IRIS

Integrated and Replicable Solutions for Co-Creation in Sustainable Cities

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Deliverable 9.2

Report on monitoring and evaluation schemes for integrated solutions

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Disclaimer

Executive Summary

The IRIS project has defined goals and targets in the project proposal and the monitoring and evaluation work package (WP) 9 will analyse to what extent the project reaches these goals and objectives. The monitoring and evaluation will also provide information concerning the performance of the different solutions demonstrated in the LH cities in IRIS which is important for the replication of the solutions both in the LH cities and in other cities.

The deliverable particularly addresses the IRIS Lighthouse Cities partners responsible for specific solutions and the leaders from the five Transition Tracks. The main objective of D9.2 is to present an all-embracing evaluation plan and monitoring program. A set of Key Performance Indicators (KPIs) has been selected to evaluate the effectiveness and impact of the cities proposed integrated solutions. Deliverable D9.2 sets out the requirements and objectives for the monitoring and evaluation to be carried out in the lighthouse cities and their integrated solutions and is a significant step towards the establishment of the unified monitoring infrastructure of the IRIS project.

The selection of the KPI set was carried out in collaboration with key representatives from the lighthouse cities and involved their partners responsible for specific solutions and the leaders from the five Transition Tracks. The final selection of KPIs fulfil the ambitions of the Grant Agreement and set targets, as well as specific input from partners wishing to assess more accurately the success level of each solution or methodology tested by the demonstrators.

The definition of Key Performance Indicators has been harmonized with other European projects working on energy smartification of European cities. The main initiatives that have been consulted for the definition of the key performance indicators (KPIs) are SCIS and CITYkeys, although some new indicators originate from the work conducted within the IRIS project. The use of SCIS and CITYkeys KPIs in IRIS will facilitate incorporation of all performance data into the SCIS throughout the project.

The work done in D9.2 will be used in D9.3 that is due in month 14 (M14). D9.3 will create the data model and the management plan for the integrated solutions and forms the basis for the establishment of a unified framework for harmonized data gathering, analysis and reporting which will be concluded in deliverable D9.4 which is due M18. Deliverable D9.2 will also provide input for WPs 3, 5-7 and 8.

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List of Abbreviations and Acronyms

Abbreviation	Definition
CHP	Combined Heat and Power
CIP	City Innovation Platform
CITYkeys	Smart City performance measurement system (Project funded by the European Union HORIZON 2020)
DC	Direct Current
DER	Distributed Energy Resources
DH	District Heating
DHW	Domestic Hot Water
DNO	Distribution Network Operator
DR	Demand Response
DSM	Demand Side Management
DSOs	Distribution System Operators
EIP-SCC	European Innovation Partnership on Smart Cities and Communities
ESCO	Energy Service Company
ESU	Energy Supply Unit
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
MHD	Maximum Hourly Deficit
MO	Market Operator
PM	Particulate Matter
PuT	Public Transport
PV	Photovoltaic
RES	Renewable Energy Sources
ROI	Return on Investment
SAIDI	System Average Interruption Duration Index
SAIFI	System Average Interruption Frequency Index
SCIS	Smart Cities Information System (Project funded by the European Union HORIZON 2020)
TES	Thermal Energy Storage
TSP	Technology and Services Provider
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 has defined goals and targets for each LH city in the project proposal (1) and the work package on monitoring and evaluation (WP) 9 will analyse to what extent the project reaches these goals and objectives. The monitoring and evaluation will also provide information concerning the performance of the different solutions demonstrated in the LH cities in IRIS which is important for the replication of the solutions both in the LH cities and in other cities.

Deliverable D9.2 *Report on monitoring and evaluation schemes for integrated solutions* is the result of Task 9.1 *A comprehensive evaluation plan and monitoring program to enable an evaluation of the effectiveness and impact of the LH cities' integrated solutions*. The main objective of this deliverable is to present an all-embracing evaluation plan and monitoring program for the IRIS project. The specific objectives are;

- To define a **set of KPIs** to evaluate the effectiveness and impact of the cities proposed integrated solutions
- Define an **evaluation plan** for assessing the performance of the demonstrated integrated solutions on solution level, transition track level, LH city level and IRIS project level
- Define a concrete **monitoring program** including monitoring protocols that take into account systems for monitoring, metering and data acquisition including appropriate time resolutions and aggregation levels

The IRIS **evaluation plan** is developed for assessing the performance of the LH 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 to transition track level, LH city level and IRIS project level. The evaluation plan will be based on a set of Key Performance Indicators (**KPIs)** selected to assess the performance of the cities' proposed integrated solutions according to IRIS targets and objectives. This enables comparison between the cities and supports further replication. The KPIs are customized to suit the integrated solutions of the LH cities and are selected through a process involving the LH cities and their partners.

Subsequently, a comprehensive and **complete 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.

1.2. Contributions of partners

Deliverable D9.2 has been authored by RISE and reviewed by UU and CAH. The work on selecting the KPIs for the evaluation plan was done by RISE in cooperation with UU, CERTH and the LH partners in Nice, Utrecht and Gothenburg.

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

Deliverable D9.2 is part of WP9 *Monitoring and Evaluation* and builds on WP1 *Transition strategy: five tracks to maximize integration synergy and replicability* where a predefined list of KPIs has been established in D1.1 (2). In WP1 there is also an ongoing process where KPI's with focus on citizen engagement are developed by HKU together with the LH cities. There might be KPIs that will be added into WP9 when that task is finished.

This deliverable is also based on input from WP2 *EU wide cooperation with ongoing projects, initiatives, communities*, utilizing the SCIS database KPIs and learning from CITYkeys project. In collaboration with IRIS WP5-7, the LH cities are assessed within WP9 with the aim of developing an all-embracing monitoring program for evaluation of the five transition tracks and the corresponding solutions. D9.2 also provides performance data to WP3 *Development of Bankable Business Models and Exploitation* to facilitate the creation and evaluation of business models for the IRIS solutions.

Within Work Package 9, deliverable D9.2 is directly related to deliverable D9.3 *Report on data model and management plan for integrated solutions* as the lists of data required to calculate the KPIs selected in the evaluation plan will be needed as input in the data model and data management plan. Based on this, the IRIS unified framework for harmonized data gathering, analysis and reporting will be developed and implemented in the LH cities as part of tasks T9.3 and T9.4, resulting in deliverables D9.4 and D9.5. The actual performance data collection and reporting, based in part on this deliverable, will be carried out in task T9.5 starting month M25. Task T9.5 will produce its first deliverable in month M38, D9.6 *Intermediate report after one year of measurements*. The final report, which is also part of task T9.5, summarizing the evaluation and impact analysis for the IRIS integrated solutions, D9.7, will be presented at the end of the project.

The following table presents the deliverables of WP1, WP5, WP6, WP7 and WP9 that are related to D9.2. WP3 and WP8 will also utilize results from WP9 in their work on business models and replication activities.

Table 1 – Deliverables related to D9.2

Number	Title
D1.1	Report on the list of selected KPIs for each Transition Track
D5.1	Report on baseline, ambition and barriers for Utrecht lighthouse interventions
D6.1	Report on Nice baseline, ambitions and barriers
D7.1	Report on Gothenburg baseline, ambitions and barriers
D9.1	First report on data management plan
D9.3	Report on data model and management plan for integrated solutions
D9.4	Report on unified framework for harmonized data gathering, analysis and reporting
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 solutions
D9.8	First update of the data management plan
D9.9	Second update of the data management plan
D9.10	Third update of the data management plan
D9.11	Fourth and final update of the data management plan

1.4. Structure of the deliverable

Section 2 presents the methodology used to select the KPIs through involvement of the LH stakeholders and the relation to the KPI repository developed in WP1. Further, section 2 also describes the methodology for defining the monitoring protocols and how the results from D9.1 will be used in the following tasks in WP9.

Section 3 presents a literature review of KPI frameworks and monitoring strategies used in previous projects that have been used as an inspiration when creating the IRIS evaluation plan and monitoring program.

Section 4 contains the evaluation plan and describes how the solutions, transition tracks, LH demonstration and IRIS project as a whole will be evaluated.

Section 5 includes descriptions of the monitoring protocols that define what data will be needed for the evaluation and the requirements of that data. The specific protocols for each LH city can be found in the annexes at the end of the report.

Section 6 contains the D9.2 outputs that will be used from other Tasks and Work packages.

Section 7 contains the conclusions of the deliverable.

Section 8 includes the references.

The annexes (section 9&10) contain the selected KPIs for each solution in the LH cities and KPI description cards containing a description and definition of each selected KPI.

1.5. Disclaimer

Due to the complexity of the project and varying stages for the Lighthouse Cities and their solutions, there may be changes required in KPIs, data points and sources mentioned in this deliverable compared to what will be implemented in the establishment of a unified framework for harmonized data gathering, analysis and reporting, to be implemented over the following year.

2. Process

This section aims to describe the process of developing the main results from IRIS T9.1: The IRIS evaluation plan and monitoring program. The development process is depicted in Figure 1 below. The resulting evaluation plan and monitoring program as well as a description of the evaluation and monitoring processes are described in detail in chapter 4 and 5.

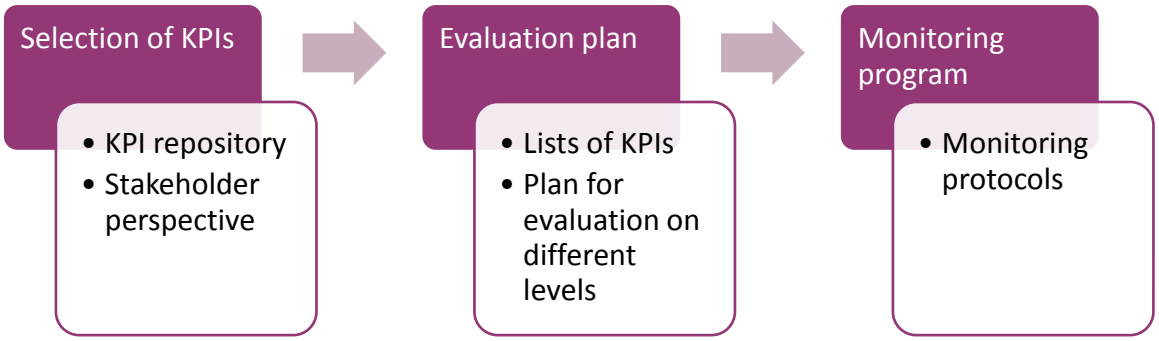


Figure 1: The process of developing the IRIS evaluation plan and monitoring program

Taking its starting point in the KPI repository developed in WP1, the work within T9.1 has focused on selecting the most relevant KPIs to evaluate each solution, TT and LH city. A bottom-up approach was taken to ensure relevance for key stakeholders. The evaluation plan contains lists of selected KPIs and a plan for evaluation on solution, TT and LH city level. The evaluation plan lays the foundation for the monitoring program that contains city-specific protocols.

2.1.Evaluation plan: Selection of KPIs

2.1.1. Relation to IRIS WP1 and the development of a KPI repository

In IRIS WP1 a KPI repository was established in the initial phase of the project, to identify and gather KPIs that can be used for the evaluation and monitoring of the theoretical ISs that are grouped in WP1 under each TT. These solutions will be implemented in IRIS WP5, WP6 and WP7. The repository is presented in IRIS D1.1 (2) and is based on KPIs and definitions from existing platforms such SCIS and CITYkeys that are described in more detail in chapter 0 of this report. T9.1 provided input to the KPI repository during its development. The repository has thereafter been used as a source of relevant KPIs when drafting the evaluation plan and monitoring program. The IRIS KPI repository is categorized along

the definition of IRIS domains, namely technical, economic, environmental, social ICT and legal. In WP9, however, the KPIs are presented from their relevance for each TT and not according to the domains.

2.1.1. IRIS stakeholder perspective

The stakeholder perspective is crucial in T9.1. This report determines what KPIs and thereby also which data that is required from each LH city and must be guided not only by the goals set for the whole IRIS project but also by the priorities, strategies and goals for each LH city. In the IRIS Grant Agreement (1), table 2.1a *IRIS expected impacts for various stakeholders* contains impact indicators for all LH cities. These indicators provide information about what LH city aims to achieve during the project and thereby they also constitute a basis for the selection of KPIs from a stakeholder perspective.

The LH cities' capabilities of delivering data for the KPIs has also been taken into consideration; Each LH city' perspectives and priorities have been captured via workshops and individual communication and have provided valuable input to the resulting evaluation plan and monitoring program. The IRIS T9.1-team has held specific KPI workshops in each LH city, where representatives from key partner organisations participated. The workshops were structured in two sessions: 1) What to measure, and 2) How to measure. The main questions that were discussed in the workshops are presented in Table 2 below.

Table 2 Overview of the workshops with the LH city partners

Session	Topic	Specific question
Session 1: What to measure	**Setting the target**	What is the LH's goal with the solution?
		What is the analysis object? (the object whose effects are to be studied)
	What to measure	How to know when the goals are reached?
		What should be measured during the project to achieve the best result?
		What needs to be reported to EU and other IRIS partners?
		What needs to be measured to analyse upscaling possibilities?
	Unit and target	What should be the unit and target?
Session 2: How to measure	**Information required**	What information is required and how can it be collected?
		How can the quality of information be assured?
	Actors	Who needs to be involved to collect the information?
	Baseline	What is the baseline?

Based on table 2.1a and the Work Package descriptions from the IRIS Grant Agreement as well as the results from the workshops, the T9.1 team proposed KPIs for each LH on solution, TT and LH city level. LH cities were invited to provide feedback on these KPI lists and individual communication to ensure

relevance and mutual understanding has been taking place. The approved lists of KPIs were thereafter compiled into comprehensive evaluation plans for each LH city, presented in chapter 0. The lists of KPIs have been cross-checked with table 2.1a in the IRIS Grant Agreement to ensure that all impact indicators have been captured.

2.2.Monitoring program: Protocols

The KPIs selected for each solution, TT and LH city contains specific descriptions of the data required for calculations (see the detailed descriptions of KPIs provided in Annex 1). All the required data has been compiled into tables for each LH city, specifying what data is needed (data point), which partner that is responsible for providing the data (source), what specific solution(s) the data is related to and related KPIs. These tables are the protocols in the IRIS monitoring program, presented in chapter 0.

3. Smart city evaluation frameworks

Project or process evaluation frameworks containing quantitative indicators such as KPIs are valuable tools to describe or assess individual characteristics of a project, product or process. They also allow evaluation, monitoring, comparison and benchmarking. KPIs are methods or systems that measure the effectiveness of a project or process towards the achievement of its specific key objectives. The desired characteristics of KPIs are described in detail in D1.1 (2) but in general KPIs should express to what extent an aim, a goal or a standard has been reached.

For cities working towards a more sustainable urban environment through the implementation of technical solutions, evaluation frameworks and specific KPIs can be used as decision support tools to support efficient management. There are several initiatives within the EU aiming to support urban development through evaluation frameworks, especially within the field of Smart Cities[1]. Some of the most common evaluation frameworks for Smart Cities in the EU are CITYkeys and SCIS.

CITYkeys and SCIS are specifically developed for smart city projects. The two frameworks have different scopes and contain different KPIs, and their content sometimes overlaps. Due the fact that CITYkeys and SCIS are the most widely used and well-established evaluation frameworks for smart cities in the EU, both the work in IRIS WP1 and in IRIS T9.1 mainly focus on these sources for identification of relevant KPIs. However, in a few cases during the work within IRIS T9.1 these frameworks are lacking suggestions for relevant indicators. In such cases, other evaluation frameworks (presented below) can provide input and inspiration to the development of new KPIs.

3.1. CITYkeys

A performance evaluation framework has been developed and validated within the project CITYkeys. CITYkeys is a collaboration platform initiated by several research institutes and European cities, funded by the European Commission (3).

Based on the needs of European cities and citizens and developed with input from 40 other sustainable smart urban performance systems, CITYkeys takes an overarching approach for harmonized and transparent monitoring and comparability during the implementation of Smart City solutions in Europe. The project has developed a large set of KPIs on project and city level (4) as well as guidelines for data collection. There are also recommendations for the implementation into the cities' decision-making process and for the development of new business.

The framework is structured according to the categories of People, Planet, Prosperity, Governance and Propagation. It both contains output indicators (e.g. number of open data sets) that enable measuring the progress on short term and impact indicators (e.g. reduced energy consumption) that can be either

[1] The European Commission definition of Smart City is (26): Cities using technological solutions to improve the management and efficiency of the urban environment.

estimated in the beginning of a project through simulation or monitored on a longer time scale (after the implementation of the project) (5).

3.2. SCIS

Smart Cities Information System (SCIS) is a knowledge platform where stakeholders from across Europe can exchange data and experience on the creation of smart cities and an energy-efficient urban environment (6). SCIS is funded by the European Commission and its content focuses on energy, mobility & transport and ICT. Within SCIS, indicators from different initiatives and existing sets of KPI´s have been analysed and compared which has resulted in the SCIS Key Performance Indicator Guide (7). Examples of KPI initiatives that have been included in the work is the CONCERTO Premium Indicator Guide (8) and the CITYkeys project (9).

The purpose of the SCIS indicator guide is to enable performance evaluation and comparison between different initiatives and projects. There are indicators for different aggregation levels (building, set of buildings, energy supply unit, set of energy supply units, neighbourhood, etc.). The SCIS indicator guide does not contain indicators concerning aspects such as governance, safety or prosperity. Such indicators have been developed in other initiatives.

3.3. Other evaluation frameworks

Some of the existing Smart City evaluation frameworks have been developed from well-established research or standards. For instance, a few are based on scientific models: Triple Bottom Line (10), the DPSIR framework (11) and the City Anatomy (12). Other frameworks base their indicator systems on international standards such as ISO 37120 (Sustainable cities and communities – Indicators for city services and quality of life).

3.3.1. Scientific models

Triple Bottom Line

Triple Bottom Line (10) is an established scientific model that has been applied in several contexts on different system levels, from national strategies to corporate policy. Several other evaluation frameworks are based on the Triple Bottom Line, for instance Eurbanlab (13) and ISO 37120.

The concept “triple bottom line” was established in the mid-1990’s and refers to that companies should take three different bottom lines into consideration. One bottom line is the traditional measure of corporate profit: the account for profit and loss. The second is the company's “people” account, a measure of the organisation’s social responsibility. The third is the company's “planet” account, measuring environmental responsibility. The triple bottom line thus consists of the three Ps: profit, people and planet aiming to measure the financial, social and environmental performance of the organisation. According to this theory, only a company that produces a triple bottom line is taking account of the full cost involved in doing business.

DPSIR

The DPSIR framework (11) is a model to describe cause and effect in the interaction between the society and the environment. It can be used to categorise environmental indicators into Drivers, Pressures, State, Impact and Response. DPSIR depicts human activities as the Drivers behind environmental impact. These Drivers lead to environmental Pressures due to emissions, pollutants etc. This may imply changes in the State of the environment or a reduced quality of ecosystems (Impact). Society can act upon these changes by taking measures to alter the Drivers or Pressures such as taxes, incentives or legislation (Response). The model is used by EEA, the European Environment Agency.

City Anatomy

The City Protocol Society (14) is a society of cities, corporations, academia and NGOs aiming to develop more efficient, resilient and sustainable future cities through a collaborative platform, tools and other activities. The society has developed the City Anatomy (12) as a foundation for their work.

The City Anatomy has three system elements: The physical structure (Structure), the people who live in it (Society) and the Interactions through which the Society engages the Structure. Each system element contains several layers. The City Anatomy indicator framework is structured accordingly and can be used for benchmarking across cities. Many of the indicators in the framework match the indicators in ISO 37120.

3.3.2. European frameworks

Among the European frameworks several are developed within specific projects as support to the European Commission's city-related initiatives. The frameworks often focus on specific aspects of urban development and administration. Some examples are:

- Civitas initiative, a network of cities for cities dedicated to cleaner, better transport (15).
- CONCERTO. This was an initiative within the European Research Framework Programme (FP6 and FP7) mainly focused on the building sector.
- EU Covenant of Mayors. This initiative brings together more than 7000 local and regional authorities committed to implementing EU climate and energy objectives (16).
- European Green Capital Award is one of the policy tools used by the European Commission to address urban environmental challenges, the economy and the quality of life in cities (17).
- Green Digital Charter, an initiative that commits cities to work together to improve the quality of life in cities using digital solutions (18).
- Reference Framework for Sustainable Cities, an online toolkit for local European authorities aiming to enhance the dialogue on sustainable development within a city and with peer cities (19).

