for the KPIs can be recapped as follows:

- *Contractual problems:* the demo owner is a third party to the project, **therefore, specific contractual arrangements had been necessary, delaying the process**. Specific GDPR related questions/risks had to be handled.
- *Technological problems*: **exploitation systems/BMS and its related IT services are not explicitly conceived to provide data to third parties**.
- *Definition problems:* **KPIs were not clearly defined from the beginning**, as the overall project approach (or of the concerned Parties) was rather based on the "technology efficiency" of the demonstration base, needing a more qualitative and sociological evaluation to identify the feasibility of the approach.
- The fact that a measure (Measure 3) relies on the results of the experimental campaign performed on another measure (Measure 2) in two social housing high-rise buildings recently renovated, can **create a bottlenec**k.
- **There are challenges in installing the sensors and instruments in social housing buildings, especially inside appartments where the occupant can sometimes be** reluctant to accept this intrusion in his privacy.
- The frequency of data measurement for the KPIs has not been consistent drifted over time.
- It was very difficult to evaluate KPIs related to citizen engagement.

Concerning the relevance of the chosen KPIs for demonstration, there is mixed feedback:

- In principle, KPIs are relevant for identifying the impact of the demonstration. Nevertheless, a common understanding of the exact system boundaries to be included was rather difficult due to each demonstration's specificities in terms of implemented technology and its very specific regulatory and economic framework (often barely comparable among countries).
- **Certain KPIs are rather difficult to be fully meaningful under the project's lifetime**, specifically for identifying equipment's performances under specific conditions or over longer time-frames.
- **KPIs are deemed useful to understand better the potential causes of performance gaps between initial predictions (theoretical simulations) and measures or energy bills**. This will increase social acceptance of energy-saving measures, as end-users, especially building owners, will be reassured that the money spent on these measures is not wasted.

The process of implementing the IRIS project KPI framework was deemed as not very effective:

- A major challenge in the process was the involvement of data owners and providers, as they are not always project Partners and, thus rather, not concerned with the data collection.
- **The process was seen as too complex**, and it is suggested that the KPIs should be adapted to "real situations".

Concerning whether some of the KPIs could have been measured in a different way (and in that case, how):

- The aim of "centralizing" and "automatizing" data collection and KPIs calculation, involving APIs development and IT system interfacing might have been avoided. This was a rather laborious process, as **the Project relevant KPIs are not relevant for involved stakeholders**.
- **KPIs collection as a "fully automated" process should have been restrained from the beginning** to specific and very restrained demonstrators or parts of it, where technical requirements/specificities were available/put in place, independently of the KPIs collection framework itself.
- A partner pointed out that it is **not very engaging to have to choose from a "KPI bank**" that had been drafted in advance and that **the operating mode is imposed on the partners** and proves to be complex. A suggestion is to **co-construct the KPIs together with the partners** so that they can take ownership of it.

The specific challenges related to the demo sites are reported below:

- Ensure a correct and secure data stream from the DHCN operator: changes in the DHCN SCADA programming and configuration (due to O&M needs or simply by adding new customers/clients), **created frequent changes in the received data and their structuring/naming**. Consequently, regular quality controls and code adaptations had to be done to ensure data/KPIS were complete, and the displayed values were correct.
- **Contractual arrangements** and implication/management of interfaces among the project and the data owner and providers, managing both design and operation phases, as concerned parties were in both stages not involved in the project itself.
- Management of the COVID crisis, **inducing delays and changes** in the work plans of the demonstration sites. Many management and communication efforts were necessary to keep the project's objectives and delays.

4.2.2 About the IRIS project

If the project were to start again, this is what the partners would like to do differently:

- **Harden the "risk" driven approach and ensure regulatory, contractual and commercial and other non-technical risks are well identified and qualified for all demonstrators**.
- Ensure to treat public tendering related processes more carefully or **even leave certain demonstration activities "open",** in terms of definition of the responsible Partners, avoiding to engage Partners in actions related to an imminent or even open tendering process.
- **Involve all stakeholders** (social housing company, engineering companies, heating plant managers, monitoring operators, etc.) in the reflection from the beginning to define the most relevant KPIs for the selected demonstration site.
- More knowledge exchange between partners

The partners would like to have more information beforehand concerning the project in the following areas:

- Ensure a **detailed understanding of a project's commercialization or implementation stage** to be able to qualify commercialization, regulatory or legal risks correctly.
- Schedule of the expected deliverables with its requested content

Finally, concerning the communication side, some difficulties have been reported:

- **The communication was rather unclear concerning the KPI collection objectives and validation boundaries** (define demo site specific indicators or enable a cross comparison among demonstrators) and the "responsibility" of collecting/sharing/calculating KPIs (Partners involved were not always concerned by the KPI collection itself).
- **The expectation was clear from the management side**, but the difficulty was more on the operational side.