3.3.3. International and European standards:

- ISO 37120, a standard for Sustainable cities and communities – Indicators for city services and quality of life.

- CEN-CENELEC-ETSI Coordination Group “Smart and Sustainable Cities and Communities” (SSCC-CG), is a is a joint group of the European Standardization Organisations that acts as an advisory and coordinating body for European standardization activities related to this topic (20).
- ISO 37151, a standard for Smart community infrastructures - Principles and requirements for performance metrics.

3.3.4. Neighborhood certification schemes

Neighborhood certification schemes assess the sustainability of the built environment in a holistic manner, often based on building certification schemes. A few examples of such schemes are;

- BREEAM Communities International standard. The Building Research Establishment Environmental Assessment Method (BREEAM) has developed an international standard that supports the development of sustainable communities. It can be used to assess and certify the performance of medium to large scale developments such as new communities and projects (21).
- CASBEE Cities and CASBEE Urban Development. The Comprehensive Assessment System for Built Environment Efficiency (CASBEE) can be used for evaluating and rating the environmental performance of buildings and the built environment. It consists of a set of assessment tools on different scales: construction (housing and buildings), urban (town development) and city management (22).
- The DGNB scheme for New Urban Districts assesses and certifies buildings and urban districts according certain sustainability criterion (23).
- LEED v4 for Neighborhood Development. The U.S. Green Building Council (USGBC) has developed a green certification program called Leadership in Energy and Environmental Design (LEED) (24).

4. Evaluation plan

The evaluation plan is based on a set of Key Performance Indicators (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. Based on the impact indicators from table 2.1a and the Work Package descriptions in the IRIS Grant Agreement (1), work conducted in workshops in the LH cities (see chapter 2) and the KPI repository developed in WP1 (2), KPIs have been assigned to the individual solutions in the LH cities. Every solution has an individual table with KPIs selected for that solution, together with the *units* of the KPIs, a short version of the *definition* of the KPIs, the *source* of the KPIs (e.g. whether they originate from SCIS, CITYkeys or another source including the IRIS project itself) and in some cases a *target* from the IRIS Grant Agreement that is related to that specific solution. The complete list of KPIs selected for each solution is listed in Annex 1. The lists of KPIs have been cross-checked with table 2.1a in the IRIS Grant Agreement to ensure that all impact indicators have been captured. An example of a solution KPI table is shown below in Table 3.

Table 3 Example of solution KPI table for a car sharing solution

KPI	Unit	Definition	Source	Target
Carbon dioxide Emission Reduction	tonnes CO_2/year	Reduction of emissions of carbon dioxide related to measure.	SCIS	308 tonnes in 5 years
Improved access to vehicle sharing solutions	Likert scale through observations/interviews	Improved accessibility to vehicle sharing solutions	CITYkeys	
Access to vehicle sharing solutions for city travel	Number of vehicles/100 000 inhabitants	Number of vehicles per 100 000 inhabitants	CITYkeys	
Yearly km driven in e-car sharing system	Km/year	Yearly km driven through the e-car sharing system instead of private conventional cars	IRIS	270.000 km

4.1. Aggregation of KPIs

In IRIS, the solutions implemented in the LH cities have been clustered into Transition Tracks representing a general sector of interest in the IRIS project. The Transition Tracks are presented in Figure 2. All Transition Tracks are represented in all three LH cities, although the solutions in each Transition Track differ between the cities. To compare the results of the LH demonstrations, it is therefore of interest to not only evaluate the project on the individual solution level, but on Transition Track level as well as LH city level. Additionally, the performance of the entire IRIS project also needs to be evaluated.

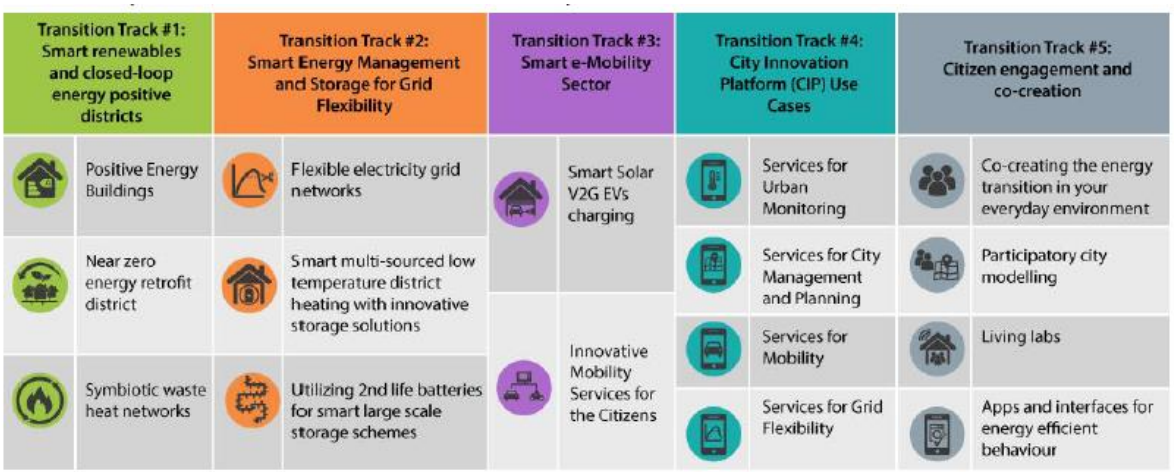


Figure 2 The IRIS Transition Tracks and Solutions (1)

Based on the tables in Annex 1 where each solution in the LH cities has been assigned KPIs to evaluate their performance, KPIs have also been aggregated to the higher levels to evaluate the performance of each Transition Track in the LH cities, the total performance of each LH city as well as the entire IRIS project. The KPIs on Transition Track level have been chosen to reflect the theme of each Transition Track, but since each LH city has its own set of solutions and targets, the KPIs for the Transition Tracks vary between the LH cities. In the same way the KPIs on LH level reflect the objectives and demonstrated solutions of each LH city. On IRIS level only two KPIs have been chosen, energy savings and CO_2 emission reduction. These KPIs have been chosen since they reflect the performance of all the IRIS Transition Tracks and can be aggregated to evaluate the impact of the whole project. Other KPIs are also of importance to the IRIS project but they are of most interest in the context of the LH city where they are implemented, not on an aggregated level.

The aggregation of KPIs is illustrated by a house, where the first floor of the house contains the KPIs calculated on individual solution level (a), the second floor contains KPIs that can be aggregated to Transition Track level (b), the third floor has KPIs that can be aggregated to LH city level (c) and the attic has the KPIs that can be aggregated all the way up to IRIS project level. The house is illustrated in

Figure 3. The KPIs are only represented in the “house” at their highest aggregated level, even though the same KPI can be represented in several solutions in every LH city.

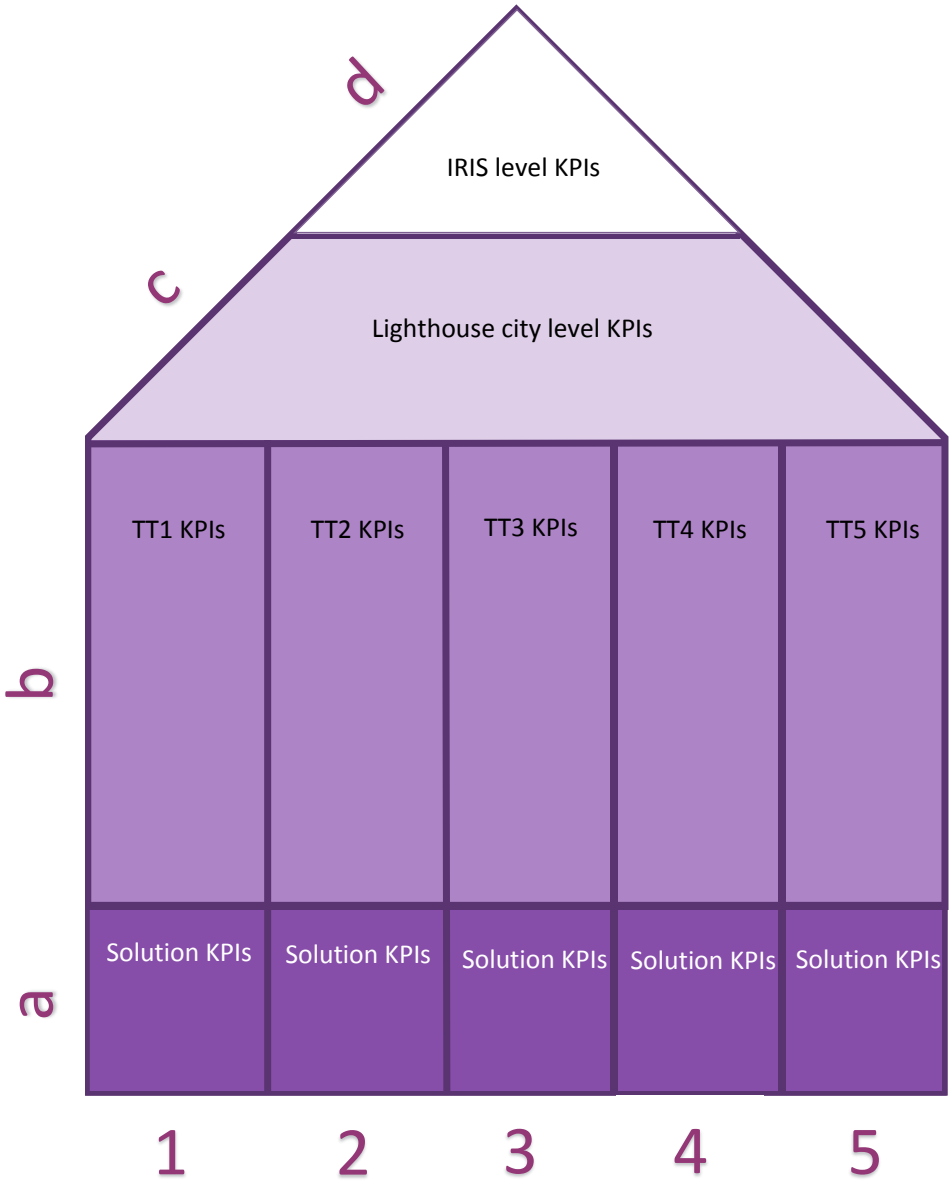


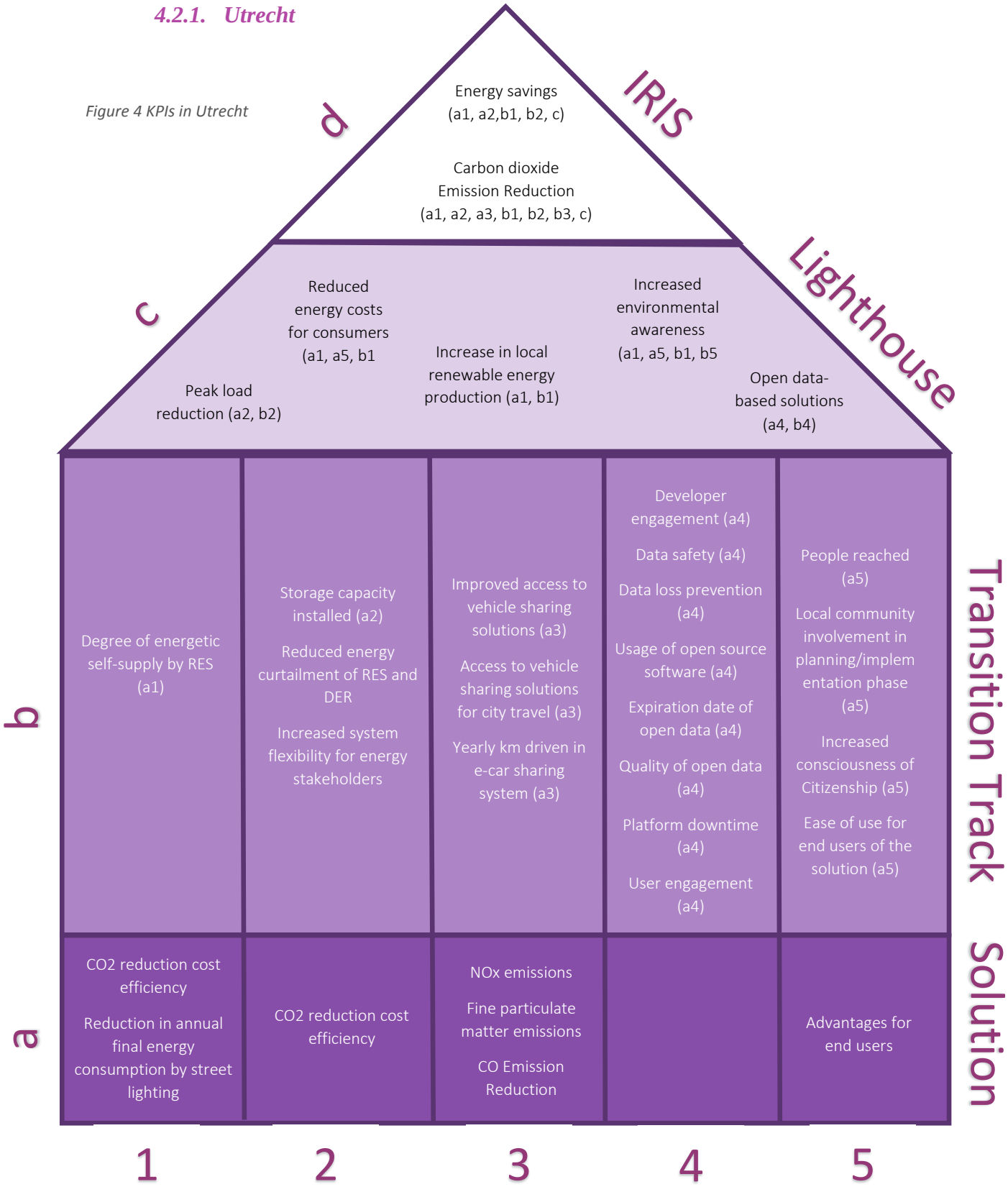
Figure 3 Aggregation of KPIs. The KPIs are only represented in the "house" at their highest aggregated level, even though the same KPI can be represented in several solutions in every LH city.

4.2. Aggregation of KPIs for each LH city

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 solution level, the KPIs may vary between the cities since different solutions are implemented in each city and the cities have different objectives, but 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 Transition Track level. The KPI houses for each LH city are presented in Figure 4, *Figure 5* and Figure 6.

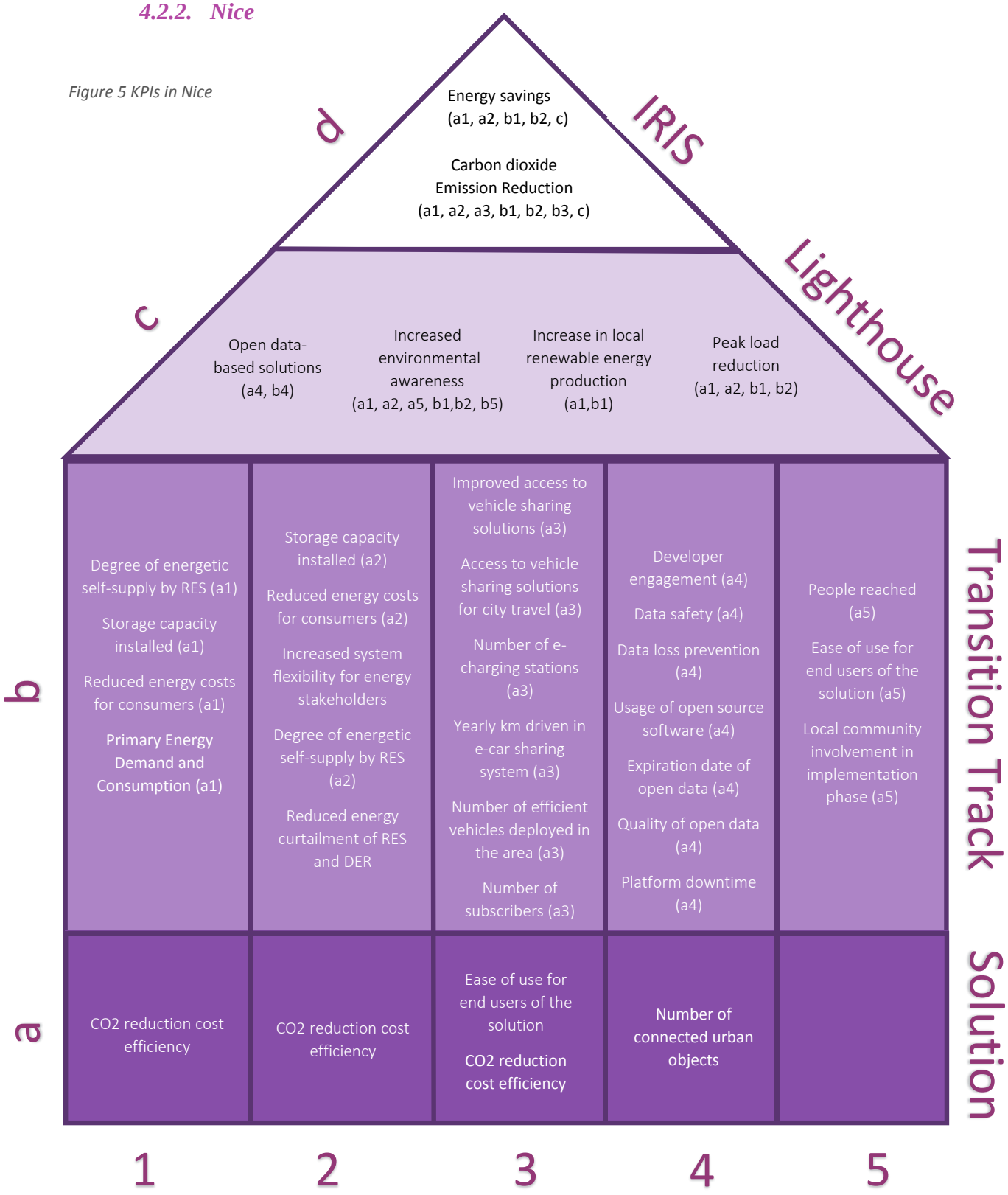
4.2.1. Utrecht

Figure 4 KPIs in Utrecht



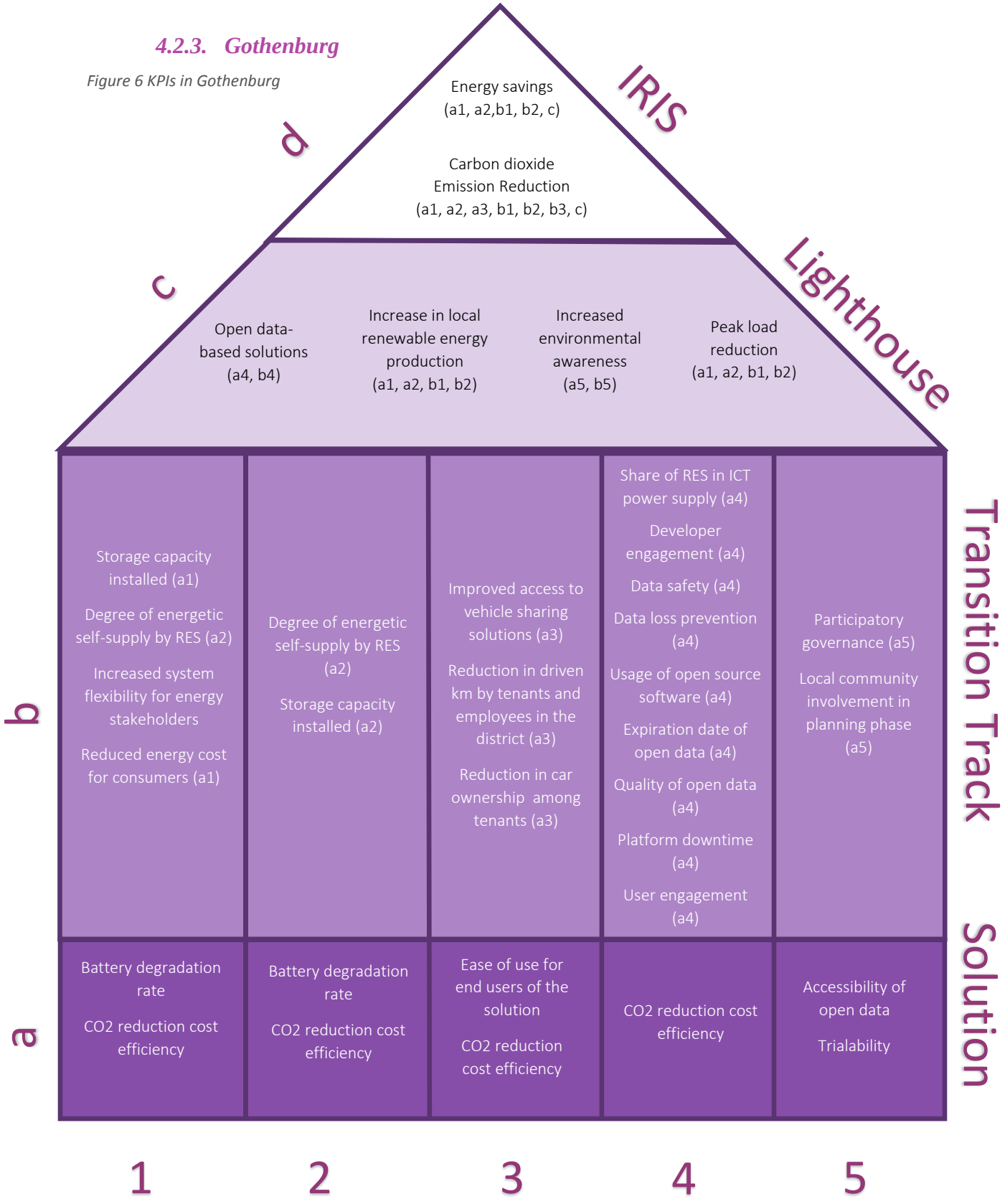
4.2.2. Nice

Figure 5 KPIs in Nice



4.2.3. Gothenburg

Figure 6 KPIs in Gothenburg



5. Monitoring program

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.

5.1. 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.

The data required for the baseline for the monitoring is included in the monitoring protocols below. The verification of the baseline for each specific dataset will be determined as part of Task 9.4. The work on verifying the baseline will include data from the baseline reports from the LH cities (D5.2, D6.2 and D7.2).

5.2. 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. In Annex 1 all targets found in the Grant Agreement have been assigned to their respective solutions in the KPI tables. 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.

5.2.1. Additional targets not related to protocols

Additional goals for the Lighthouse ecosystem not related to specific solution:

Nice

- 90 % of new buildings in Nice-Meridia connected to a geothermal district heating & cooling network.
- V2G battery storage: 41 000 kWh/year.
- 15 300 000 km yearly travelled with V2G cars

Gothenburg

- Sub-district energy consumption (target: <24 kWh/m2/a)
- 88 kWh V2G battery storage

5.3.Monitoring protocols

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 source followed by the related solution(s). The protocols also indicate if a baseline will be established for the measure.

The definition of the related KPIs can be found in Annex 2 and in Annex 1 the KPIs related to each solution are listed.

5.3.1. Monitoring protocols for Utrecht

Transition Track 1

Table 4 Input data for assessment of Transition Track 1 Utrecht

Data point (unit)	Source Utrecht	Related measures	Baseline	Related KPIs
Investment cost	BOEX	District-scale integrated PV-system	No	CO_2 reduction cost efficiency
	ENEC	RES and LT district heating		
	UTR	Smart DC street lighting		
	BOEX	Energy savings towards Nzeb		
	BOEX	Smart hybrid electric heating and ventilation		
	BOEX	Small-scale demonstration of hybrid AC/DC switchbox		
Local renewable energy generation	BOEX + STED	District-scale integrated PV-system	Yes	Increase in local renewable energy production Degree of energetic self-supply by RES
Electricity consumption in district	STED	District-scale integrated PV-system	Yes	Degree of energetic self-supply by RES Carbon dioxide Emission Reduction Reduction of annual final energy consumption by street lighting
	STED	Smart DC street lighting	Yes	
Electricity consumption building level	STED	Energy savings towards Nzeb	Yes	Energy savings Carbon dioxide

	BOEX +STED	Smart hybrid electric heating and ventilation	Yes	Emission Reduction
	BOEX	Small-scale demonstration of hybrid AC/DC switchbox	Yes	
Energy consumption	ENEC	RES and LT district heating	Yes	Energy savings Carbon dioxide Emission Reduction
	BOEX	Energy savings towards Nzeb	Yes	
	BOEX +STED	Smart hybrid electric heating and ventilation	Yes	
	BOEX	Small-scale demonstration of hybrid AC/DC switchbox	Yes	
Delivered DH	ENEC	RES and LT district heating	Yes	Energy savings Carbon dioxide Emission Reduction
	BOEX + STED	Energy savings towards Nzeb	Yes	
	BOEX + STED	Smart hybrid electric heating and ventilation	Yes	
	BOEX	Small-scale demonstration of hybrid AC/DC switchbox	Yes	
CO_2 emission from average electricity consumption in demonstration area	STED	District-scale integrated PV-system	Yes	Carbon dioxide Emission Reduction
	STED	Energy savings towards Nzeb	Yes	
	STED	Smart hybrid electric heating and ventilation	Yes	
	STED	Small-scale demonstration of hybrid AC/DC switchbox	Yes	
Cost for energy consumption for consumers on an aggregated level, based on energy savings and	BOEX + STED + ENEC	Energy savings towards Nzeb	Yes	Reduced energy costs for consumers

current energy prices				
Imported electricity from external grid	STED	District-scale integrated PV-system	Yes	Carbon dioxide Emission Reduction
Awareness of energy use	BOEX	Installation of innovative HEMS	Yes	Increased awareness of energy usage/Increased environmental awareness

Transition Track 2

Table 5 Input data for assessment of Transition Track 2 Utrecht

Data point (unit)	Source Utrecht	Related measures	Baseline	Related KPIs
Investment cost (Euro)	LOM	Smart solar V2G chargers	No	CO_2 reduction cost efficiency
	QBUzz	Smart solar/wind V2G charging spots for e-buses		
	LOM	Stationary storage in 12 apartment buildings		
Electricity peak load (kW)	LOM	Smart solar V2G chargers	Yes	Peak load reduction
	QBUzz	Smart solar/wind V2G charging spots for e-buses	Yes	
	LOM	Stationary storage in 12 apartment buildings	Yes	
Storage capacity installed (kWh)	LOM	Stationary storage in 12 apartment buildings	No	Storage capacity installed
Hosting capacity (MW)	STED	Stationary storage in 12 apartment buildings	Yes	Increased hosting capacity for RES
Energy not injected (kWh)	LOM	Smart solar V2G chargers	Yes	Reduced energy curtailment of RES and DER
	QBUzz	Smart solar/wind V2G charging spots for e-buses	Yes	
	LOM	Stationary storage in 12 apartment buildings	Yes	
CO_2 emission from average electricity consumption in demonstration area (tonnes/kWh)	STED	Smart solar V2G chargers	Yes	Carbon dioxide Emission Reduction
		Smart solar/wind V2G charging spots for e-buses		CO_2 reduction cost efficiency

Electricity consumption (MWh/year) in demonstration area	STED	Smart solar V2G chargers	Yes	Carbon dioxide Emission Reduction CO_2 reduction cost efficiency
	STED	Smart solar/wind V2G charging spots for e-buses	Yes	
	STED	Stationary storage in 12 apartment buildings	Yes	
Load capacity participating in demand side management	STED	District EMS	Yes	Increased system flexibility for energy stakeholders
Investment cost (Euro)	LOM	Smart solar V2G chargers	No	CO_2 reduction cost efficiency
	QBUzz	Smart solar/wind V2G charging spots for e-buses		

Transition Track 3

Table 6 Input data for assessment of Transition Track 3 Utrecht

Data point (unit)	Source Utrecht	Related measures	Baseline	Related KPIs
Investment cost (Euro)	LOM + STED	V2G e-car sharing system 'We Drive Solar'	No	
Yearly km driven in carsharing system (km/year)	LOM	V2G e-car sharing system 'We Drive Solar'	Yes	Yearly km driven in e-car sharing system
Number of carsharing vehicles in the city	LOM + UTR	V2G e-car sharing system 'We Drive Solar'	Yes	Access to vehicle sharing solutions for city travel
Number of inhabitants in the city	LOM + UTR	V2G e-car sharing system 'We Drive Solar'	Yes	Access to vehicle sharing solutions for city travel
CO_2 emission from vehicles in carsharing (kg/km driven)	LOM + UTR	V2G e-car sharing system 'We Drive Solar'	Yes. Baseline CO_2 emissions from alternative transport/ vehicles used (kg/km driven)	Carbon dioxide Emission Reduction
NO_X emissions from vehicles in carsharing (kg/km driven)	LOM + UTR	V2G e-car sharing system 'We Drive Solar'	Yes. NO_X emissions from alternative transport/ vehicles used (kg/km driven)	Nitrogen oxide emissions (NO_X),
Particulate emissions from vehicles in carsharing (kg/km driven)	LOM + UTR	V2G e-car sharing system 'We Drive Solar'	Yes. Baseline Particulate emissions from alternative transport/ vehicles used (kg/km driven)	Fine particulate matter emissions (PM10)

CO emissions from vehicles in carsharing (kg/km driven)	LOM + UTR	V2G e-car sharing system 'We Drive Solar'	Yes. Baseline CO emissions from alternative transport/ vehicles used (kg/km driven)	Carbon monoxide, CO
Surveys/interviews concerning access to vehicle sharing solutions	LOM + UTR	V2G e-car sharing system 'We Drive Solar'	Yes	Improved access to vehicle sharing solutions

Transition Track 4

Table 7 Input data for assessment of Transition Track 4 Utrecht

Data point (unit)	Source Utrecht	Related measures	Baseline	Related KPIs
Investment cost	CIV	City Innovation Platform (CIP)	No	-
Number of API calls per month	CIV	City Innovation Platform (CIP)	No	Developer engagement
Number of blocked malicious hacking attempts per year	CIV	City Innovation Platform (CIP)	No	Data safety
Number of lost datapoints in a year	CIV	City Innovation Platform (CIP)	No	Data loss prevention
Number of outdated datasets on a city platform per week	CIV	City Innovation Platform (CIP)	No	Expiration date of open data
% of data that uses DCAT standards	CIV	City Innovation Platform (CIP)	No	Quality of open data
Downtime per day	CIV	City Innovation Platform (CIP)	No	Platform downtime
Number of services based on open data per quarter	CIV	City Innovation Platform (CIP)	No	Open data-based solutions

Transition Track 5

Table 8 Input data for assessment of Transition Track 5 Utrecht

Data point (unit)	Source Utrecht	Related measures	Baseline	Related KPIs
Environmental awareness (Likert)	BOEX	Community building	Yes. Survey and/or interviews before activities with Residents of Kanaleneiland	Increased environmental awareness
Satisfaction of involvement from the tenants (Likert)	BOEX	Community building	Yes. Survey and/or interviews before activities with Residents of Kanaleneiland	Local community involvement in planning/ implementation phase
Number of change agents	BOEX Data from change agents in Kanaleneiland	Community building	No	Local community involvement in planning/ implementation phase
Number of Outdoor community building events and social media campaigns	BOEX. Data from outdoor community building events and social media campaigns	Community building	No	Local community involvement in planning/ implementation phase
Number of residents that have been taking part of activities	BOEX. Data from outdoor community building events and change agent activities	Community building	No	People reached
Feeling of involvement in the community/ Social cohesion (Likert)	BOEX	Community building	Yes. Surveys done by BOEX or the city before IRIS (for Kanaleneiland)	Increased consciousness of Citizenship
Number of students reached by Campaign District school involvement	UTR Students at primary schools Kaleidoscoop and Schatkamer	Campaign District school involvement	No	People reached

Satisfaction of involvement in campaign from the students (Likert)	UTR Survey and/or interviews after activities with Students at primary schools Kaleidoscoop and Schatkamer after activities.	Campaign District school involvement	No	Local community involvement in planning/ implementation phase
Satisfaction of tenants/ How the home EMS TOON is perceived as easy or difficult to understand and use. (Likert)	BOEX. Survey and/or interviews with residents that have the home EMS TOON.	Evaluation and co-creation	No	Ease of use for end users of the solution
Advantages of EMS TOON for end users (Likert or lowered energy bills)	BOEX. Survey/ interviews or lowered energy bills for Residents that have the home EMS TOON.	Evaluation and co-creation	No	Advantages for end users
Satisfaction of implementation of the EMS TOON (Likert)	BOEX. Survey and/or interviews with Residents that have the home EMS TOON.	Evaluation and co-creation	No	Local community involvement in implementation phase
Environmental awareness by using EMS TOON (Likert)	BOEX.	Evaluation and co-creation	Yes. Survey and/or interviews before using EMS TOON	Increased environmental awareness
Environmental awareness by Campaign using Smart lamp posts (Likert)	UTR	Campaign using Smart lamp posts	Yes. Survey and/or interviews before campaign with Residents of Kanaleneiland	Increased environmental awareness
Satisfaction from tenants using the virtual reality platform (Likert)	BOEX Survey and/or interviews with Residents experiencing Oculus Rift VR.	New Home & District Experience	No	Ease of use for end users of the solution

5.3.2. Monitoring protocols for Nice

Table 9 Input data for assessment of Transition Track 1 Nice

Data point (unit)	Source Nice	Related measures	Baseline	Related KPIs
Local renewable energy generation	CSTB	Promoting self-consumption of PV electricity in new office buildings equipped with battery systems	Yes	Increase in local renewable energy production Degree of energetic self-supply by RES
Electricity consumption on a building level	CSTB	Promoting self-consumption of PV electricity in new office buildings equipped with battery systems	Yes	Energy savings Carbon dioxide Emission Reduction Peak load reduction Increased awareness of energy usage
	CAH, CSTB	Improving energy efficiency of 3 high-rise apartment buildings		
	UNS, CAH, VEOLIA, CSTB	Developing and testing energy awareness services		
	VEOLIA, CSTB	Installing smart appliances for optimisation of the heating load curve		
DH consumption on a building level	CAH	Improving energy efficiency of 3 high-rise apartment buildings	Yes	Energy savings Carbon dioxide Emission Reduction Peak load reduction

	UNS, CAH, VEOLIA, CSTB	Developing and testing energy awareness services		Increased awareness of energy usage
	VEOLIA, CSTB	Installing smart appliances for optimisation of the heating load curve		
Cost for energy consumption for consumers for heating, cooling and DHW	CAH, CSTB	Improving energy efficiency of 3 high-rise apartment buildings	Yes. Energy costs on an aggregated level.	Reduced energy costs for consumers
CO_2 emission from average electricity consumption in demonstration area	CSTB	Promoting self-consumption of PV electricity in new office buildings equipped with battery systems	Yes	Carbon dioxide Emission Reduction
	CAH, CSTB	Improving energy efficiency of 3 high-rise apartment buildings		
	UNS, CAH, VEOLIA, CSTB	Developing and testing energy awareness services		
	VEOLIA, CSTB	Installing smart appliances for optimization of the heating load curve		
Awareness of energy use	IRIS	Developing and testing energy awareness services	Yes	Increased awareness of energy usage

Investment cost	CSTB	Promoting self-consumption of PV electricity in new office buildings equipped with battery systems	No	CO_2 reduction cost efficiency
	CAH, CSTB	Improving energy efficiency of 3 high-rise apartment buildings		
	VEOLIA, CSTB	Installing smart appliances for optimisation of the heating load curve		
	UNS, CAH, VEOLIA, CSTB	Developing and testing energy awareness services		
	EDF	Installing an advanced and energy efficiency urban waste heat recovery solution		
Amount of kWh storage installed	CSTB	Promoting self-consumption of PV electricity in new office buildings equipped with battery systems	No	Storage capacity installed

Transition Track 2

Table 10 Input data for assessment of Transition Track 2 Nice

Data point (unit)	Source Nice	Related measures	Baseline	Related KPIs
Electricity and heat consumption (MWh/year) in demonstration area	EDF	Smart meter roll-out	Yes	Energy savings Carbon dioxide Emission Reduction CO_2 reduction cost efficiency Degree of energetic self-supply by RES
	EDF	LEM		
	EDF	LT district heating and cooling network		
	EDF	Smart DHC optimization algorithms		
	EDF//NEXITY/UNS	2nd life batteries		
CO_2 emissions from average electricity consumption in demonstration area	IRIS	Smart meter roll-out	Yes	Carbon dioxide Emission Reduction CO_2 reduction cost efficiency
		LEM		
		LT district heating and cooling network		
		Smart DHC optimization algorithms		
		2nd life batteries		
Electricity and heat peak load (kW)	EDF	LEM	Yes	Peak load reduction
	EDF	Smart DHC optimization algorithms		

	EDF//NEXITY/UNS	2nd life batteries		
Electricity and heat production (MWh) from RES in demonstration area	EDF	LEM	Yes	Degree of energetic self-supply by RES
	EDF	LT district heating and cooling network		
Energy not injected (kWh)	EDF	LEM	Yes	Reduced energy curtailment of RES and DER
CO_2 emissions from average heat production in demonstration area	EDF	LT district heating and cooling network	Yes	Carbon dioxide Emission Reduction CO_2 reduction cost efficiency
	EDF	Smart DHC optimization algorithms		
Battery capacity (kWh) after a number of years/cycles	EDF//NEXITY/UNS	2nd life batteries	Yes. Initial battery capacity.	Battery degradation rate
Hosting capacity (MW)	EDF/NEXITY/UNS	2nd life batteries	Yes	Increased hosting capacity for RES
Load capacity participating in demand side management	EDF	LEM	Yes	Increased system flexibility for energy stakeholders
Energy use in specific building	EDF	LEM	Yes	Reduced energy cost for consumers
Average electricity price	EDF	LEM	Yes	Reduced energy cost for consumers
Awareness of energy usage (Likert scale, surveys)	EDF	LEM	Yes. Surveys measuring awareness of energy use before implementation.	Increased awareness of energy usage
Investment cost (Euro)	EDF/NEXITY/UNS	Smart meter roll-out	No	CO_2 reduction cost efficiency

		LEM LT district heating and cooling network Smart DHC optimization algorithms 2nd life batteries		
Storage capacity installed (kWh)	EDF	2nd life batteries	No	Storage capacity installed

Transition Track 3

Table 11 Input data for assessment of Transition Track 3 Nice

Data point (unit)	Source Nice	Related measures	Baseline	Related KPIs
Investment cost	VULOG	The free floating project	No	CO_2 reduction cost efficiency
Surveys/interviews concerning access to vehicle sharing solutions	VULOG	The free floating project	Yes	Improved access to vehicle sharing solutions
Number of carsharing vehicles in the city	VULOG	The free floating project	Yes	Access to vehicle sharing solutions for city travel
Number of inhabitants in the city	IRIS	The free floating project	Yes	Access to vehicle sharing solutions for city travel
Number of e-charging stations deployed in the area	VULOG	The free floating project	Yes	Number of e-charging stations deployed in the area
Yearly km driven in e-car sharing system	VULOG	The free floating project	Yes	Yearly km driven in e-car sharing system
Number of efficient vehicles deployed in the area	VULOG	The free floating project	Yes	Number of efficient vehicles deployed in the area
Number of Free Floating subscribers	VULOG	The free floating project	No	Number of Free Floating subscribers
Survey concerning ease of use for end users of the solution	VULOG	The free floating project	No	Ease of use for end users of the solution
CO_2 emission from vehicles in carsharing (kg/km driven)	VULOG	The free floating project	Yes. Baseline CO_2 emissions from alternative transport/vehicles used (kg/km driven)	CO_2 reduction cost efficiency Carbon dioxide Emission Reduction