4.3 Göteborg

4.3.1 KPI Framework and monitoring

- As for the problems experienced when collecting data for the KPIs, **it was difficult to find examples at the beginning**, and the partners "did not know where to look". **The SCIS website provided good examples** and inspiration, but some professional guidance would have been appreciated, especially in the first phases of the project.
- The chosen KPIs were considered as "not completely relevant" for the demos, even though the satisfaction was high as it was **perceived as a learning process**.
- The process of implementing the IRIS project KPI framework was considered as "reasonably effective", getting better and better as the project was progressing. **The persistence and tenacity on part of the WP9 management** was pointed out as the key factor in the success of the framework implementation.
- As whether some of the KPIs could have been measured in a different way, there are no clear answers as the subject is very complex and would require more in-depth knowledge. **The partners would like to get further help from within and without the IRIS consortium**, so a lesson learned is to find enough time and engagement for the collection and passing of the needed information. Another useful remark is that "**KPIs need to be backed up by a description or narrative** to put them in a context".
- Concerning the challenges related to the demo sites, it was pointed out that the demonstrator has not been as widely used as anticipated/hoped for, so **the KPI data does not feel statistically sound**. More specifically:
    - TT#4 CIM pilot: Difficulties to get a hold of BIM data. Lack of procedures within the City of Gothenburg collecting and structuring data. Good lessons learnt.
    - TT#2 Kylkopplingen: Challenges regarding budget and risk.

4.3.2 About the IRIS project

The lessons learned related to the implementation and monitoring of the KPI framework are as follows:

- Regarding KPIs: **Set up regular meetings** for the collections of KPIs, to go forward **step by step**.
- **Allocate a higher budget** for involving some more **administrative help/staff** because that part of the project was more time consuming than expected.
- Design the project in a way that would **force the cities to collaborate much more** than what has been the case.

- Know more exactly the **amount of time & budget for administration**, coordination, management, planning and communication activities.

Concerning the communication from the project management's side on the project in general, there was a high level of satisfaction:

- Overall it was perceived as clear and structured most of the time
- It was desired to have **pre-information about possibilities for spreading the results in different European networks**. It was perceived as a little bit unclear what WP2 and WP10 should do or how it was possible to contribute at times.
- In general, it has been reasonably good, and there **has always been a readiness to explain or clarify if needed**.

5 Lessons learned from other Lighthouse projects and related initiatives

5.1 SCIS: Why may replication (not) be happening

In the course of 2019-2023, TG Replication and TG Monitoring and Evaluation converged on the topic of KPIs for replication. In both groups, the question was what KPIs can measure replication. As mentioned in D2.1 *Lessons learnt through cooperation with other Lighthouse projects*, replication turned out to be not an activity, but the result of a complex process, the nature of which little proved to be known by the start of IRIS in 2017. What does replication take? A first answer to this question was provided by the Smart City Information System (SCIS) report ***Why may replication (not) be happening*** **(November 2018).** The report identified eight aspects of replicability of smart city solutions, that might be seen as a **first effort at defining KPIs of replicability**:

- technologies
- business models
- governance
- legal context
- social acceptance
- user motivation
- capacities & knowledge
- budget

5.2 EIP-SCC: Smart City Guidance Package

Half a year later the ***Smart City Guidance Package***[1] **(May 2019)** was published. This guide was developed by the Marketplace of the European Innovation Partnership on Smart Cities and Communities, specifically its Action Cluster on Integrated Planning, Policy and Regulation, in cooperation with NTNU. The Smart City Guidance Package is an overall urban governance and planning manual meant to help plan and implement smart city low energy district projects. Main elements of its methodology were:

- Political mandate for implementing sustainable development;
- Identifying and engaging stakeholders, developing consensus on priorities;
- Evaluating, benchmarking and measuring current and future conditions that impact progress toward sustainable development;
- Developing and implementing a coherent action plan;

[1] Borsboom, Judith & Gindroz, Bernard & Costa, Simona & Georgiev, Georgi. (2019). Smart City Guidance Package.