NO_X emissions from vehicles in carsharing (kg/km driven)	VULOG	The free floating project	Yes. NO_X emissions from alternative transport/ vehicles used (kg/km driven)	Nitrogen oxide emissions (NO_X),
Particulate emissions from vehicles in carsharing (kg/km driven)	VULOG	The free floating project	Yes. Baseline Particulate emissions from alternative transport/ vehicles used (kg/km driven)	Fine particulate matter emissions (PM10, PM2,5)

Transition Track 4

Table 12 Input data for assessment of Transition Track 4 Nice

Data point (unit)	Source Nice	Related measures	Baseline	Related KPIs
Investment cost	NCA	City Innovation Platform (CIP)	No	
Number of connected urban objects	NCA	City Innovation Platform (CIP)	No	Number of connected urban projects
Share of RES in ICT power supply	NCA	City Innovation Platform (CIP)	No	Share of RES in ICT power supply
Number of API calls per month	NCA	City Innovation Platform (CIP)	No	Developer engagement
Number of blocked malicious hacking attempts per year	NCA	City Innovation Platform (CIP)	No	Data safety
Number of lost datapoints in a year	NCA	City Innovation Platform (CIP)	No	Data loss prevention
Number of outdated datasets on a city platform per week	NCA	City Innovation Platform (CIP)	No	Expiration date of open data
% of data that uses DCAT standards	NCA	City Innovation Platform (CIP)	No	Quality of open data
Downtime per day	NCA	City Innovation Platform (CIP)	No	Platform downtime
Number of services based on open data per quarter	NCA	City Innovation Platform (CIP)	No	Open data-based solutions

Transition Track 5

Table 13 ***Input data for assessment of Transition Track 5 Nice***

Data point (unit)	Source Nice	Related solution	Baseline	Related KPIs
Number of citizens using SERVICE BLEU	NCA. Data from SERVICE BLEU	SERVICE BLEU	Yes. Number of citizens using SERVICE BLEU before IRIS	People reached
Satisfaction from users of SERVICE BLEU, how the app is perceived as easy or difficult to understand and use. (Likert)	NCA. Survey and/or interviews after changes with users	SERVICE BLEU	Yes. Ease of use before IRIS	Ease of use for end users of the solution
Number of co-creations sessions with citizens to develop SERVICE BLEU	NCA	SERVICE BLEU	No	Local community involvement in implementation phase
Environmental awareness by using Smart Management of Peak Pollution	VEOLIA. Survey and/or interviews with users	Smart Management of Peak Pollution	Yes. Environmental awareness before using Smart Management of Peak Pollution	Increased environmental awareness
Number of users of the Smart Management of Peak Pollution	VEOLIA. Data from Smart Management of Peak Pollution	Smart Management of Peak Pollution	No	People reached
Satisfaction from users of Smart Management of Peak Pollution (Likert)	VEOLIA. Survey and/or interviews with users	Smart Management of Peak Pollution	No	Ease of use for end users of the solution
Number of citizens using CIVOCRACY	NCA. Data from CIVOCRACY	CIVOCRACY	Yes	People reached
Satisfaction from users of CIVOCRACY (Likert)	NCA. Survey and/or interviews with users	CIVOCRACY	No	Ease of use for end users of the solution
Number of ideas from CIVOCRACY that are being used in decision making	NCA	CIVOCRACY	No	Local community involvement in planning phase

5.3.3. Monitoring protocols for Gothenburg

Table 14 Input data for assessment of Transition Track 1 Gothenburg

Data point (unit)	Source Gothenburg	Related measures	Baseline	Related KPIs
Electricity consumption	Rb	2nd life batteries	Yes	Peak load reduction Carbon dioxide Emission Reduction
Battery Capacity after a number of years/ cycles	Rb	2nd life batteries	Yes. Initial battery capacity.	Battery degeneration rate
Maximum power consumption	Rb	Local energy storages	Yes	Peak load reduction
		Seasonal energy trading (cooling in summer season) with adjacent office block		
		Energy Management System to integrate PV, DH, grid and storage		
Energy Consumption	Rb	Energy Management System to integrate PV, DH, grid and storage	Yes	Energy savings
Local renewable energy generation	HSB	Demonstration of how Building Integrated Photovoltaics (BIPV) can be used in façade renovation process	Yes	Increase in local renewable energy production

CO_2 emission from average electricity consumption in demonstration area	Rb	Demonstration of how Building Integrated Photovoltaics (BIPV) can be used in façade renovation process	Yes	Carbon dioxide Emission Reduction
		Cooling from geo energy without chillers		
		Seasonal energy trading (cooling in summer season) with adjacent office block		
		Energy Management System to integrate PV, DH, grid and storage		
Amount of kWh storage installed	Rb	2nd life batteries	No	Storage capacity installed
		Local energy storages		
Investment cost	Rb	2nd life batteries	No	CO_2 reduction cost efficiency
	Rb	Demonstration of heating from geo energy with heat pumps		
	Rb	Cooling from geo energy without chillers		
	Rb	Local energy storages		

	Rb	Seasonal energy trading (cooling in summer season) with adjacent office block		
	Rb	Energy Management System to integrate PV, DH, grid and storage		
	HSB	Demonstration of how Building Integrated Photovoltaics (BIPV) can be used in façade renovation process		
Locally produced thermal energy and monitored thermal energy consumption	Rb	Demonstration of heating from geo energy with heat pumps	No	Degree of energetic self-supply by RES
		Cooling from geo energy without chillers		
		Energy Management System to integrate PV, DH, grid and storage		
Amount of load capacity participating in demand side management [W]	Rb	Seasonal energy trading	Yes	Increased system flexibility for energy stakeholders
		Energy Management System to integrate PV, DH, grid and storage		
Locally produced electrical energy and monitored electrical energy consumption	Rb	Energy Management System to integrate PV, DH, grid and storage	Yes	Degree of energetic self-supply by RES

	HSB	Demonstration of how Building Integrated Photovoltaics (BIPV) can be used in façade renovation process		
	Rb	Demonstration of heating from geo energy with heat pumps		
	Rb	Cooling from geo energy without chillers		
Cost for energy consumption for consumers on an aggregated level, based on energy savings and current energy prices	Rb	Seasonal energy trading	Yes	Reduced energy cost for consumers

Transition Track 2

Table 15 Input data for assessment of Transition Track 2 Gothenburg

Data point (unit)	Source Gothenburg	Related measures	Baseline	Related KPIs
Electricity and heat production (kWh/year) from RES in demonstration area	AH	350 V DC building microgrid	Yes	Increase in local renewable energy production Degree of energetic self-supply by RES
	Rb	Low temperature DH 45/30 system		
Electricity consumption (kW per hour) in demonstration area	AH	350 V DC building microgrid	Yes	Peak load reduction
	AH	1700 kWh PCM pilot facility		
	Rb	200kWh energy storage		
CO_2 emission from average electricity and heat consumption in demonstration area (tonnes/kWh)	IRIS	350 V DC building microgrid	Yes	Carbon dioxide Emission Reduction CO_2 reduction cost efficiency
		1700 kWh PCM pilot facility		
		200kWh energy storage		
		Low temperature DH 45/30 system		
Electricity and heat consumption (MWh/year) in demonstration area	AH	350 V DC building microgrid	Yes	Energy savings Degree of energetic self-supply by RES Carbon dioxide Emission Reduction CO_2 reduction cost efficiency
	AH	1700 kWh PCM pilot facility		
	Rb	200kWh energy storage		
	Rb	Low temperature DH 45/30 system		
Storage capacity installed (kWh)	AH	350 V DC building microgrid	No	Storage capacity installed
	AH	1700 kWh PCM pilot facility		
	Rb	200kWh energy		

		storage		
	Rb	A low temperature DH 45/30 system for six buildings in Riksbyggen sub-district (geo energy solution)		
Investment cost (Euro)	AH	350 V DC building microgrid	No	CO_2 reduction cost efficiency
	Rb	Low temperature DH 45/30 system		
	AH	1700 kWh PCM pilot facility		
	Rb	200kWh energy storage		
Battery capacity after a number of years/cycles (kWh)	Rb	200kWh energy storage	Yes. Initial battery capacity.	Battery degradation rate

Transition Track 3

Table 16 Input data for assessment of Transition Track 3 Gothenburg

Data point (unit)	Source Gothenburg	Related measures	Baseline	Related KPIs
Survey concerning ease of use for end users of the solution	TRIV	EC2B	Yes	Ease of use for end users of the solution
Yearly km driven in e-car sharing system	TRIV	EC2B	Yes	Yearly km driven in e-car sharing system Carbon dioxide Emission Reduction
CO_2 emission from vehicles in carsharing (kg/km driven)	TRIV/IRIS	EC2B	Yes. CO_2 emissions from alternative transport/vehicles used (kg/km driven)	Carbon dioxide Emission Reduction
Surveys/interviews concerning access to vehicle sharing solutions	TRIV	EC2B	Yes	Improved access to vehicle sharing solutions
Km driven by tenants and employees in the district	TRIV	EC2B	Yes	Reduction in driven km by tenants and employees in the district Energy savings
Number of cars per apartment	TRIV	EC2B	Yes	Reduction in car ownership among tenants

Transition Track 4

Table 17 Input data for assessment of Transition Track 4 Gothenburg

Data point (unit)	Source Gothenburg	Related measures	Baseline	Related KPIs
Share of RES in ICT power supply	GOT/METRY	City Information Model (CIM) Energy Cloud	Yes	Share of RES in ICT power supply
Number of API calls per month	GOT	City Information Model (CIM)	Yes	Developer engagement
Number of blocked malicious hacking attempts per year	GOT	City Information Model (CIM)	Yes	Data safety
Number of lost datapoints in a year	GOT	City Information Model (CIM)	Yes	Data loss prevention
Number of outdated datasets on a city platform per week	GOT	City Information Model (CIM)	Yes	Expiration date of open data
% of data that uses DCAT standards	GOT	City Information Model (CIM)	Yes	Quality of open data
Downtime per day	GOT	City Information Model (CIM)	Yes	Platform downtime
Electricity and heat consumption (kW per hour) in Energy Cloud demonstration area	METRY	Energy Cloud	Yes	Peak load reduction
Electricity and heat consumption (MWh/year) in Energy Cloud demonstration area	METRY	Energy Cloud	Yes	Carbon dioxide Emission Reduction CO_2 reduction cost efficiency
CO_2 emission from average electricity and heat consumption in Energy Cloud demonstration area (tonnes/kWh)	METRY	Energy Cloud	Yes	Carbon dioxide Emission Reduction CO_2 reduction cost efficiency
Investment cost	GOT	City Information	No	CO_2 reduction cost efficiency

		Model (CIM)		
	METRY	Energy Cloud		
Number of services based on open data per quarter	METRY	City Information Model (CIM) Energy Cloud	No	Open data-based solutions

Transition Track 5

Table 18 Input data for assessment of Transition Track 5 Gothenburg

Data point (unit)	Source Gothenburg	Related solution	Baseline	Related KPIs
Number of participants in Minecraft contest	GOT Statistics after competition	Spatial planning design contest for children and youths	No	Participatory governance
Satisfaction of the involvement in the Minecraft competition (Likert)	GOT Survey and/or interviews with participants after competition	Spatial planning design contest for children and youths	No	Local community involvement in planning phase
Number of participants in Min Stad platform	GOT Yearly summery of participants in the platform	Citizen engagement in the city of Gothenburg:"Min Stad"	Yes	Participatory governance
Number of ideas in Min Stad platform	GOT Yearly summery of ideas in the platform	Citizen engagement in the city of Gothenburg: "Min Stad"	Yes	Participatory governance
Number of workshops with citizens	GOT Number of workshops during the project (3+3)	Citizen engagement in the city of Gothenburg: Co-creation and collaborative innovation	No	Local community involvement in planning phase
Satisfaction of the open data (Likert)	GOT Survey and/or interviews with users of Smart city hub	Citizen engagement in the city of Gothenburg: Release more available data (smart city hub)	No	Accessibility of open data
Satisfaction of citizen engagement challenge (Likert)	GOT Survey and/or interviews with Participants of Inclusive Life Challenge	Citizen engagement in the city of Gothenburg: "Inclusive Life Competition"	No	Trialability
Environmental awareness (Likert)	HSB Living Lab Survey and/or interviews with users of Building Information Modelling,	BIM (Building Information Modelling)	No	Increased environmental awareness
Environmental awareness (Likert)	HSB Living Lab Survey and/or interviews with users of PET	Personal Energy Threshold (PET)	No	Increased environmental awareness

Number of users	HSB Living Lab Yearly data from PET	Personal Energy Threshold (PET)	No	Participatory governance
Satisfaction from the tenants using PET (Likert)	HSB Living Lab Survey and/or interviews with users of PET	Personal Energy Threshold (PET)	No	Local community involvement in implementation phase

6. Output to other work packages

The work done in D9.2 will be used in D9.3 that is due in month 14 (M14). D9.3 will create the data model and the management plan for the integrated solutions and forms the basis for the establishment of a unified framework for harmonized data gathering, analysis and reporting which will be concluded in deliverable D9.4 which is due M18.

Deliverable D9.2 will also provide input for WPs 3, 5, 6, 7 and 8.

7. Conclusions

The IRIS project has defined goals and targets in the project proposal and the monitoring and evaluation work package (WP) 9 will analyse to what extent the project reaches these goals and objectives. The monitoring and evaluation will also provide information concerning the performance of the different solutions demonstrated in the LH cities in IRIS which is important for the replication of the solutions both in the LH cities and in other cities.

The main objective of D9.2 is to present an all-embracing evaluation plan and monitoring program. A set of Key Performance Indicators (KPIs) have been selected to evaluate the effectiveness and impact of the cities proposed integrated solutions. The KPIs are adapted to suit the integrated solutions of the LH cities and were selected through a process involving the LH cities and their partners.

Based on this KPI set, an evaluation plan has been developed for assessing the performance of the interventions from a holistic point-of-view, addressing such issues as the energy and economic performance, social acceptance, urban mobility and the integrated infrastructures actions. The evaluation plan describes how the project will be evaluated on several different levels from a solution level to transition track level, LH city level and IRIS project level. Subsequently, a comprehensive and complete monitoring program is defined based on the evaluation plan. The data requirements are specified in monitoring protocols based on the selection and definition of KPIs. The monitoring protocols also consider the data needed to create a baseline for the evaluation.

Deliverable D9.2 sets out the requirements and objectives for the monitoring and evaluation to be carried out in the lighthouse cities and their integrated solutions and is a significant step towards the establishment of the unified monitoring infrastructure of the IRIS project.

The selection of the KPI set was carried out in collaboration with key representatives from the lighthouse cities and involved their partners responsible for specific solutions and the leaders from the five Transition Tracks. The final selection of KPIs fulfil the ambitions of the Grant Agreement and set targets, as well as specific input from partners wishing to assess more accurately the success level of each solution or methodology tested by the demonstrators.

The definition of Key Performance Indicators has been harmonized with other European projects working on energy smartification of European cities. The main initiatives that have been consulted for the definition of the key performance indicators (KPIs) are SCIS and CITYkeys, although some new indicators originate from the work conducted within the IRIS project. The use of SCIS and CITYkeys KPIs in IRIS will facilitate incorporation of all performance data into the SCIS and EIP-SCC throughout the project.

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9. Annex 1 – KPIs per solution in LH cities

Annex 1 contain the selected KPIs for each solution in the LH cities.

9.1. Utrecht

Demonstrating Transition Track #1: Smart renewables and near zero energy district

The demonstration activities of TT#1 on Smart renewables and near zero energy district in the lighthouse city of Utrecht comprise of the integration of a set of solutions integrated and deployed in 12 four-storey apartment buildings of social housing corporation BOEX (8 buildings with gas-infra; 4 with DH-infra, 644 apartments in total) and 3 school buildings (Kaleidoscoop, Schatkamer, MBO Utrecht). In particular:
- ***District-scale integrated PV-system*** installed on 12 apartment buildings and 3 schools and by means of open ICT interconnected to a district smart energy grid, leading in a high share of locally produced and consumed renewable power at district scale making PV profitable without subsidies.
- ***RES*** and ***LT district heating*** (to be demonstrated in 4 apartment buildings).
- ***Energy savings*** towards ***nZEB*** (***refurbishment*** of 12 apartment buildings from label E/F to A
- Installation of innovative HEMS (***home EMS TOON***) in all 644 apartments, providing feedback on energy consumption, the PV-system, hybrid E/G heating and ventilation and facilitating citizen engagement.
- ***Smart hybrid electric heating*** and ***ventilation*** will be demonstrated in 8 apartment buildings, using novel smart hybrid heat pumps for heating and hot water.
- Energy savings thanks to Small-scale demonstration of ***hybrid AC/DC switchbox*** power grid in 8 apartments.
- Medium-scale demonstration of ***smart DC street lighting*** (50 lamp posts allowing DC), powered by ***renewable energy***, providing district WiFi, dynamic and energy efficient lighting, powered by renewable energy.
- Installing performance testing and measurement equipment.

Targets:

(i) Energy savings in households of 81 %-86 %, resulting in 4,6 million kWh/year and 1.300 tonnes CO_2 reduction/year (BEST table),

(ii) Energy savings in street lighting of 20 MWh or 9 tonnes CO_2 reduction in 5 years, and

(iii) Increase renewables: from 0 MWp to 1,8 MWp PV-power integrated in the district micro-grid, or 100% of building power demand, and 667 MWh/yr wind power at sea for e-bus charging (BEST table)

9.1.1. District-scale integrated PV-system

KPI	Unit	Definition	Source	Target
Increase in local renewable energy production	% in kWh	Ratio of produced energy from renewable production over a period (e.g. month, year)	CITYkeys	(iii)
Degree of energetic self-supply by RES	%	Ratio of locally produced energy from RES and the energy consumption over a period (e.g. month, year)	SCIS	
Carbon dioxide Emission Reduction	tonnes CO_2/year	Reduction of emissions of carbon dioxide related to measure.	SCIS	
Reduced energy costs for consumers	Euro/m2	Reduction in cost for energy consumption on an aggregated level, based on energy savings and current energy prices.	IRIS	
CO_2 reduction cost efficiency	Euro/ton CO_2 saved per year	Costs in euros per ton of CO_2 saved per year	CITYkeys	

9.1.2. RES and LT district heating

KPI	Unit	Definition	Source	Target
Energy savings	MWh/year	Reduction in delivered energy to the thermal grid production units.	SCIS	
CO_2 reduction cost efficiency	Euro/ton CO_2 saved per year	Costs in euros per ton of CO_2 saved per year	CITYkeys	
Carbon dioxide Emission Reduction	tonnes CO_2/year	Reduction of emissions of carbon dioxide related to measure.	SCIS	(i)

9.1.3. Energy savings towards Nzeb

KPI	Unit	Definition	Source	Target
Energy savings	(kWh/(m2 year); MWh/(year))	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.	SCIS	(i)
Carbon dioxide Emission Reduction	tonnes CO_2/year	Reduction of emissions of carbon dioxide related to measure.	SCIS	(i)
Reduced energy costs for consumers	Euro/m2	Reduction in cost for energy consumption on an aggregated level, based on energy savings and current energy prices.	IRIS	
CO_2 reduction cost efficiency	Euro/ton CO_2 saved per year	Costs in euros per ton of CO_2 saved per year	CITYkeys	
Degree of energetic self-supply by RES	%	Ratio of locally produced energy from RES and the energy consumption over a period	SCIS	(iii)

(e.g. month, year)

9.1.4. *Installation of innovative HEMS (home EMS TOON)*

KPI	Unit	Definition	Source	Target
Increased awareness of energy usage/Increased environmental awareness	Likert	The extent to which the project has used opportunities for increasing awareness of energy use	IRIS	

9.1.5. *Smart hybrid electric heating and ventilation*

KPI	Unit	Definition	Source	Target
Energy savings	(kWh/(m2 year); MWh/(year))	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.	SCIS	(i)
Carbon dioxide Emission Reduction	tonnes CO_2/year	Reduction of emissions of carbon dioxide related to measure.	SCIS	(i)
CO_2 reduction cost efficiency	Euro/ton CO_2 saved per year	Costs in euros per ton of CO_2 saved per year	CITYkeys	

9.1.6. *Small-scale demonstration of hybrid AC/DC switchbox*

KPI	Unit	Definition	Source	Target
Energy savings	MWh/year	The reduction of the energy use compared to a situation without the switchbox.	SCIS	
Carbon dioxide Emission Reduction	tonnes CO_2/year	Reduction of emissions of carbon dioxide related to measure.	SCIS	
CO_2 reduction cost efficiency	Euro/ton CO_2 saved per year	Costs in euros per ton of CO_2 saved per year	CITYkeys	

9.1.7. *Smart DC street lighting*

KPI	Unit	Definition	Source	Target
Energy savings	MWh/year	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.	SCIS	(ii)
Reduction in annual final energy consumption by	(kWh/yr)	The reduction of the energy consumption for street lighting	CITYkeys	

street lighting			
Carbon dioxide Emission Reduction	tonnes CO_2/year	Reduction of emissions of carbon dioxide related to measure.	SCIS (ii)
CO_2 reduction cost efficiency	Euro/ton CO_2 saved per year	Costs in euros per ton of CO_2 saved per year	CITYkeys

Demonstrating Transition Track #2: Smart energy management and storage for flexibility

In a front running solar and EV city like Utrecht, grid flexibility and self-consumption, provided by storage and smart energy management, are prerequisites for accommodating high shares of both PV-generation and shared e-mobility. Grid operator STED needs to accommodate large shares of renewables and e-mobility, while preventing grid stress due to PV-generation and e-charging peaks on the grid. Therefore, grid flexibility is crucial. Pre-proposal efforts have demonstrated the feasibility of the Smart Solar Charging system: shared e-cars and public transport e-buses are charged with solar power, demand driven and bi-directional (V2G), to be able to sell solar power to the highest profit. Activities will be focusing on the integration of a district wide power storage system for maximum grid flexibility and self-consumption, consisting of primary storage (V2G batteries of e-cars and public transport e-buses) and additional secondary storage (stationary batteries in all buildings including 2nd life batteries), demonstrating how grid stress and grid investments are minimalized and how to best deploy storage at district level, supported by an open ICT system for interconnection, performance monitoring and cost effective new information services for aggregators, grid operators, municipality and citizens. The demonstration activities will comprise of the installation of:
- 18 ***smart solar V2G chargers*** in the district, at district scale ***interconnected with the PV-systems***
- 10 ***smart solar/wind V2G charging spots*** for ***e-buses*** in Westraven
- ***district-wide*** additional ***stationary storage*** in 12 apartment buildings, including ***2nd life batteries***, interconnected to primary V2G-storage and PV-systems by green ICT.
- ***district EMS***, the district ICT platform providing interconnection and monitoring at district scale, allowing deployment of the Universal Smart Energy Framework (USEF, fundament of the business model 'Value of Flexibility).