- Forecasting and back casting methods for bridging visions, targets and actions;
- Setting targets and KPI's for sustainable development;
- Meeting city's needs to carry out all these functions;
- Monitoring, reporting and verification. clarify responsibilities;
- Ensuring that there is consensus on who holds the coordinating role that has the needed competency and can be a vision holder to safeguard that the project fulfils the decided KPI goals and that criteria are met.

The Smart City Guidance Package was tested by two Fellow Cities of IRIS: Santa Cruz de Tenerife, and Vaasa.

The Smart City Guidance Package may be considered a second effort at defining KPIs of replicability.

5.3 Scalable Cities: systemic changes in governance

In 2022, the Scalable Cities service contract (established in 2021 in support of the Board of Coordinators of the 18 Lighthouse projects and its Task Groups) formed an **Expert Group on systemic changes in governance structures**[2]. The expert group was to perform a study and deliver a report (+ Solution Booklet) on systemic changes in governance, that should equip local governments to realize climate-neutral and smart cities.

Why a study on systemic changes in governance? According to the **100 climate-neutral cities by 2030** report (September 2020), the present silo-based form of governance, designed and developed for traditional city operations and services, cannot drive an ambitious climate transition. Therefore, a systemic transformation is urgent, accompanied by a more strategic, holistic and long term climate investment approach, together with a new city governance for climate action. The holistic approach, as opposed to the silo approach, will require a change of habits and style of management. The main capabilities/competences that should be assured at the city level are:

a) Organizational capabilities, including orchestration; connection with regional, national and European initiatives; and political support.

b) Technical capabilities, including capacitation; learning by experimenting; advising; financial and project management.

c) Design and monitoring capabilities, including designing; strategic and evolutionary evaluation; and KPI monitoring.

In the preliminary findings of the study of the Expert Group (downloadable at https://smart-cities-marketplace.ec.europa.eu/sites/default/files/2023-01/HZ-04-23-005-EN-C.pdf), the following definition of 'governance' was used, based on findings of the Task Group Replication and Scalable Cities City Coordinators Group: "*Governance is the framework of rules, procedures, roles and responsibilities that constitute decision-making processes and project management*". In the preliminary findings it is stated

[2] Judith Borsboom-van Beurden, Adriano Bisello, Dusan Jakovljevic, Tomas Vacha, Daniele Vettorato

that "*the transition to climate neutrality calls for inclusive co-design processes for urban planning and implementation of solutions, requiring new ways of thinking, working and collaborating. The main challenge seems to be the work in silos of themes, data, tasks, responsibilities, and timelines. The resulting different perceptions of problems and solutions seem to hinder a holistic innovative approach*".

The preliminary findings state that agreement on a common agenda is illusory without agreement on how to measure and report success. Collecting data and measuring results consistently on a short list of indicators at the community level and among all participating organisations not only ensures that all efforts remain aligned, but also allows participants to hold each other accountable and learn from each other's successes and failures.

With this, the Scalable Cities Expert Group study on systemic changes in governance structures may be considered a third effort at defining KPIs of replicability.

How do you do it locally, how to bring about the systemic change? The Expert Group studied innovative governance structures that had proven their value. Among the main learning points collected were **new topics for monitoring:**

- Smart City standards.
- Digital Twins: how to integrate Building Information Models in Digital Twins? how to set up integrated workflows?
- Monitoring in the context of the EU General data Protection Regulation (GDPR).
- Renewable Energy Communities.

A shared measurement system is considered essential for collective impact.

The preliminary findings mention an example of this from the Triangulum Lighthouse project: the Morgenstadt approach is based on an integrated reporting of indicators and fields of action. Each indicator is compared with a benchmark to find critical indicators. The results of the on-site evaluation of the Morgenstadt City Lab in Prague showed the solution's ability to identify the city's strengths and weaknesses in different areas and fields of action for smart and future-proof development. It was also able to identify key future opportunities and current obstacles to be overcome and show possible paths for sustainable development of Prague.

In order to achieve an in-depth understanding of the sustainability performance of cities both qualitatively and quantitatively, the Morgenstadt model is structured into three levels of analysis: 1. performance indicators (quantitative analysis); 2. key action areas (qualitative analysis); 3. impact factors (qualitative analysis). The first two levels of analysis, i.e. performance indicators and action areas, are generic, which means that they should be applied without differentiation to the sustainability performance assessment of each city participating in the City Lab project. The third level of analysis - the impact factors - aims to identify factors and barriers that are specific to each city and depend on its unique historical, cultural, economic, climatic, morphological, etc. characteristics. In this way, the impact factors complement the overall model and tailor it to the unique needs of each city, thus providing an objective performance profile while setting the basis for an individual sustainability roadmap. In this way, the combination of quantitative and qualitative analytical tools ensures the creation of an objective performance profile.

5.3.1 SCC01 Task Group Replication (chaired by IRIS, T2.1, Oct 2019 – Sep 2022)

The SCC01 Task Group Replication was established in support of the 18 Lighthouse projects around 2015. The TG Replication had around 70 members 2019-2022, of which the core members – the projects'

Replication Managers - convened monthly for two hours. In these sessions, experiences, best practices and lessons learnt on replication were exchanged through presentations and discussions.

In Task Group Replication of Feb 2020, the interesting idea was put on the table that if one could align the KPIs for SECAPs and Lighthouse projects, this would clarify how Lighthouse solutions could support the implementation of SECAPs by cities, hence accelerate replication/take-up of Lighthouse solutions by cities who signed the Covenant of Mayors and have to report on implementation of their SECAP anyway. The idea was to establish a specific Task Group for this, but this did not materialize.

In Task Group Replication of March 2020, the Triangulum project presented a study on the use of environmental and social KPIs for smart city solutions among Lighthouse projects. Observations were that:

- all 12 Lighthouse projects studied had collected environmental KPIs related to energy consumption and GHG emissions;
- all (but especially more recent) projects had collected KPIs related to air pollution;
- most projects had collected social KPIs related to mobility solutions;some projects had collected KPIs on e-government services, as social KPIs for the open data platform solutions.
- The proposed next steps, a.o. evaluate how social and environmental impact is disclosed and reported by projects, were to be proposed to the Task Group Monitoring and Evaluation.

5.3.2 SCC01 Task Group Monitoring and Evaluation

The IRIS project participated in the Task Group Monitoring and Evaluation activities and shared the experiences from its monitoring and evaluation process. IRIS contributed to the following main objectives of the TG:

- Create a common understanding of the scope and meaning of evaluation & monitoring
- Addressing common methodological evaluation issues
- Solving common practical monitoring & reporting issues

The means of collaboration were monthly meetings, joint surveys and joint documents. In the monthly meetings, each project presented a topic related to monitoring and evaluation. The IRIS project presented the KPI tool in May 2021 (beta version) and December 2022 (final version).

The TG Monitoring and Evaluation organised a physical meeting during the Scalable Cities and IRIS event in Utrecht on 2 June 2022. The key issues facing the projects and ways for the TG to assist were revealed during the discussion. In particular:

- **List of KPIs:** There are too many KPIs. The list should be reduced to 10-15 KPIs.
- **Standardisation of the calculation of KPIs:** There is a need for standardisation in the calculation of KPIs in different projects and cities. Currently, there is no standardisation, and the KPIs are not calculated the same way, making comparisons difficult. The TG Monitoring and Evaluation should work on uniformising the calculation of basic KPIs. Moreover, the definition of many KPIs is vague. The TG is urged to collaborate with the TG Business Model & Financing to address this issue, particularly for economic KPIs.
- **Relevance & interpretation of the KPIs:** The KPIs do not fully reflect the projects' achievements. The KPIs have limitations, especially during the current sanitary crisis, as they may not accurately reflect success or failure. Moreover, the usefulness of calculating a long list of KPIs is questioned

in light of the ongoing climate crisis and the need for immediate, impactful action. In any case, additional information, apart from the KPIs, is needed to tell the story of the demonstrations.

- **Self-reporting tool:** The tool is not working as expected, and only a few projects managed to partially submit monitoring data. The projects have already their own tools to store monitoring data and calculate the KPIs. The TG Monitoring will discuss the issue with the SCALE.