By further installing performance testing and measurement equipment, the ratio storage needed in e-car batteries to supplementary stationary storage will be analysed, allowing the optimisation of algorithms for integrated energy system, matching USEF standards.

Targets:

(i) Smart storage capacity of 396 kWh primary storage in V2G e-cars/ 3.600 kWh secondary storage (stationary batteries).
(ii) Local emissions of 1.300 ton CO2 /year will be avoided from peak reduction.

9.1.8. 18 Smart solar V2G chargers

KPI	Unit	Definition	Source	Target
Peak load reduction	%	Reduction in maximum peak load of a building or a group of buildings.	SCIS	
Carbon dioxide Emission Reduction	tonnes CO_2/year	Reduction of emissions of carbon dioxide related to measure.	SCIS	(ii)
Reduced energy curtailment of RES and DER	%	Reduction of energy curtailment due to technical and operational problems	SCIS	
CO_2 reduction cost efficiency	Euro/ton CO_2 saved per year	Costs in euros per ton of CO_2 saved per year	CITYkeys	

9.1.9. 10 Smart solar/wind V2G charging spots for e-buses in Westraven

KPI	Unit	Definition	Source	Target
Peak load reduction	%	Reduction in maximum peak load for the charging spots.	SCIS	
Reduced energy curtailment of RES and DER	%	Reduction of energy curtailment due to technical and operational problems	SCIS	
CO_2 reduction cost efficiency	Euro/ton CO_2 saved per year	Costs in euros per ton of CO_2 saved per year (input data may be difficult to obtain)	CITYkeys	

9.1.10. District-wide additional stationary storage in 12 apartment buildings, including 2nd life batteries

KPI	Unit	Definition	Source	Target
Storage capacity installed	kWh	kWh storage capacity installed		(i)
Peak load reduction	%	Ratio of the peak demand reduction and peak demand before the measure	SCIS	
Increased Self-consumption of PV-energy by e-cars	kWh	Increase in use of solar energy generated in the district by the e-cars	IRIS	

9.1.11. District EMS

KPI	Unit	Definition	Source	Target
Increased system flexibility for energy players	%	The change in load capacity participating in demand side management before and after the measure.	SCIS	

Demonstrating Transition Track #3: Smart e-mobility

Utrecht is a frontrunner in e-mobility, regarding the number of 4.035 e-cars and 260 charging stations in the city (as of December 2015). Furthermore, Utrecht introduced the first small-scale solar powered V2G pilot for public use in Europe in June 2015. Building upon this experience, a district wide V2G e-car sharing system will be installed, offering zero-emission mobility, decreasing household mobility costs, mostly powered by the sun. The sharing system is integrated with smart solar charging, using V2G charging systems that can load and unload the solar power stored in V2G batteries. As a result, the e-cars are mostly solar powered, grid stress is reduced thanks to the V2G storage, local air quality is improved and children get more room to play since less parking space is needed. LOM is provider of the Smart Solar Charging system, developed with STED in the preceding research pilot in the Lombok district in Utrecht (2012-2015).

The main demonstration activities in this task will focus on the **V2G e-car sharing system '*We Drive Solar*'**, consisting of 14 V2G e-cars (specially prepared Renault ZOEs) plus 4 V2G maintenance vans, along with 10 smart solar V2G e-buses that can be charged and discharged with locally produced solar and wind power for public transport. Furthermore, an analysis will be contacted on how citizens actually use the smart solar powered e-car sharing system 'We Drive Solar' and testing and co-creation of IT interfaces and **apps motivating citizens** to change their mobility patterns, adopting the mobility provided by the district wide V2G e-cars sharing system.

Targets:

(i) Air quality: Direct CO2 emission reduction: 308 tonnes in 5 yr (e-cars & e-vans) and 4785 tonnes in 5 yr (e-buses); Direct CO emission reduction: 3 tonnes in 5 y (e-cars & e-vans) and 1,6 tonnes (e-buses); Direct Fine dust emission reduction (PM10): 0,02 tonnes in 5 yr (e-cars & e-vans) and 0,26 tonnes in 5 yr (e-buses); Direct Soot emission reduction: 0,2 tonnes in 5 yr (e-cars & e-vans) and 0,6 tonnes in 5 yr (e-buses); Direct NOx emission reduction: 1 tonnes in 5 yr (e-cars & e-vans) and 22 tonnes in 5 yr (e-buses), and

(ii) Yearly 270.000 km are made through the e-car sharing system instead of private conventional cars (210.000 by e-cars and 60.000 by e-vans)

9.1.12. V2G e-car sharing system 'We Drive Solar'

KPI	Unit	Definition	Source	Target
Nitrogen oxide emissions (NOx)	%	Percentage reduction in NOx emissions (NO and NO2) achieved by the measure	CITYkeys	(i)
Fine particulate matter emissions (PM10)	%	Percentage reduction in PM10 emissions achieved by the measure	CITYkeys	(i)
Carbon monoxide, CO	%	Percentage reduction in carbon monoxide emissions achieved by the measure	IRIS	(i)
Carbon dioxide Emission Reduction	tonnes CO2/year	Reduction of emissions of carbon dioxide related to measure.	SCIS	(i)
Improved access to vehicle sharing solutions	Likert scale through observations/interviews	Improved accessibility to vehicle sharing solutions	CITYkeys	
Access to vehicle sharing solutions for city travel	Number of vehicles/100 000 inhabitants	Number of vehicles per 100 000 inhabitants	CITYkeys	
Yearly km driven in e-car sharing system	Km/year	Yearly km driven through the e-car sharing system instead of private conventional cars	IRIS	(ii)

Demonstrating Transition Track #4: City Innovation Platform (CIP)

Cross-cutting ICT enables the integration of the above-mentioned solutions, maximising the profitability of the integrated infrastructure. To achieve this, open ICT-system and open APIs are necessary, providing the CIP and meaningful data services serving households, municipality and other stakeholders, together allowing for the new business models that emerge in the Utrecht lighthouse project. T5.6 concerns a large-scale demonstration of ICT enabling the integration of the above-mentioned energy and mobility solutions, and providing a CIP for meaningful information services, serving households, municipality and other stakeholders, including:
- Citizen info services: 3D Utrecht City Innovation Model, Smart Street Lighting Multi-sensoring,
- Municipality info services: City Data Market, Monitoring e-Mobility with LoRa network,
- Stakeholder info services: Monitoring Grid Flexibility, Fighting Energy Poverty

Targets:
(i) Information services realized, evaluated, optimized,
(ii) Green ICT: All V2G charging operations and EMSs are solar powered

9.1.13. City Innovation Platform (CIP) and information services

KPI	Unit	Definition	Source	Target
Developer engagement	Number of API calls per month	Use of open datasets by developers	IRIS (WP1)	
Data safety	Attempts per month/ year	Number of blocked malicious hacking attempts	IRIS (WP1)	
Data loss prevention	Number of lost datapoints in a timeframe.	Lost datapoints in a period.	IRIS (WP1)	
Usage of open source software	Likert	How easy is it to connect systems	IRIS (WP1)	
Expiration date of open data	% of obsolete data on city data platform	Number of outdated datasets on a city platform per week	IRIS (WP1)	
Quality of open data	Number of standardized datasets	% of data that uses DCAT standards	IRIS (WP1)	
Platform downtime	Minutes of downtime per (hour/day/ week/month)	Downtime per day	IRIS (WP1)	
Open data-based solutions	New solutions per quarter	Number of services based on open data	IRIS (WP1)	
User engagement	Number of users	Number of users involved	IRIS	

Demonstrating Transition Track #5: Citizen engagement and motivating feedback

The Utrecht LH district Kanaleneiland is a challenging district, characterized by mainly social housing and schools. It is a densely populated district, home to in majority low-income and multicultural families. This calls for demonstrating extensive and innovative citizen engagement methods, resulting in citizens who understand, trust, use and feel ownership of the integrated energy and mobility solutions offered in their homes and district.

This task involves demonstration of **user-centred design methods for engaging households** in ***renewables***, ***energy efficiency*** and ***shared e-mobility***, based on the baseline definition (in ***T5.1***) of actual ***citizen energy*** and ***mobility behaviour***, ***citizen engagement***, ***neighbourhood dynamism***, ***demographic situation***, ***citizen concerns*** and other barriers hampering implementation. Housing corporation BOEX is very experienced in citizen engagement methods. Lessons learnt in pilots in the Utrecht and other Dutch cities will be applied: intrinsic motivation seems to be strongly related to personal interests (low and predictable bills and increased quality of life) and fun (infotainment), while ease of use, a sense of ownership and trust in the system and its providers are crucial preconditions.

Citizen engagement activities will include:

- ***Community building*** by means of ***change agents***, outdoor community building events and social media campaigns
- ***Campaign District school involvement*** to involve children and parents (through primary schools Kaleidoscoop and Schatkamer) and to provide ***training*** and ***possibly jobs*** to youngsters living in the district, while installing and maintaining the integrated smart solutions in the demo district (through professional school MBO Utrecht)
- ***Evaluation*** and ***co-creation*** using the Local Innovation Hub of the feedback given by the ***home EMS TOON*** in homes, to what extent is the interface motivating, easy to use, trusted, offering fun and lower energy bills. Citizen co-creation to develop a personal interface of HEMS and/or apps, suiting their specific needs (e.g. language, complexity).
- ***Campaign*** using ***Smart lamp posts*** for dynamic street lighting, powered by local renewable power, making a visible connection between renewables and improved quality of the living environment, safety and wellbeing.
- ***New Home & District Experience***, demonstrating a ***virtual reality platform***, extending the existing Oculus Rift VR experience for BOEX apartment buildings so households can experience their future 'new' home and district, including infotainment and interactive training about the new smart energy and mobility services they may expect.

Targets:

(i) Citizen engagement is a conditional factor for reaching the energy savings of the renovations and of the e-car sharing system. In that sense, the energy saving of citizen engagement is 4.6 million kWh/year or 1.300 tonnes CO_2 reduction/year for the buildings. Plus 308 tonnes CO_2 reduction/year for the e-cars.

(ii) Actively engaging 200 out of 644 households through the measures mentioned above.

9.1.14. Community building

KPI	Unit	Definition	Source	Target
Increased environmental awareness	Likert scale	The extent to which the project has used opportunities for increasing environmental awareness and educating about sustainability and the environment	CITYkeys (IRIS)	(i)
People reached	# people	Percentage of people in the target group that have been reached and/or are activated by the project	CITYkeys (IRIS)	(ii)
Local community involvement in planning/ implementation phase	Likert/ # change agents/ #events	The extent to which residents/users have been involved in the planning process (satisfaction of the involvement)	CITYkeys/ Eurbanlab; Green Digital Charter (IRIS, workshop)	
Increased consciousness of Citizenship (social cohesion)	Likert	The extent to which the project has contributed to the individual being involved in the life of the community	CITYkeys/ITU (workshop)	

9.1.15. Campaign District school involvement

KPI	Unit	Definition	Source	Target
People reached	# of students	People in the target group that have been reached and/or are activated by the project	CITYkeys (IRIS)	(ii)
Local community involvement in planning/ implementation phase	Likert/ # of school activities	The extent to which residents/users have been involved in the planning process (satisfaction of the involvement)	CITYkeys/ Eurbanlab; Green Digital Charter (IRIS, workshop)	

9.1.16. Evaluation and co-creation

KPI	Unit	Definition	Source	Target
Ease of use for end users of the solution	Likert	The extent to which the solution is perceived as difficult to understand and use for potential end users. (Satisfaction of tenants)	CITYkeys/ Eurbanlab (workshop)	
Advantages for end users	Likert / # lowered energy bills	The extent to which the project offers clear advantages for end users	CITYkeys/ Eurbanlab (IRIS)	
Local community involvement in implementation phase	Likert/	The extent to which residents/users have been involved in the implementation process	CITYkeys (IRIS)	
Increased environmental awareness	Likert	The extent to which the project has used opportunities for increasing environmental awareness and educating about sustainability and the environment	CITYkeys	(i)

9.1.17. Campaign using Smart lamp posts

KPI	Unit	Definition	Source	Target
Increased environmental awareness	Likert	The extent to which the project has used opportunities for increasing environmental awareness and educating about sustainability and the environment	CITYkeys	(i)

9.1.18. New Home & District Experience

KPI	Unit	Definition	Source	Target
Ease of use for end users of the solution	Likert	The extent to which the solution is perceived as difficult to understand and use for potential end users. (Satisfaction of tenants)	CITYkeys/ Eurbanlab	

9.2.Nice

Demonstrating Transition Track #1: Smart renewables and near zero energy district

The demonstration activities of TT#1 on smart renewables and near zero energy district in the lighthouse city of Nice will include a set of energy-efficient solutions and dedicated applications for users to raise awareness and promote behavioural change, integrated and deployed in 2 high-rise positive energy office buildings under construction and 3 high-rise apartment buildings (133 flats built in the sixteen's) refurbished with the objective to bring their energy performance close to nZEB in Nice. More specifically, activities carried out in the LH of Nice will try to demonstrate that energy consumption in new or existing buildings at an urban scale can be significantly reduced by:

- Promoting ***self-consumption of PV electricity*** in new office buildings equipped with battery systems
- Improving ***energy efficiency*** of 2 high-rise apartment buildings (social housing) by:
    - Rolling out a large panel of energy conservation measures (not funded through IRIS project)
    - Installing smart appliances for ***optimization of the heating load*** curve (from heating plant to end-users) in ***refurbished*** apartment buildings
    - Developing and testing ***energy awareness services***, including smart metering to track water and energy consumptions (hot water, cold water, electricity, space heating, internal temperature), data collection through wireless sensors network mesh (concentrators and data transmitters) for tenants (apartment buildings) and users (office buildings) to raise awareness and promote behavioural change
- A ***dedicated commissioning process will be put in place*** to check from the design to the operation that energy efficient technologies have been correctly implemented in refurbished apartment buildings. This process will be associated to a measurement and verification protocol to verify that other actions generate the expected energy savings.

- Developing and testing ***energy awareness services***, including smart metering to track water and energy consumptions (hot water, cold water, electricity, space heating, internal temperature), data collection through wireless sensors network mesh (concentrators and data transmitters) for tenants (apartment buildings) and users (office buildings) to raise awareness and promote behavioural change
- Installing an ***advanced and energy efficient urban waste heat recovery solution*** from sewage water ensuring primary energy and GHG emission savings (not funded through IRIS project). A dashboard that provides on real-time the energy balance of the district, the instantaneous energy available and the calculation of the optimal configuration will be developed, implemented and tested accordingly.

Targets: Success is measured in terms of (by 2022):

(i) Energy savings: 9.1 million kWh/year and 1.620 tonnes CO_2 reduction/year, and

(ii) Increase renewables: from almost 0 MWp to 4 MWp of installed PV power capacity in the 3 demonstration and replication areas.

(iii) 90 % of new buildings in Nice-Meridia connected to a geothermal district heating & cooling network.

9.2.1. *Promoting self-consumption of PV electricity in new office buildings equipped with battery systems*

KPI	Unit	Definition	Source	Target
Increase in local renewable energy production	% in kWh	Ratio of produced energy from renewable production over a period (e.g. month, year)	CITYkeys	(ii)
Degree of energetic self-supply by RES	%	Ratio of locally produced energy from RES and the energy consumption over a period (e.g. month, year)	SCIS	
Storage capacity installed	kWh	kWh storage capacity installed	IRIS	
Carbon dioxide Emission Reduction	tonnes CO_2/year	Reduction of emissions of carbon dioxide related to measure.	SCIS	
CO_2 reduction cost efficiency	Euro/ton CO_2 saved per year	Costs in euros per ton of CO_2 saved per year	CITYkeys	

9.2.2. *Improving energy efficiency of 3 high-rise apartment buildings*

KPI	Unit	Definition	Source	Target
Energy savings	kWh/m2 year; MWh/year	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.	SCIS	(i)
Reduced energy costs for consumers	Euro/m2	Reduction in cost for energy consumption on an aggregated level, based on energy savings and current energy prices.	IRIS	
Carbon dioxide Emission Reduction	tonnes CO_2/year	Reduction of emissions of carbon dioxide related to measure.	SCIS	(i)
CO_2 reduction cost efficiency	Euro/ton CO_2 saved per year	Costs in euros per ton of CO_2 saved per year	CITYkeys	

9.2.3. *Installing smart appliances for optimization of the heating load curve*

KPI	Unit	Definition	Source	Target
Energy savings	MWh/year	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.	SCIS	(i)
Peak load reduction	%	Reduction in maximum peak load of a building or a group of buildings.	SCIS	
Carbon dioxide Emission Reduction	tonnes CO_2/year	Reduction of emissions of carbon dioxide related to measure.	SCIS	(i)

CO_2 reduction cost efficiency	Euro/ton CO_2 saved per year	Costs in euros per ton of CO_2 saved per year	CITYkeys

9.2.4. Developing and testing energy awareness services

KPI	Unit	Definition	Source	Target
Energy savings	kWh/m2 year; MWh/year	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.	SCIS	(i)
Carbon dioxide Emission Reduction	tonnes CO_2/year	Reduction of emissions of carbon dioxide related to measure.	SCIS	(i)
Reduced energy costs for consumers	Euro/m2	Reduction in cost for energy consumption on an aggregated level, based on energy savings and current energy prices.	IRIS	
Increased awareness of energy usage	Likert	The extent to which the project has used opportunities for increasing awareness of energy use	IRIS	
CO_2 reduction cost efficiency	Euro/ton CO_2 saved per year	Costs in euros per ton of CO_2 saved per year	CITYkeys	

9.2.5. Installing an advanced and energy efficient urban waste heat recovery solution

KPI	Unit	Definition	Source	Target
Energy savings	MWh/year	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.	SCIS	(i)
Carbon dioxide Emission Reduction	tonnes CO_2 /year	Reduction of emissions of carbon dioxide related to measure.	SCIS	(i)
CO_2 reduction cost efficiency	Euro/ton CO_2 saved per year	Costs in euros per ton of CO_2 saved per year	CITYkeys	
Primary Energy Demand and Consumption	MWh/year	Primary energy use before and after implementation of the measure	SCIS	

Demonstrating Transition Track #2: Smart energy management and storage for flexibility

Activities carried out on TT#2 in the LH of Nice will try to demonstrate that smart energy management and storage at an urban scale can have a significant impact on reducing peak load and fuel spending, deferring investment in network reinforcement while still meeting carbon targets and reducing the need for a significant increase in reserve generation capacity. More specifically, the following activities will be supported by the IRIS project:

- Rolling out of around 403 000 smart meters (together with the supporting infrastructure) by the end of 2020 over the Metropolis of Nice Cote d'Azur (not funded through IRIS project).
- In case of bankable business model, development and test of a ***LEM*** on two areas: Grand Arenas and Nice Meridia. This solution will optimize at a district scale **a)** the energy consumption and energy bill reduction, reached through demand side response (to reduce peak demand), **b)** the implementation and management of self-consumption measures at building and district scales, **c)** the injection of PV surplus power into the grid properly remunerated, **d)** the management of EV charging ports, including peak shaving for distribution grids management, **e)** the deployment of a strategy to aggregate flexibilities, up- or downwards, to be valued on energy markets or through DSOs to release grid constraints and **f)** energy storage managements.
- Creation of a ***LT district heating and cooling network*** connected to a ***geothermal*** plant together with a centralized heat pump as backup (not funded through IRIS project).
- Deployment and test of smart DHC optimization algorithms, aggregating DHC connected building consumptions and production forecast, to minimize the production of heat/cold/electricity, by optimally matching production with the actual and forecasted needs.
- Deployment and test in the IMREDD building of ***2nd life batteries*** (associated to PV) as a reliable and cost-effective solution to manage at building scale peak loads and reduce demand charges and at urban scale as a reserve power.

Targets: Success is measured in terms of (by 2022):

(i) Energy savings: 1 million kWh/year and 420 tonnes CO_2 reduction/year, and
(ii) Storage capacity of 2120 kWh in the 2 demonstration and replication areas, and
(iii) V2G battery storage: 41 000 kWh/year.
(iv) Peak shaving: 3,1 MW
(v) CO2 reduction/year: 300 tonnes

9.2.6. Rolling out of around 403 000 smart meters

KPI	Unit	Definition	Source	Target
Energy savings	MWh/year	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.	SCIS	(i)
Carbon dioxide Emission Reduction	tonnes CO_2 /year	Reduction of emissions of carbon dioxide related to measure.	SCIS	(i)
CO_2 reduction cost efficiency	Euro/ton CO_2 saved per year	Costs in euros per ton of CO_2 saved per year	CITYkeys	

9.2.7. Development and test of a LEM on two areas

KPI	Unit	Definition	Source	Target
Energy savings	MWh/year	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.	SCIS	(i)
Peak load reduction	%	Reduction in maximum peak load of a building or a group of buildings.	SCIS	(iv)
Storage capacity installed	kWh	kWh storage capacity installed	IRIS	(ii)
Reduced energy costs for consumers	Euro/m2	Reduction in cost for energy consumption on an aggregated level, based on energy savings and current energy prices.	IRIS	
Increased awareness of energy usage	Likert	The extent to which the project has used opportunities for increasing awareness of energy use	IRIS	
Increased system flexibility for energy players	%	The change in load capacity participating in demand side management before and after the measure.	SCIS	
Degree of energetic self-supply by RES	%	Ratio of locally produced energy from RES and the energy consumption over a period (e.g. month, year)	SCIS	
Reduced energy curtailment of RES and DER	%	Reduction of energy curtailment due to technical and operational problems	SCIS	
Carbon dioxide Emission Reduction	tonnes CO_2 /year	Reduction of emissions of carbon dioxide related to measure.	SCIS	(i), (v)
CO_2 reduction cost efficiency	Euro/ton CO_2 saved per year	Costs in euros per ton of CO_2 saved per year	CITYkeys	

9.2.8. *Creation of a LT district heating and cooling network connected to a geothermal plant*

KPI	Unit	Definition	Source	Target
Energy savings	MWh/year	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.	SCIS	(i)
Degree of energetic self-supply by RES	%	Ratio of locally produced energy from RES and the energy consumption over a period (e.g. month, year)	SCIS	
Carbon dioxide Emission Reduction	tonnes CO_2 /year	Reduction of emissions of carbon dioxide related to measure.	SCIS	
CO_2 reduction cost efficiency	Euro/ton CO_2 saved per year	Costs in euros per ton of CO_2 saved per year	CITYkeys	

9.2.9. *Deployment and test of smart DHC optimization algorithms*

KPI	Unit	Definition	Source	Target
Energy savings	MWh/year	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.	SCIS	(i)
Peak load reduction	%	Reduction in maximum peak load of a building or a group of buildings.	SCIS	
Carbon dioxide Emission Reduction	tonnes CO_2 /year	Reduction of emissions of carbon dioxide related to measure.	SCIS	(i)
CO_2 reduction cost efficiency	Euro/ton CO_2 saved per year	Costs in euros per ton of CO_2 saved per year	CITYkeys	

9.2.10. *Deployment and test in the IMREDD building of 2nd life batteries*

KPI	Unit	Definition	Source	Target
Storage capacity installed	kWh	kWh storage capacity installed	IRIS	(ii)
Peak load reduction	%	Reduction in maximum peak load of a building or a group of buildings.	SCIS	(iv)
Battery degradation rate	%	Capacity losses of the batteries used in the project after use for a certain number of cycles or a specific time period.	InteGRIDy	
CO_2 reduction cost efficiency	Euro/ton CO_2 saved per year	Costs in euros per ton of CO_2 saved per year (input data may be difficult to obtain)	CITYkeys	(v)

Demonstrating Transition Track #3: smart e-mobility

Activities carried out on TT#3 on ***smart e-mobility*** will try to demonstrate that electric mobility could be boosted by the implementation of a second generation of EV car sharing system: the Free Floating project. To summarize this project: a simplified access to car anywhere anytime in such a way that the car rotation is five to ten times more than the former model (like actual AUTOBLEUE). This leads to a sustainable service having a real impact on the modal shift from private to public transport. The following activities will prepare the transition from AUTOBLEUE, launched in 2011, to Free Floating project:

- Developing and testing tools for positioning and operate rapid charge to optimize fleet rotation.
- Developing and testing tools for public/professional car sharing efficient mixt (mixing service like AUTOBLEUE & city Car Pool, working days and week end for example).
- Installing and testing a new SW module of supervision and business intelligence centre, on the operating mode.
- Applying business model for data collection such as air & noise.
- Developing a dynamic charge plan and car/charger interface.

Targets: Success is measured in terms of (by 2022):

(i) Number of EV: 2000,
(ii) Number of EV charging stations: 1000,
(iii) Number of Free Floating subscribers (resident, workers and long stay tourists): 100.000.
(iv) 1,829 ton CO_2 reduction/year
(v) NO_2 reduction/year: 7 %
(vi) PM10 reduction/year: 6%
(vii) PM2,5 reduction/year: 6%
(viii) 15 300 000 km yearly travelled with V2G cars
(ix) Peak shaving: 3,1 MW
(x) CO2 reduction/year: 300 tonnes

9.2.11. The free floating project

KPI	Unit	Definition	Source	Target
Improved access to vehicle sharing solutions	Likert scale through observations/interviews	Improved accessibility to vehicle sharing solutions	CITYkeys	
Access to vehicle sharing solutions for city travel	Number of vehicles/100 000 inhabitants	Number of vehicles per 100 000 inhabitants	CITYkeys	
Number of e-charging stations deployed in the area	#	Number of e-charging stations deployed in the defined area before and after implementation	SCIS	(ii)
Yearly km driven in e-car sharing system	Km/year	Yearly km driven through the e-car sharing system instead of private conventional cars	IRIS	
Number of efficient vehicles deployed in the area	Vehicles/km2	Number of efficient vehicles per square kilometre	SCIS	(i)
Number of Free Floating subscribers	# of subscribers	Number of subscribers in the free floating system	IRIS	(iii)
Ease of use for end users of the solution	Likert/app rating	The extent to which the solution is perceived as difficult to understand and use for potential end users	CITYkeys	
CO_2 reduction cost efficiency	Euro/ton CO_2 saved per year	Costs in euros per ton of CO_2 saved per year (input data may be difficult to obtain)	CITYkeys	

Demonstrating Transition Track #4: City Innovation Platform (CIP) and information services

Since 2011, Nice metropolis has been developing a ***digital data infrastructure*** as the backbone of the City Innovation platform to collect, aggregate and share all data generated on its territory by the activities of the local authority departments. The activities carried out by the TT #4 to build the CIP are:

- Build a ***Data Hub architecture*** to register and manage all connected sensors deployed on the territory (IoT) and to collect urban data produced by these sensors to fuel the existing mutualized city data warehouse;
- Architecture definition and Implementation of a generic programming interface based on standards (such as CitySDK) allowing external accesses to shared data and full interoperability with external databases implementing similar standard based programming interface and communication protocols;
- Architecture definition and implementation of a services oriented layer on top of the data Hub based on standards (such as FIWARE) to enable the development of value services by the city departments and by 3rd parties for both city operation purposes or commercial applications;
- Implements the IT resources in the platform to support big data processing based on local data analytics tools or cloud based tools in a SaaS mode;
- Develop a data management system to operate a city smart lab (called in Nice Smart City Innovation Centre) to enable the use of city data by academic research or industry;

The use of industry and European standards to design the open architecture model of the CIP will be instrumental to replicate the CIP model in any cities and to offer the required scaling flexibility.

Targets (by 2022):

(i) Implementation of standards such as FIWARE and CitySDK when relevant in the CIP model
(ii) Number of connected urban objects: >100.000
(iii) Support of mobile connected objects: connectivity with city fleet vehicles and city public transportation (tramways)
(iv) Development of applications using data retrieved simultaneously from the three CIPs of the LH cities Nice, Utrecht and Gothenburg.
(v) Apps developed & launched: 5

9.2.12. City Innovation Platform (CIP) and information services

KPI	Unit	Definition	Source	Target
Number of connected urban objects	Number of objects	Number of connected urban objects in the CIP	IRIS	(ii)
Developer engagement	Number of API calls per month	Use of open datasets by developers	IRIS (WP1)	
Data safety	Attempts per month/ year	Number of blocked malicious hacking attempts	IRIS (WP1)	
Data loss prevention	Number of lost datapoints in a timeframe.	Lost datapoints in a period.	IRIS (WP1)	
Usage of open source software	Likert	How easy is it to connect systems	IRIS (WP1)	
Expiration date of open data	% of obsolete data on city data platform	Number of outdated datasets on a city platform per week	IRIS (WP1)	
Quality of open data	Number of standardized datasets	% of data that uses DCAT standards	IRIS (WP1)	
Platform downtime	Minutes of downtime per (hour/day/ week/month)	Downtime per day	IRIS (WP1)	
Open data-based solutions	New solutions per quarter	Number of services based on open data	IRIS (WP1)	(v)
User engagement	Number of users	Number of users involved	IRIS	

Demonstrating Transition Track #5: Citizen engagement and motivating feedback

Activities carried out on TT#5 in the LH of Nice will demonstrate a set of user-centred design methods and activities for citizen engagement into energy efficiency and smarter cities solutions. Citizen engagement activities will include:

- Evaluation of the conditions leading households to change their behaviour in response to requests and notifications from energy providers (CITYOPT/ EnergyABC app) – this activity will highlight how a community approach, serious gaming and crowdfunding mechanisms can enhance citizen engagement and participation.
- Demonstration of the Civocracy online platform currently being implemented by Nice in the context of a collaboration agreement with the Civocracy start-up based in Amsterdam through Nice Metropolis. The IRIS demonstration will aim at connecting other cities in Europe using the same tool and launching joint discussions to exchange on best practices and exchange on common issues.
- Evaluation of energy feedback and awareness solutions in social housing (CUSA solution)

Targets:

(i) Feedback mechanism for households motivating them to save energy with 10%, to shift 10% of their energy consumption to off-peak periods.
(ii) Active engagement of 500+ households in the above-mentioned demonstration activities.

In addition to this, Nice will act as receiver for the following solutions demonstrated by Utrecht and Gothenburg: Citizen's engagement through Living Labs

9.2.13. *SERVICE BLEU (app for citizens to interact with the municipality by reporting small incidents)*

KPI	Unit	Definition	Source	Target
People reached	# of people	People in the target group that have been reached and/or are activated by the project	CITYkeys (IRIS)	(ii)
Ease of use for end users of the solution	Likert	The extent to which the solution is perceived as difficult to understand and use for potential end users. (Satisfaction of tenants)	CITYkeys/ Eurbanlab (workshop)	(i)
Local community involvement in implementation phase	# of co-creation sessions	The extent to which residents/users have been involved in the implementation process	CITYkeys (IRIS)	(i)

9.2.14. *Smart Management of Peak Pollution*

KPI	Unit	Definition	Source	Target
Increased environmental awareness	Likert	The extent to which the project has used opportunities for increasing environmental awareness and educating about sustainability and the environment	CITYkeys (IRIS)	(i)
People reached	# of people	People in the target group that have been reached and/or are activated by the project	CITYkeys (IRIS)	(ii)
Ease of use for end users of the solution	Likert	The extent to which the solution is perceived as difficult to understand and use for potential end users. (Satisfaction of tenants)	CITYkeys/ Eurbanlab (workshop)	(i)

9.2.15. *CIVOCRACY*

KPI	Unit	Definition	Source	Target
People reached	# of people	People in the target group that have been reached and/or are activated by the project	CITYkeys (IRIS)	(ii)
Ease of use for end users of the solution	Likert	The extent to which the solution is perceived as difficult to understand and use for potential end users. (Satisfaction of tenants)	CITYkeys/ Eurbanlab (workshop)	(i)
Local community involvement in planning phase	# of ideas being used by the city	The extent to which residents/users have been involved in the planning process (use of the involvement)	CITYkeys/ Eurbanlab; Green Digital Charter (workshop)	

9.3. Gothenburg

Demonstrating Transition track #1 Smart renewables and closed-loop energy positive districts

Gothenburg will demonstrate a positive energy sub-district consisting of 6 buildings (132 apartments). These buildings will be connected to a further 55 buildings on the Chalmers campus for trading surplus heating and cooling solar PV, Planned activities include:

1. Demonstration of at least 200 kWh electricity storage in 2nd life automotive (bus) batteries powered by 140kW local PV
2. Demonstration of heating from geo energy with heat pumps (2-300 m deep boreholes),
3. Demonstration of cooling from geo energy without chillers.
4. Demonstration of local energy storages consisting of water buffer tanks, structural (thermal inertia of the building) storage and long-term storage in boreholes
5. Demonstration of seasonal energy trading (cooling in summer season) with adjacent office block
6. Development and demonstration of advanced Energy Management System to integrate PV, DH, grid and all abovementioned storage options to achieve peak shaving and minimal environmental impact
7. Demonstration of how Building Integrated Photovoltaics (BIPV) can be used in façade renovation process

Targets:

(i) Sub-district energy consumption (target: <24 kWh/m2/a),
(ii) Peak power shaving (target: >80% reduction in peak power compared to control)
(iii) Net energy surplus on annual basis (target: >10 MWh/a)
(iv) Energy savings: 67 kWh/m2/y, or totally 1,5 GWh/y energy saving compared to average Swedish buildings
(v) Integrated PV power (420 kW)

9.3.1. At least 200 kWh electricity storage in 2nd life automotive (bus) batteries powered by 140kW local PV

KPI	Unit	Definition	Source	Target
Storage capacity installed	kWh	kWh storage capacity installed	IRIS	200 kWh
Peak load reduction	%	Reduction in maximum peak load of a building or a group of buildings.	SCIS	(ii)
Battery degradation rate	%	Capacity losses of the batteries used in the project after use for a certain number of cycles or a specific time period.	InteGRIDy	
Carbon dioxide Emission Reduction	tonnes CO_2 /year	Reduction of emissions of carbon dioxide related to measure.	SCIS	
CO_2 reduction cost efficiency	Euro/ton CO_2 saved per year	Costs in euros per ton of CO_2 saved per year	CITYkeys	

9.3.2. Heating from geo energy with heat pumps (2-300 m deep boreholes)

KPI	Unit	Definition	Source	Target
Degree of energetic self-supply by RES	%	Ratio of locally produced energy from RES and the energy consumption over a period (e.g. month, year)	SCIS	(iii)
Carbon dioxide Emission Reduction	tonnes CO_2 /year	Reduction of emissions of carbon dioxide related to measure.	SCIS	
CO_2 reduction cost efficiency	Euro/ton CO_2 saved per year	Costs in euros per ton of CO_2 saved per year	CITYkeys	

9.3.3. Cooling from geo energy without chillers

KPI	Unit	Definition	Source	Target
Degree of energetic self-supply by RES	%	Ratio of locally produced energy from RES and the energy consumption over a period (e.g. month, year)	SCIS	(iii)
Carbon dioxide Emission Reduction	tonnes CO_2 /year	Reduction of emissions of carbon dioxide related to measure.	SCIS	
CO_2 reduction cost efficiency	Euro/ton CO_2 saved per year	Costs in euros per ton of CO_2 saved per year	CITYkeys	

9.3.4. Local energy storages

KPI	Unit	Definition	Source	Target

Storage capacity installed	kWh	kWh storage capacity installed	IRIS	(iii)
Peak load reduction	%	Reduction in maximum peak load of a building or a group of buildings.	SCIS	
CO_2 reduction cost efficiency	Euro/ton CO_2 saved per year	Costs in euros per ton of CO_2 saved per year	CITYkeys	

9.3.5. Seasonal energy trading (cooling in summer season) with adjacent office block

KPI	Unit	Definition	Source	Target
Peak load reduction	%	Reduction in maximum peak load of a building or a group of buildings.	SCIS	(ii)
Reduced energy cost for consumers	Euro/m2	Reduction in cost for energy consumption on an aggregated level, based on energy savings and current energy prices.	IRIS	
Carbon dioxide Emission Reduction	tonnes CO_2 /year	Reduction of emissions of carbon dioxide related to measure.	SCIS	
CO_2 reduction cost efficiency	Euro/ton CO_2 saved per year	Costs in euros per ton of CO_2 saved per year	CITYkeys	

9.3.6. Energy Management System to integrate PV, DH, grid and storage

KPI	Unit	Definition	Source	Target
Energy savings	MWh/year	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.	SCIS	(iv)
Peak load reduction	%	Reduction in maximum peak load of a building or a group of buildings.	SCIS	(ii)
Increased system flexibility for energy players	%	The change in load capacity participating in demand side management before and after the measure.	SCIS	
Degree of energetic self-supply by RES	%	Ratio of locally produced energy from RES and the energy consumption over a period (e.g. month, year)	SCIS	(iii)
Carbon dioxide Emission Reduction	tonnes CO_2 /year	Reduction of emissions of carbon dioxide related to measure.	SCIS	
CO_2 reduction cost efficiency	Euro/ton CO_2 saved per year	Costs in euros per ton of CO_2 saved per year	CITYkeys	

9.3.7. Demonstration of how Building Integrated Photovoltaics (BIPV) can be used in roof and façade renovation process

KPI	Unit	Definition	Source	Target
Increase in local renewable energy production	% in kWh	Ratio of produced energy from renewable production over a period (e.g. month, year)	CITYkeys	(iii), (v)
Degree of energetic self-supply by RES	%	Ratio of locally produced energy from RES and the energy consumption over a period (e.g. month, year)	SCIS	
Carbon dioxide Emission Reduction	tonnes CO_2 /year	Reduction of emissions of carbon dioxide related to measure.	SCIS	
CO_2 reduction cost efficiency	Euro/ton CO_2 saved per year	Costs in euros per ton of CO_2 saved per year	CITYkeys	

Demonstrating Transition Track #2: Smart energy management and storage for flexibility

In this task, Gothenburg will demonstrate:

1. A 350 V DC building microgrid utilizing 140 kW rooftop PV installations and 200 kWh battery storage. The demonstration will include (i) PV and battery integration with energy management system, (ii) DC installations in building (e.g. LED lighting, pumps, fans and actuators), (iii) Regulatory and legislator aspects of DC installations in buildings
2. A low temperature DH 45/30 system for six buildings in Riksbyggen sub-district. Including a shallow geo energy solution where the boreholes also are used as long-time thermal storage and to cool nearby office buildings in summertime.
3. A 1 700 kWh PCM (Phase Change Material) pilot facility inside the JSP2-building in order to test different ways of storing energy for cooling purposes to reduce peak cooling power requirement
4. Integration and evaluation of a 200kWh energy storage with 10-14 2nd life Li-Ion batteries from electrical buses during 5-year operation in the Riksbyggen sub-district with 132 apartments that will be finalized in 2018. The batteries will store energy from solar PVs, balancing in that way the load of the building, including the charging of an electric vehicle pool, and providing energy to the grid

In addition to this, GOT will act as receiver for the following solutions demonstrated by UTR and NICE: Smart solar V2G EV charging and Wireless inductive charging.