6 Conclusions

The process of successfully implementing a KPI selection and evaluation framework can be summarized as follows:

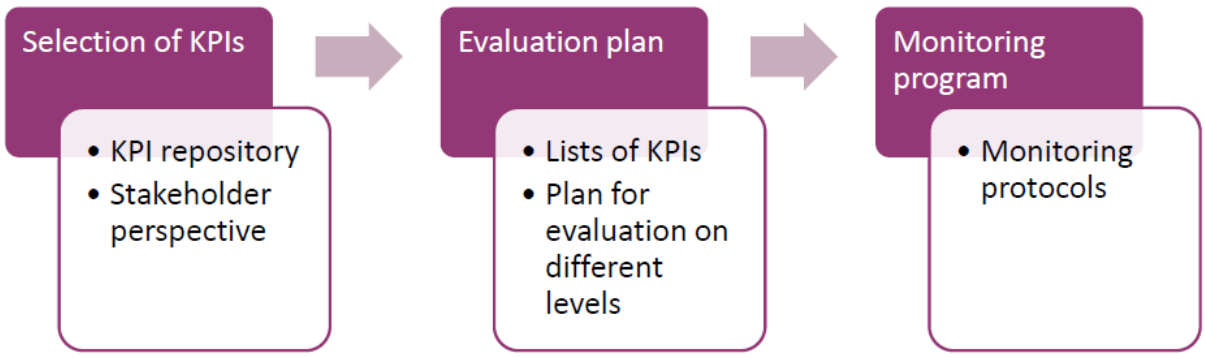

Figure 5. KPI selection and evaluation framework at a glance (from D9.6)

The guiding criteria for the definition of KPIs are as follows:

- The KPI should be quantifiable and measurable
- The KPI should be relevant for the relevant stakeholders working

It should always be possible to modify certain problematic KPIs during the project period. Progressive insight, changes in the demonstrators or the emergence of interesting new indicators will **require flexibility in the methods of monitoring and evaluation.** When modifications are made, a detailed record of them should be kept to make sure that any unforeseen side-effects can be dealt with.

6.1 Lessons learned in KPI revision

Even though much effort was put into defining the KPIs for each measure at an early stage in the project, the revision was a critical step to making a more realistic overview of the final project outcomes. The most important lessons learned in this process are:

- When it comes to setting up a physical monitoring plan, **certain KPIs turn out not to be measurable**. This can be due to:
  - Misunderstanding of what the KPI exactly means at the start of the project.
  - Discovering physical limits in time/space. For example, when specific measures are taken simultaneously at the same place, it is impossible to analyse their separate effects.
- From a monitoring perspective, it is very important **to stay flexible during the project** in order to be able to adjust the monitoring goals when necessary.
- Even though KPIs seem to be well-defined and used by others, **still misunderstandings or mistakes can arise**, which have to be solved for each case.

- It is of great importance to keep a comprehensive overview of how KPIs are interpreted or modified on Measure level, in order to maintain the possibility for aggregation and comparison of KPIs.
- The definition of KPIs, together with setting up a proper monitoring plan, can become a complicated and therefore, sluggish procedure. It is very important to be well-prepared and **keep project partners engaged during this process**.
- When revising which KPIs are being monitored, **make sure that the goals mentioned in the Grant Agreement are still met.**

6.2 Lessons learned from the KPI assessment

Now that the IRIS project has been almost completed, the following lessons concerning data collection for the IRIS KPI tool were learned:

- **Automatic data collection takes a lot of time to setup and deliver** results.
- **Automatic data collection should be combined with data validation mechanisms** (automatic and manual).
- The KPIs tool provides a central repository for monitoring data
- Automatic data collection offers a **viable long-term solution**
- **Manual** data collection is a **hassle-free solution for shorter monitoring periods** (1-2 years)

During the project, many challenges arose, meaning that additional info to complement KPIs might be needed – something that should be considered.

1. Contextual information

- Different building/district characteristics
- Different renovation concepts
- Different demographic characteristics

2. Changes in the scope of demonstrations

- Changes in the demonstration area
- Changes in the innovative elements

3. Sensitivity of the emission factors

- Emission factors are different per country and also per year.
- Emission factors are different compared to Grant Agreement

6.3 Lessons learned from the LH cities

There is an overall satisfaction concerning the IRIS project and WP management, and the partners managed to successfully delivery the implementation of the KPI framework in the demo sites. There were some recurring problems that should be remarked for a better KPI implementation and assessment in the coming projects:

- A more practical approach to KPI definition is desired in all demo sites, as some of the initial KPIs were not deemed relevant or practical for the specific cases.
- A more shared creation approach to KPI definition is also desired, involving all the stakeholders that will work in the demo sites
- Trust has to be gained – both the citizens, especially in social housing, but also of the industrial partners who often do not see the KPIs collection process as very useful.
- Allow for some "deviation" in the demonstration process, leaving some activities "open" as the tendering processes can come in the way
- Provide some kind of "narrative" to give extra meaning to the KPIs, to better convey the lessons learned and to facilitate its acceptance from the different stakeholders

6.4 Lessons learned by using KPIs for evaluating the impact of measurements

KPIs are used in a smart city project to evaluate the project's impacts through monitoring and evaluating different measures. Furthermore, the KPI results of the measures can be compared to each other and aggregated on different project levels. There are several advantages and challenges to using KPIs in smart city projects.