Targets:

(i) Electric storage capacity (target: 400 kWh),
(ii) Cooling PCM storage capacity (target: 1 700 kWh),
(iii) Peak power shaving from DC/PV/PCM installation (target >80 % peak power reduction).
(iv) 105 MWh geothermal storage
(v) 88 kWh V2G battery storage

9.3.8. A 350 V DC building microgrid utilizing 140 kW rooftop PV installations and 200 kWh battery storage

KPI	Unit	Definition	Source	Target
Increase in local renewable energy production	% in kWh	Ratio of produced energy from renewable production over a period (e.g. month, year)	CITYkeys	
Degree of energetic self-supply by RES	%	Ratio of locally produced energy from RES and the energy consumption over a period (e.g. month, year)	SCIS	
Storage capacity installed	kWh	kWh storage capacity installed	IRIS	(i)
Peak load reduction	%	Reduction in maximum peak load of a building or a group of buildings.	SCIS	(iii)
Carbon dioxide Emission Reduction	tonnes CO_2 /year	Reduction of emissions of carbon dioxide related to measure.	SCIS	
CO_2 reduction cost efficiency	Euro/ton CO_2 saved per year	Costs in euros per ton of CO_2 saved per year	CITYkeys	

9.3.9. A low temperature DH 45/30 system for six buildings in Riksbyggen sub-district

KPI	Unit	Definition	Source	Target
Energy savings	MWh/year	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.	SCIS	
Storage capacity installed	kWh	kWh storage capacity installed	IRIS	(iv)
Degree of energetic self-supply by RES	%	Ratio of locally produced energy from RES and the energy consumption over a period (e.g. month, year)	SCIS	
Carbon dioxide Emission Reduction	tonnes CO_2 /year	Reduction of emissions of carbon dioxide related to measure.	SCIS	
CO_2 reduction cost efficiency	Euro/ton CO_2 saved per year	Costs in euros per ton of CO_2 saved per year	CITYkeys	

9.3.10. A 1700 kWh PCM (Phase Change Material) pilot facility

KPI	Unit	Definition	Source	Target
Storage capacity installed	kWh	kWh storage capacity installed	IRIS	(ii)

Peak load reduction	%	Reduction in maximum peak load of a building or a group of buildings.	SCIS	(iii)
Carbon dioxide Emission Reduction	tonnes CO_2 /year	Reduction of emissions of carbon dioxide related to measure.	SCIS	
CO_2 reduction cost efficiency	Euro/ton CO_2 saved per year	Costs in euros per ton of CO_2 saved per year	CITYkeys	

9.3.11. Integration and evaluation of a 200kWh energy storage with 10-14 2nd life Li-Ion batteries

KPI	Unit	Definition	Source	Target
Storage capacity installed	kWh	kWh storage capacity installed	IRIS	(i)
Peak load reduction	%	Reduction in maximum peak load of a building or a group of buildings.	SCIS	
Carbon dioxide Emission Reduction	tonnes CO_2 /year	Reduction of emissions of carbon dioxide related to measure.	SCIS	
CO_2 reduction cost efficiency	Euro/ton CO_2 saved per year	Costs in euros per ton of CO_2 saved per year	CITYkeys	
Battery degradation rate	%	Capacity losses of the batteries used in the project after use for a certain number of cycles or a specific time period.		

Demonstrating Transition Track #3: smart e-mobility

One example is Riksbyggen's BRF Viva in Johanneberg, where the city has allowed the construction of a property of 132 apartments with no regular parking included. In this project, these two developments are brought together as the new MaaS concept EC2B is implemented in the district of Johanneberg.

EC2B is a new mobility concept that offers customers an attractive alternative to owning their own car, allowing easy a variety of transport modes (e-cars, e-bikes, public transport etc) in connection to where customers live and make their everyday choices for transport. A variety of electric vehicles and public transport suppliers already active in the district will provide the transportation services. The service will be augmented by an ICT system that will offer the users a seamless transport experience and also includes the possibility to create a sharing community among users. Furthermore, EC2B draws upon recent research about how users can be "nudged" towards more sustainable travel habits through receiving personalised information about their travel. EC2B will reduce car ownership and hence demand for parking space, which creates value for property developers as building parking lots and underground garages is very expensive. This also means space is released that can be used for other purposes, creating a more liveable city. In district Johanneberg, the EC2B e-mobility service will be implemented at two different levels.

a) In Riksbyggen's BRF Viva, tenants in the 132 apartments will get direct access to EC2B through accommodation, with specific measures implemented in connection to the building. They will have exclusive access to 4 electric cars (Renault), 2 light e-vehicles (Renault Twizy or similar), 4 electric cargo bikes and 5 electric bikes, as well as charging infrastructure for all types of electric vehicles (55 recharging polls for e-bikes, 4 for e-cars and 2 for light e-vehicles).

b) The other 15 000 residents/employees in the district (e.g. tenants to HSB and Akademiska Hus) will get access to a light version of EC2B, which includes information, community and access to e-mobility vehicles at several locations around the district but does not include specific measures in connection to each building.

Targets:

(i) Direct CO_2 reduction: 1040 tonnes in 5 years;
(ii) Car mileage among tenants and employees in the district reduced by 1 360 500 km/year
(iii) Yearly, 904 000 km are made through EC2B (car-sharing, public transport etc) instead of with private, conventional cars.
(iv) 5000 MWh/a saved in reduced car driving and shift to e-car

9.3.12. EC2B

KPI	Unit	Definition	Source	Target
Improved access to vehicle sharing solutions	Likert scale through observations/ interviews	Improved accessibility to vehicle sharing solutions	CITYkeys	
Yearly km driven in e-car sharing system	Km/year	Yearly km driven through the e-car sharing system instead of private conventional cars	IRIS	(iii)
Reduction in driven km by tenants and employees in the district	Km/year	Km driven by employees and tenants in the district before and after implementation of the measure	IRIS	(ii)
Ease of use for end users of the solution	Likert/app rating	The extent to which the solution is perceived as difficult to understand and use for potential end users	CITYkeys	
Carbon dioxide Emission Reduction	tonnes CO_2/year	Reduction of emissions of carbon dioxide related to measure.	SCIS	(i)
Reduction in car ownership among tenants	Number of cars per apartment among tenants in Brf Viva	Number of care ownership among tenants before and after moving in to the demonstration area.	IRIS	
Energy savings	MWh/year	The reduction of the energy consumption to reach the same services after the interventions, taking into consideration the energy consumption from the reference period.	SCIS	(iv)

Demonstrating Transition Track #4: City Innovation Platform

Gothenburg will demonstrate the following solutions.

1. Implementation of a CIM (City Information Model) pilot that facilitates city management and planning by including building information, infrastructure, geodata and planning data in the Johanneberg district. In a digital model of the city, decisions, documents and plans can be connected to geographic locations, and forecasts, taking benefit of the visualization and planning application innovations provided by combining GIS (Geographical Information Systems) data with BIM (Building Information Model) data and 3D data in a way that captures both existing and planned structures to support the Urban area with analyses and maps. An innovation challenge will be held to stimulate the development of new applications making use of the CIM data.
2. Development and implementation an "Energy Cloud" on the Chalmers Campus. Near real-time data from energy (electricity, heat, water) consumption will be collected, integrated and made available for further analysis, thereby opening up for new applications to optimise energy supply and management on campus. For instance, setting maximum power limits dynamically adapting to varying consumption, predicting energy use automatically, analysing energy mix and calculating resulting CO_2 footprint and more. Additionally, a connection with Gothenburg City's open data is foreseen to further enhance the scope and usefulness of potential applications. An innovation contest will be held to stimulate the development of new application making use of the Energy Cloud.

This task is closely linked to the work carried out in WP4 and will make use of those common features and structures that are developed within that work package. Targets:

(i) > 10 applications developed and launched by 3rd parties: new applications using the CIM (target: >5) and Energy Cloud (target: >5), respectively.
(ii) Peak shaving for the Chalmers Campus Area (target >80 % peak power reduction).
(iii) Green ICT - >50 % RE powers all ICT

9.3.13. City Information Model (CIM)

KPI	Unit	Definition	Source	Target
Share of RES in ICT power supply	%	Share of RES in power supply to ICT solutions	IRIS	(iii)
Developer engagement	Number of API calls per month	Use of open datasets by developers	IRIS (WP1)	
Data safety	Attempts per month/ year	Number of blocked malicious hacking attempts	IRIS (WP1)	
Data loss prevention	Number of lost datapoints in a timeframe.	Lost datapoints in a period.	IRIS (WP1)	
Usage of open source software	Likert	How easy is it to connect systems	IRIS (WP1)	
Expiration date of open data	% of obsolete data on city data platform	Number of outdated datasets on a city platform per week	IRIS (WP1)	
Quality of open data	Number of standardized datasets	% of data that uses DCAT standards	IRIS (WP1)	
Platform downtime	Minutes of downtime per (hour/day/ week/month)	Downtime per day	IRIS (WP1)	
Open data-based solutions	New solutions per quarter	Number of services based on open data	IRIS (WP1)	(i)
User engagement	Number of users	Number of users involved	IRIS	

9.3.14. Energy Cloud

KPI	Unit	Definition	Source	Target
Open data-based solutions	New solutions per quarter	Number of services based on open data	IRIS (WP1)	(i)
Peak load reduction	%	Reduction in maximum peak load of a building or a group of buildings	SCIS	(ii)
Share of RES in ICT power supply	%	Share of RES in power supply to ICT solutions	IRIS	(iii)
Carbon dioxide Emission Reduction	tonnes CO_2/year	Reduction of emissions of carbon dioxide related to measure.	SCIS	
CO2 reduction cost efficiency	Euro/ton CO_2 saved per year	Costs in euros per ton of CO_2 saved per year	CITYkeys	

Demonstrating Transition track #5: Citizen engagement and motivating feedback

In Gothenburg, four solutions will be demonstrated that engage and involve citizens from different parts of society as participants and co-creators, thereby creating a strong momentum for innovation and ultimately, impact:

- **Spatial planning design contest** for children and youths based on a Minecraft® model of Gothenburg;
- **Citizen engagement** in the city of Gothenburg: a) Further develop the city's online citizen sourcing platform "Min Stad" (My City) b) Release more available data (smart city hub) c) Investigate and evaluate how to increase citizen interaction and engagement based on models of co-creation and collaborative innovation d) Invite and collect innovative ideas from citizens from an "Inclusive Life Competition"
- Demonstrate a BIM (Building Information Modelling) based **3D Virtual Reality Environment** that will virtually immerse users in the inner workings and properties of a building, providing deeper understanding and involvement in the building's processes. This demonstrator will be housed in the HSB Living Lab, where the innovative environment and extensive sensor network will provide relevant inputs to the demonstrator.
- Demonstrate the **Personal Energy Threshold** (PET), to motivate actively engaged users to change their energy consumption behaviour. This tool will integrate real-time data on energy production and consumption (availability and demand), and thus enable end-users in their homes to actively contribute to peak shaving in smart energy networks by providing them with alternatives on how to modulate their energy needs, matching the currently available energy mix from the grid, local PV, local energy storages, etc.

Targets:

(i) Number of participants in spatial planning contest (target: >100),
(ii) Inflow of ideas for "Green Life" contest (target: 200),
(iii) Infrastructure added to "Min Stad" (>25 % of existing infrastructure in the district).

9.3.15. *Spatial planning design contest for children and youths*

KPI	Unit	Definition	Source	Target
Participatory governance	# of participants in contest	Number of participating in online platform contest	CITYkeys (workshop)	
Local community involvement in planning phase	Likert scale by interviews, survey or observation	The extent to which residents/users have been involved in the planning process (satisfaction of the involvement in the competition)	CITYkeys/ Eurbanlab; Green Digital Charter (IRIS, workshop)	

9.3.16. *Citizen engagement in the city of Gothenburg*

KPI	Unit	Definition	Source	Target
Participatory governance	# of participants and/or ideas (yearly)	People participating in online platform (Min stad)	CITYkeys (workshop)	
Local community involvement in planning phase	# of workshops with citizens / Likert (survey/ interviews)	The extent to which residents/users have been involved in the planning process (Workshops and satisfaction of involvement)	CITYkeys/ Eurbanlab; Green Digital Charter (workshop)	
Accessibility of open data	Y/N Likert scale	Make open data accessible Satisfaction of the open data	CITYkeys (IRIS)	
Trialability	Likert (interview/ survey)	The extent to which the solution can be experimented with on a limited basis in the local context before full implementation (satisfaction of competition/challenge)	CITYkeys/Eurbanlab (IRIS)	

9.3.17. *BIM (Building Information Modelling)*

KPI	Unit	Definition	Source	Target
Increased environmental awareness	Likert	The extent to which the project has used opportunities for increasing environmental awareness and educating about sustainability and the environment	CITYkeys	

9.3.18. Personal Energy Threshold (PET)

KPI	Unit	Definition	Source	Target
Increased environmental awareness	Likert scale	The extent to which the project has used opportunities for increasing environmental awareness and educating about sustainability and the environment	CITYkeys	
Participatory governance	# of users	People participating in online platforms	CITYkeys	
Local community involvement in implementation phase	Likert scale	The extent to which residents/users have been involved in the implementation process and satisfaction of the involvement	CITYkeys	

10. Annex 2 – KPI cards

Annex 2 presented all Key Performance Indicator (KPI) in a detailed table (KPI card) that contains all the requisite information for its calculation. The KPI card provides a brief description of the KPI, a guidance regarding the required data collection and calculation. Moreover, it includes the responsible partner for KPI data collection.

10.1. Accessibility of open data

Accessibility of open data					
KPI Description	Open data, especially open government data, is a tremendous resource that is as yet largely untapped (opendatahandbook.org). In a large number of areas, open city data is already creating value. Examples include participation, self-empowerment, innovation, improved efficiency and effectiveness of government services, etc. While there are numerous instances of the ways in which open data is already creating both social and economic value, we don't yet know what new things will become possible. New combinations of data can create new knowledge and insights, which can lead to whole new fields of application. The ease of use of open data is an important quality because the main aim of opening data is to make it widely available to the public (City Protocol), e.g. to create new applications. Therefore, evaluating the quality of the open data from this perspective is important to promote the ease of use and the openness of city data				
KPI Formula	Total stars of all data/total # data Each dataset has to be rated according to below scheme. All the stars of all the datasets are added up and divided by the total number of datasets. Average stars across all datasets according to the 5 star deployment scheme for Open Data defined by Tim Berners Lee (5stardata.info): 1. Making data online available in whatever format under an open license 2. Making data available as structured data (e.g. Excel instead of image scan of a table) 3.Making data available in a non-proprietary open format (e.g. CSV) 4. Use URIs to denote things, so that people can point at your data 5. Link your data to other data to provide context				
Measurement procedure	1. Data collection 2. KPI calculation				
Unit of Measurement	No unit		**Threshold/ Target**		
Object of assessment	Building		**Stakeholders**	DSO	X
	Set of Buildings			TSP	X
	Energy Supply Unit			End-Users	X
	Set of Energy Supply Units			Governance	X
	Neighbourhood	X		Citizens	
	City	X		Representative Citizen Groups	
				Citizen Ambassadors	
Responsible Partner for KPI Data Collection			GOT		

10.2. Access to vehicle sharing solutions for city travel

Access to vehicle sharing solutions for city travel					
KPI Description	Providing opportunities for sharing vehicles like (e-)bicycles, (e-)cars and (e-) scooters, can decrease the need for and use of private cars, thereby contributing to an accessible, green and healthy neighbourhood. Cycling is a healthy, flexible, cheap and sustainable way to get from a to b over a short distance. Many European cities therefore would like to stimulate cycling, but in countries without a cycling culture there is limited private ownership of bikes. Car-sharing is about not owning a car but renting it from a car-sharing company or sharing the car with friends, family, neighbours or co-workers (1,2). Car-sharing is an attractive option for people who drive less than 10.000 km a year. Car-sharers are more likely to travel by bike, saving on car use and improving their health. Car-sharing also decreases the need for parking space, less vehicles are on the road and less pollution is emitted. Car sharing may furthermore improve social cohesion in the neighbourhood				
KPI Formula	Number of vehicles available for sharing per 100.000 inhabitants				
Measurement procedure	3. Data collection 4. KPI calculation				
Unit of Measurement	%		**Threshold/ Target**		
Object of assessment	Building		**Stakeholders**	DSO	X
	Set of Buildings	X		TSP	X
	Energy Supply Unit			End-Users	X
	Set of Energy Supply Units			Governance	X
	Neighbourhood	X		Citizens	x
	City	X		Representative Citizen Groups	x
				Citizen Ambassadors	x
Responsible Partner for KPI Data Collection			LOM, UTR; VULOG; IRIS;		

10.3. Advantages for end-users

<table>
<tr><th colspan="6">Advantages for end-users</th></tr>
<tr><td>KPI Description</td><td colspan="5">The extent to which the project offers clear advantages for end users. The advantage can take many forms, for instance cost savings, improved quality and increased comfort. It is presumed that solutions which have a higher level of advantages to end users will be more likely to be adopted than solutions which have negative or no advantages.</td></tr>
<tr><td>KPI Formula</td><td colspan="5">Likert Scale

No advantage– 1 — 2 — 3 — 4 — 5 — Very high advantage

1. No advantage: The project does not offer clear advantages for end users. The technologies or principles applied in the project are not at all beneficial to end users.
2. Little advantage: The project offers very little advantage to end users. The vast majority of the technologies/principles offer an indirect and insignificant advantage to end users.
3. Some advantage: The project offers some advantage to end users who to a certain extent experience direct benefits from the technologies/principles applied in the project.
4. High advantage: The project offers a high advantage to end users who benefit mostly from the applied technologies or principles as the applied technologies/principles have a direct and high positive effect on end users.
5. Very high advantage: The project offers a very high advantage to end users as the applied technologies/principles have a direct and an extremely positive effect on end users (e.g. cheaper housing costs, increased comfort, increased quality of the living environment etc.).</td></tr>
<tr><td>Measurement procedure</td><td colspan="5">5. Undertaking of the survey
6. Analysis of the results</td></tr>
<tr><td>Unit of Measurement</td><td colspan="2">No unit</td><td>Threshold/ Target</td><td colspan="2"></td></tr>
<tr><td rowspan="6">Object of assessment</td><td>Building</td><td></td><td rowspan="6">Stakeholders</td><td>DSO</td><td>X</td></tr>
<tr><td>Set of Buildings</td><td></td><td>TSP</td><td>X</td></tr>
<tr><td>Energy Supply Unit</td><td></td><td>End-Users</td><td>X</td></tr>
<tr><td>Set of Energy Supply Units</td><td></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 colspan="2">Responsible Partner for KPI Data Collection</td><td colspan="3">BOEX</td></tr>
</table>