The **main advantages** of using **KPIs** in smart city projects:

- KPIs provide a **clear and concise way to track** and measure progress towards specific goals/targets
- KPIs help to **increase transparency** and accountability, as they provide clear and quantifiable data that can be shared and reviewed by all stakeholders
- KPIs allow for a **better understanding** of the impact of different measures and demonstrations.
- **Social quantitative KPIs** can provide a more comprehensive view of the impact of a measurement on the community, including social, economic, and environmental outcomes.

Challenges of using **KPIs** in smart city projects:

- KPIs are often **focused on specific outcomes** and may **not fully capture the broader impact** of a measurement.
- The **accuracy and reliability of the data** used to calculate KPIs is critical, and errors or inaccuracies can undermine the value of the KPIs.
- The selection and weighting of KPIs can be influenced by **bias and subjectivity**, which can lead to a skewed understanding of the impact of measurement.
- KPIs may not be **directly comparable** between cities due to differences in data collection methods, definitions, and indicators.
- Measuring **social outcomes with KPIs can be challenging**, as they are often more subjective and difficult to quantify than other types of outcomes.
- **Data quality** can be a major issue when using **social quantitative KPIs**, as it may be difficult to collect accurate, reliable, and relevant data in some areas.
- Measuring **social outcomes with KPIs** can be **complex and multi-faceted**, as they often involve a wide range of interrelated factors and dependencies. This can make it challenging to accurately quantify and measure the impact.

The **risk of missing the measurement narrative by using KPIs** is that KPIs, by their nature, are focused on specific and quantifiable outcomes and **may not fully capture the broader narrative** and context of the measurement. The use of KPIs can lead to a narrow and reductionist view of the impact of a measure and may **miss important** qualitative and **experiential aspects** that are difficult to quantify.

However, it is important to use KPIs as part of a more holistic and multi-faceted approach to measuring the impact of smart city measurements, and to supplement them with qualitative data, stakeholder feedback, and other forms of information that can help to provide a completer and more nuanced picture of the impact of a measurement. This includes a close dialogue between the monitoring and evaluation group and the stakeholders responsible for measurement. Workshops with all project's partners are recommended to increase awareness and general understanding of the complexity of measurement narratives and KPIs. 1

6.5 Lessons learned from other Lighthouse projects and related initiatives

The feedback from other Lighthouse projects and related initiatives confirms and expands what has been found in the framework of the IRIS project.

The preliminary findings of the Scalable Cities Expert Group state that agreement on a common agenda is illusory without agreement on how to measure and report success. Collecting data and measuring results consistently on a short list of indicators at the community level and among all participating organisations not only ensures that all efforts remain aligned, but also allows participants to hold each other accountable and learn from each other's successes and failures.

Among the main learning points collected were **new topics for monitoring**, which could be useful in future projects: Smart City standards, Digital Twins (how to integrate Building Information Models in Digital Twins and to set up integrated workflows?), Monitoring in the context of the EU General data Protection Regulation (GDPR), Renewable Energy Communities.

In order to achieve an in-depth understanding of the sustainability performance of cities both qualitatively and quantitatively, the Morgenstadt model (from the Triangulum Lighthouse project, City Lab in Prague) was proposed. It is structured into three levels of analysis: **1. performance indicators (quantitative analysis); 2. key action areas (qualitative analysis); 3. impact factors (qualitative analysis).**

From the Task Group Monitoring and Evaluation (established in support of the 18 Lighthouse projects), the following **key issues** facing the projects were identified:

- List of KPIs: **There are too many KPIs**. The list should be reduced to 10-15 KPIs.
- Standardisation of the calculation of KPIs: **There is a need for standardisation in the calculation of KPIs in different projects and cities**. Currently, there is no standardisation, and the KPIs are not calculated the same way, making comparisons difficult.
- Relevance & interpretation of the KPIs: **The KPIs do not fully reflect the projects' achievements**. The KPIs have limitations, especially during the current sanitary crisis, as they may not accurately reflect success or failure. Moreover, the usefulness of calculating a long list of KPIs is

questioned in light of the ongoing climate crisis and the need for immediate, impactful action. In any case**, additional information, apart from the KPIs, is needed to tell the story of the demonstrations.**

7 References

The following deliverables are from the IRIS Project.

D 1.1 *Report on the list of KPIs for each transition track*
D 9.2 *Report on monitoring and evaluation schemes for integrated solutions,*
D 9.5 Report on monitoring framework in LH cities and established baseline
D 9.6 Intermediate report after one year of measurement – for the description of the KPI evaluation, monitoring and follow-up plans.
D9.7 *Report on evaluation and impact analysis for integrated solution*

Appendix 1 – the questionnaire

The questionnaire that was circulated amongst the demo site project partners is presented below.

Scope

This questionnaire is to identify any main challenges and findings from application of the KPI framework, to draw some lessons that will be used as guidance in future Smart City projects, and will become part of Deliverable 2.3.

Instructions

- Please, provide as concise and descriptive information to the questions as possible.
- Any criticism is highly appreciated, so that we can identify the critical points and plan better smart city projects in the future.
- Thanks for your contribution!

KPI framework and monitoring
1. Which kind of problems, if any, did you experience collecting the data for the KPIs?
2. Do you think that the chosen KPIs were relevant for demonstration, i.e. what is being measured is useful?
3. Do you think that the process of implementing the IRIS project KPI framework was effective?
4. Do you think that some of the KPIs could have been measured-in a different way? And if so, how?
5. Were there any specific challenges related to the demo site? Which part of your demonstrations was hardest to implement?

(continues)

About the project
1. If you were to start the IRIS project again, what would you change or do differently?
2. If you were to start the IRIS project again, what would you wish to know beforehand?
3. Do you think that the communication from the project management side was good (i.e. clear expectations about what to do, instructions…)?

Appendix 2 – KPI card example

Table 2. Energy Savings KPI

<table>
<tr><th colspan="6">Energy savings</th></tr>
<tr><td>KPI Description</td><td colspan="5">This KPI determines the reduction of the energy consumption to reach the same services (e.g. comfort levels) after the interventions, taking into consideration the energy consumption from the reference period. ES may be calculated separately determined for thermal (heating or cooling) energy and electricity, or as an addition of both to consider the whole savings.</td></tr>
<tr><td>KPI Formula</td><td colspan="5">$$ES_T = 1 - \frac{TE_C}{ER_T}$$
ES_T = Thermal energy savings
TE_C = Thermal energy consumption of the demonstration-site [kWh/(m^2 year)]
ER_T = Thermal energy reference demand or consumption (simulated or monitored) of demonstration-site [kWh/(m^2 year)].
$$ES_E = 1 - \frac{TE_C}{ER_E}$$
ES_T = Electric energy savings
TE_C = Electric energy consumption of the demonstration-site [kWh/(m^2 year)]
ER_T = Electric energy reference demand or consumption (simulated or monitored) of demonstration-site [kWh/(m^2 year)].</td></tr>
<tr><td>Measurement procedure</td><td colspan="5">1. Data collection
2. KPI calculation</td></tr>
<tr><td>Unit of Measurement</td><td colspan="2">%</td><td>Threshold/ Target</td><td colspan="2"></td></tr>
<tr><td rowspan="7">Object of assessment</td><td>Building</td><td>X</td><td rowspan="7">Stakeholders</td><td>DSO</td><td>X</td></tr>
<tr><td>Set of Buildings</td><td>X</td><td>TSP</td><td>X</td></tr>
<tr><td>Energy Supply Unit</td><td>X</td><td>End-Users</td><td>X</td></tr>
<tr><td>Set of Energy Supply Units</td><td>X</td><td>Governance</td><td></td></tr>
<tr><td>Neighbourhood</td><td>X</td><td>Citizens</td><td></td></tr>
<tr><td>City</td><td>X</td><td>Representative Citizen Groups</td><td></td></tr>
<tr><td></td><td></td><td>Citizen Ambassadors</td><td></td></tr>
<tr><td colspan="3">Responsible Partner for KPI Data Collection</td><td colspan="3">CSTB, UNS, CAH, VEOLIA, EDF, Rb, AH, BOEX, STED, ENEC</td></tr>
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