10.4. Battery Degradation Rate

<table>
<tr><th colspan="6">Battery Degradation Rate</th></tr>
<tr><td>KPI Description</td><td colspan="5">The various battery storage systems, including BESS, 2nd life batteries and EVs, are essential for the flexibility of energy grids using increased amounts of electricity deriving by RES. The KPI illustrates the capacity losses of the batteries used in project, through use (some cycles) and through time (some years). The conclusions of this KPI concern the effectiveness of this technology, the need for maintenance and thus, gives useful data concerning the financial feasibility of its integration.</td></tr>
<tr><td>KPI Formula</td><td colspan="5">$$BDR_c = \frac{BC_n - BC_0}{n \cdot BC_0} \cdot 100$$
$$BDR_Y = \frac{BC_Y - BC_0}{Y \cdot BC_0} \cdot 100$$
BDR_C= BDR per cycle
BDR_Y= BDR per year
BC_0= initial battery capacity
BC_n= battery capacity after n cycles
n= number of cycles
Y= number of years</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></td><td rowspan="7">Stakeholders</td><td>DSO</td><td>X</td></tr>
<tr><td>Set of Buildings</td><td></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></td><td>Citizens</td><td></td></tr>
<tr><td>City</td><td></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">EDF, NEXITY, UNS; Rb</td></tr>
</table>

10.5. Carbon dioxide Emission Reduction

<table>
<tr><th colspan="2">Carbon dioxide Emission Reduction</th></tr>
<tr><td>KPI Description</td><td>Greenhouse gases (GHGs) are gases in the atmosphere that absorb infrared radiation that would otherwise escape to space; thereby contributing to rising surface temperatures. There are six major GHGs: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulphur hexafluoride (SF_6) (ISI/DIS 37120, 2013). The warming potential for these gases varies from several years to decades to centuries. CO_2 accounts for a major share of Green House Gas emissions in urban areas. The main sources for CO_2 emissions are combustion processes related to energy generation and transport. CO_2 emissions can therefore be considered a useful indicator to assess the contribution of urban development on climate change.</td></tr>
<tr><td>KPI Formula</td><td>The emitted mass of CO_2 is calculated from the delivered and exported energy for each energy carrier:
$$m_{CO_2} = \sum(E_{del,i}K_{del,i}) - \sum(E_{exp,i}K_{exp,i})$$
$E_{del,i}$ = the delivered energy for energy carrier i
$E_{exp,i}$ = the exported energy for energy carrier i
$K_{del,i}$ = the CO_2 coefficient for delivered energy carrier i
$K_{exp,i}$ = the CO_2 coefficient for exported energy carrier i
The indicator is calculated as the direct (operational) reduction of the CO_2 emissions over a period of time. The result may be expressed as a percentage when divided by the reference CO_2 emissions. To calculate the direct CO_2 emissions, the total energy reduced, can be translated to CO_2 emission figures by using conversion factors for different energy forms as described in below tables:
National and European emission factors for consumed electricity (Countries of IRIS LH and FCs) (source: Covenant of Mayors).
<table>
<tr><th>Country</th><th>Standard emission factor (t CO_2/MWh_e)</th></tr>
<tr><td>Spain</td><td>0.440</td></tr>
<tr><td>Finland</td><td>0.216</td></tr>
<tr><td>France</td><td>0.056</td></tr>
<tr><td>Greece</td><td>1.149</td></tr>
<tr><td>Netherlands</td><td>0.435</td></tr>
<tr><td>Sweden</td><td>0.023</td></tr>
<tr><td>Romania</td><td>0.701</td></tr>
<tr><td><u>EU-27</u></td><td><u>0.460</u></td></tr>
</table>
Standard Emission factors for fuel combustion – most common fuel types (IPCC, 2006)</td></tr>
</table>

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

Measurement procedure	1. Data collection 2. KPI calculation 3. Comparison with national emissions factor				
Unit of Measurement	tones/(year)		**Threshold/ Target**		
Object of assessment	Building	X	**Stakeholders**	DSO	X
	Set of Buildings	X		TSP	X
	Energy Supply Unit	X		End-Users	X
	Set of Energy Supply Units	X		Governance	X
	Neighbourhood	X		Citizens	
	City	X		Representative Citizen Groups	
				Citizen Ambassadors	
Responsible Partner for KPI Data Collection			VULOG; Rb; AH; IRIS; TRIV		

10.6. Carbon monoxide emission reduction

Carbon monoxide emission reduction					
KPI Description	Percentage reduction in carbon monoxide emissions achieved by the measure.				
KPI Formula	The indicator is calculated as the direct (operational) reduction of the CO emissions over a period of time. The result may be expressed as a percentage when divided by the reference CO emissions. To calculate the direct CO emissions, the total energy reduced, can be translated to CO emission figures.				
Measurement procedure	1. Data collection 2. KPI calculation				
Unit of Measurement	Ppm kg		**Threshold/ Target**		
Object of assessment	Building		**Stakeholders**	DSO	X
	Set of Buildings			TSP	X
	Energy Supply Unit			End-Users	X
	Set of Energy Supply Units			Governance	X
	Neighbourhood	X		Citizens	
	City	X		Representative Citizen Groups	
				Citizen Ambassadors	
Responsible Partner for KPI Data Collection			LOM, UTR		

10.7. CO2 reduction cost efficiency

CO2 reduction cost efficiency					
KPI Description	Many smart city projects are intrinsically aimed at reducing the amount of CO2 emitted during their lifetime. Those projects which prove to be able to significantly reduce their carbon footprint, whilst keeping the related costs at a minimum, are considered to be interesting projects for upscaling. Costs in euros per ton of CO2 saved per year.				
KPI Formula	This indicator is calculated on an annual basis, taking the annual reduction in CO2 emissions, and the annual costs of the project (which is the annualised investment plus current expenditures for a year). Note: Only the additional costs for energy/CO2 related measures (to the extent discernible) are taken into account in the total costs calculation.				
Measurement procedure	1. Data Collection 2. KPI Calculation				
Unit of Measurement	$€/((ton\ of\ CO2) \cdot y)$		**Threshold/ Target**		
Object of assessment	Building	X	**Stakeholders**	DSO	X
	Set of Buildings	X		TSP	X
	Energy Supply Unit			End-Users	
	Set of Energy Supply Units			Governance	
	Neighbourhood	X		Citizens	X
	City	X		Representative Citizen Groups	
				Citizen Ambassadors	
Responsible Partner for KPI Data Collection			CSTB, EDF, VULOG, Rb, AH, METRY, IRIS		

10.8. Data loss prevention

Data loss prevention					
KPI Description	Managing data brings a lot of opportunities but also some safety issues. To know if data has been stolen, leaked or otherwise distributed it is important that monitoring is in place. This KPI is intended to give a statement about the ability of CIP to prevent data loss.				
KPI Formula	Lost datapoints in a period.				
Measurement procedure	The CIP will keep detailed usage statistics. Monitoring access to critical files in relation with the malicious attacks, closely monitor if duplicate files are available on the web that originally are exclusively available on internal servers.				
Unit of Measurement	Number of lost datapoints per timeframe.		**Threshold/ Target**		
Object of assessment	Building		**Stakeholders**	DSO	X
	Set of Buildings			TSP	X
	Energy Supply Unit			End-Users	X
	Set of Energy Supply Units			Governance	X
	Neighbourhood			Citizens	
	City	X		Representative Citizen Groups	
				Citizen Ambassadors	
Responsible Partner for KPI Data Collection			CIVITY, NCA, GOT		

10.9. Data safety

Data safety					
KPI Description	The nature of the web environment is hostile. There are a lot of agents trying to exploit vulnerabilities in any software system. From DDoS to someone taking control of the servers, the risks are diverse. This KPI is intended to give a statement about the safety of data in the IRIS applications.				
KPI Formula	Number of blocked malicious hacking attempts				
Measurement procedure	The CIP will keep detailed usage statistics.				
Unit of Measurement	# per unit /months/ years		**Threshold/ Target**		
Object of assessment	Building		**Stakeholders**	DSO	
	Set of Buildings			TSP	X
	Energy Supply Unit			End-Users	X
	Set of Energy Supply Units			Governance	X
	Neighbourhood			Citizens	
	City	X		Representative Citizen Groups	
				Citizen Ambassadors	
Responsible Partner for KPI Data Collection			GOT, CIVITY, NCA		

10.10. Degree of energy self-supply by RES

<table>
<tr><th colspan="6">Degree of energetic self-supply by RES</th></tr>
<tr><td>KPI Description</td><td colspan="5">The degree of energetic self-supply by RES is defined as ratio of locally produced energy from RES and the energy consumption over a period of time (e.g. month, year). DE is separately determined for thermal (heating or cooling) energy and electricity. The quantity of locally produced energy is interpreted as by renewable energy sources (RES) produced energy.</td></tr>
<tr><td>KPI Formula</td><td colspan="5">$$DE_T = \frac{LPE_T}{TE_C}$$
DE_T = Degree of thermal energy self-supply based on RES
LPE_T = Locally produced thermal energy [kWh/month; kWh/year]
TE_C = Thermal energy consumption (monitored) [kWh/(month); kWh/(year)]
$$DE_E = \frac{LPE_E}{TE_C}$$
DE_E Degree of electrical energy self-supply based on RES
LPE_E Locally produced electrical energy [kWh/month; kWh/year]
EE_C Electrical energy consumption (monitored) [kWh/(month); kWh/(year)]</td></tr>
<tr><td>Measurement procedure</td><td colspan="5">1. Collection of data
2. Calculation of KPI</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></td><td rowspan="7">Stakeholders</td><td>DSO</td><td>X</td></tr>
<tr><td>Set of Buildings</td><td></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">IRIS, BOEX, STED, CSTB, EDF, NEXITY, UNS, Rb, HSB, AH</td></tr>
</table>

10.11. Developer engagement

Developer engagement					
KPI Description	Developers are important stakeholders in the open data market. It is important to gain insight in the variety, importance and value of data used and not used by the developers. This KPI measures the use of open datasets by developers.				
KPI Formula	Number of API calls per month				
Measurement procedure	Monitoring of API- calls with software. The CIP will keep detailed usage statistics.				
Unit of Measurement	#		**Threshold/ Target**		
Object of assessment	Building		**Stakeholders**	DSO	
	Set of Buildings			TSP	X
	Energy Supply Unit			End-Users	X
	Set of Energy Supply Units			Governance	X
	Neighbourhood			Citizens	
	City	X		Representative Citizen Groups	
				Citizen Ambassadors	
Responsible Partner for KPI Data Collection			CIVITY, NCA, GOT		

10.12. Ease of use for end users of the solution

Ease of use for end users of the solution					
KPI Description	The extent to which the solution is perceived as difficult to understand and use for potential end-users. End-users are conceptualised as those individuals who will be using/working with the solution. Some solutions or innovations are perceived as relatively difficult to understand and use while others are clear and easy to the adopters. It is presumed that a smart city solution that is easy to use and understand will be more likely adopted than a difficult solution.				
KPI Formula	Likert Scale Very difficult – 1 — 2 — 3 — 4 — 5 — Very easy 1. **Very difficult**: users need extensive and sustained instructions to understand the solution and without these the solution cannot be understood or used. 2. **Fairly difficult**: users need to be well instructed to be able to understand and use the solution properly. Considerable time is required to familiarize themselves with the solution. 3. **Slightly difficult**: users have to invest some time to understand the solution and get accustomed to working with it. Some time is needed before the solution has become fully familiar to end users. 4. **Fairly easy**: a small investment in time is required of the end users to understand the solution and get accustomed to it, but they are fairly quickly familiar to work with it. 5. **Very easy**: the solution is as easy to understand and use.				
Measurement procedure	1. Undertaking of the survey 2. Analysis of the results				
Unit of Measurement	No unit		**Threshold/ Target**		
Object of assessment	Building		**Stakeholders**	DSO	
	Set of Buildings			TSP	X
	Energy Supply Unit			End-Users	X
	Set of Energy Supply Units			Governance	X
	Neighbourhood	X		Citizens	
	City	X		Representative Citizen Groups	
				Citizen Ambassadors	
Responsible Partner for KPI Data Collection	BOEX, NCA				

10.13. Energy savings

Energy savings					
KPI Description	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.				
KPI Formula	$$ES_T = 1 - \frac{TE_C}{ER_T}$$ 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)].				
Measurement procedure	1. Data collection 2. KPI calculation				
Unit of Measurement	%		**Threshold/ Target**		
Object of assessment	Building	X	**Stakeholders**	DSO	X
	Set of Buildings	X		TSP	X
	Energy Supply Unit	X		End-Users	X
	Set of Energy Supply Units	X		Governance	
	Neighbourhood	X		Citizens	
	City	X		Representative Citizen Groups	
				Citizen Ambassadors	
Responsible Partner for KPI Data Collection	CSTB, UNS, CAH, VEOLIA, EDF, Rb, AH, BOEX, STED, ENEC				

10.14. Expiration date of open data

Expiration date of open data					
KPI Description	Open data can become outdated and obsolete, which acts negatively on the attractivity of using data from platforms. By monitoring the expiration dates of the data, the owner gets a message to renew or remove the datasets.				
KPI Formula	Percentage of outdated datasets on a city platform per timeframe				
Measurement procedure	Statistics from CIP.				
Unit of Measurement	% of obsolete data on city data platform per timeframe		**Threshold/ Target**		
Object of assessment	Building		**Stakeholders**	DSO	
	Set of Buildings			TSP	X
	Energy Supply Unit			End-Users	X
	Set of Energy Supply Units			Governance	X
	Neighbourhood			Citizens	
	City	X		Representative Citizen Groups	
				Citizen Ambassadors	
Responsible Partner for KPI Data Collection			GOT, CIVITY, NCA		

10.15. Fine particulate matter emission

Fine particulate matter emission					
KPI Description	Improving the air quality in urban areas has been identified by the European Innovation Partnership on Smart Cities and Communities (EIP SCC) as one of the main challenges in the vertical priority area of Sustainable Urban Mobility (EIP SCC 2013, 8). Fine particulate matter can cause major health problems in cities. According to the WHO, any concentration of particulate matter (PM) is harmful to human health. PM is carcinogenic and harms the circulatory system as well as the respiratory system. As with many other air pollutants, there is a connection with questions of environmental justice, since often underprivileged citizens may suffer from stronger exposure. The evidence on PM and its public health impact is consistent in showing adverse health effects at exposures that are currently experienced by urban populations in both developed and developing countries. The range of health effects is broad but are predominantly to the respiratory and cardiovascular systems (ISO/DIS 37120, 2013).				
KPI Formula	The unit for this indicator should for the city level be grams per capita: $$\frac{\text{PM2.5 emission (g)}}{population} = \frac{\text{g}}{cap}\ of\ PM2.5$$				
Measurement procedure	1. Data collection 2. KPI calculation				
Unit of Measurement	Annual particulate matter emissions (PM 2,5) per capita		**Threshold/ Target**		
Object of assessment	Building		**Stakeholders**	DSO	
	Set of Buildings			TSP	
	Energy Supply Unit			End-Users	
	Set of Energy Supply Units			Governance	X
	Neighbourhood	X		Citizens	
	City	X		Representative Citizen Groups	
				Citizen Ambassadors	
Responsible Partner for KPI Data Collection			LOM, UTR		

10.16. Improved access to vehicle sharing solutions

Improved access to vehicle sharing solutions					
KPI Description	Providing opportunities for sharing vehicles like (e-)bicycles, (e-)cars and (e-) scooters, can decrease the need for and use of private cars, thereby contributing to an accessible, green and healthy neighbourhood. Cycling is a healthy, flexible, cheap and sustainable way to get from a to b over a short distance. Many European cities therefore would like to stimulate cycling, but in countries without a cycling culture there is limited private ownership of bikes. Car-sharing is about not owning a car but renting it from a carsharing company or sharing the car with friends, family, neighbours or co-workers (1,2). Car-sharing is an attractive option for people who drive less than 10.000 km a year. Car-sharers are more likely to travel by bike, saving on car use and improving their health. Carsharing also decreases the need for parking space, less vehicles are on the road and less pollution is emitted. Car sharing may furthermore improve social cohesion in the neighbourhood. This indicator assesses whether the possibilities for vehicle sharing have been improved due to the project. Improvements include more vehicle sharing locations, shorter distance to the nearest location, increased number of vehicles available and to ICT solutions that provide easy access to information on vehicle sharing options.				
KPI Formula	Likert scale: No improvement - 1 – 2 – 3 – 4 – 5 – Very high improvement. 1. Not at all: the possibilities for vehicle sharing were not improved. 2. Poor: there was little improvement in the possibilities for vehicle sharing. 3. Somewhat: the possibilities for vehicle sharing were somewhat improved. 4. Good: the possibilities for vehicle sharing were sufficiently improved. 5. Excellent: the possibilities for vehicle sharing were very much improved.				
Measurement procedure	1. Data collection 2. KPI calculation				
Unit of Measurement	No Unit		**Threshold/ Target**		
Object of assessment	Building		**Stakeholders**	DSO	X
	Set of Buildings			TSP	X
	Energy Supply Unit			End-Users	X
	Set of Energy Supply Units			Governance	X
	Neighbourhood	X		Citizens	X
	City	X		Representative Citizen Groups	X
				Citizen Ambassadors	X
Responsible Partner for KPI Data Collection			LOM, UTR, VULOG, TRIV		

10.17. Increased awareness of energy usage

<table>
<tr><th colspan="6">Increased awareness of energy usage</th></tr>
<tr><td>KPI Description</td><td colspan="5">Awareness of energy usage problems is important for creating support for environmental projects and programs. This indicator, therefore, assesses the extent to which the project has used opportunities for increasing energy awareness and educating about sustainability and the environment.
The extent to which the project has used opportunities for increasing awareness of energy use and educating about sustainability and the environment.</td></tr>
<tr><td>KPI Formula</td><td colspan="5">Likert scale:
Not at all – 1 – 2 – 3 – 4 – 5 – very much
1. Not at all: opportunities to increase awareness of energy usage were not taken into account in the project communication.
2. Poor: opportunities to increase awareness of energy usage were slightly taken into account in the project communication.
3. Somewhat: opportunities to increase awareness of energy usage were somewhat taken into account in the project communication, at key moments in the project there was attention for this issue.
4. Good: opportunities to increase awareness energy usage of were sufficiently taken into account in the project communication, the project utilized many possibilities to address this issue in their communications.
5. Excellent: opportunities to increase awareness of energy usage were taken into account in the project communication, the project utilized every possibility to address this issue both in online and offline communications.</td></tr>
<tr><td>Measurement procedure</td><td colspan="5">3. Data collection
4. KPI calculation</td></tr>
<tr><td>Unit of Measurement</td><td colspan="2">No Unit</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>X</td></tr>
<tr><td>Neighbourhood</td><td>X</td><td>Citizens</td><td>X</td></tr>
<tr><td>City</td><td>X</td><td>Representative Citizen Groups</td><td>X</td></tr>
<tr><td></td><td></td><td>Citizen Ambassadors</td><td>X</td></tr>
<tr><td colspan="3">Responsible Partner for KPI Data Collection</td><td colspan="3">BOEX, CSTB, VEOLIA, CAH, UNS, IRIS, EDF</td></tr>
</table>

10.18. Increased consciousness of citizenship

Increased consciousness of citizenship					
KPI Description	Consciousness of citizenship is the awareness (consciousness) of one's community, civic rights and responsibilities and as such contributes to the sense of community. At the very least, it means that the individual is aware of what is going on around him. Ideally, it would mean that the individual is involved in the life of the community --understanding his role in the community -- seeking to contribute when he is able to do so. The extent to which the project has contributed in increasing consciousness of citizenship.				
KPI Formula	The indicator provides a qualitative measure and is rated on a five-point Likert scale: No increase – 1 — 2 — 3 — 4 — 5 — High increase 1. None: The project has made no effort to increase civic consciousness. 2. Little: The project has made a small effort to increase civic consciousness. 3. Somewhat: The project has developed some initiatives to increase civic consciousness. 4. Significant: The project has executed several activities to increase civic consciousness. 5. High: increasing civic consciousness was (one of) the main goals of the project and it has done substantial effort to enhance it.				
Measurement procedure	1. Data collection 2. KPI calculation				
Unit of Measurement	No Unit		**Threshold/ Target**		
Object of assessment	Building		**Stakeholders**	DSO	
	Set of Buildings			TSP	x
	Energy Supply Unit			End-Users	x
	Set of Energy Supply Units			Governance	x
	Neighbourhood	X		Citizens	
	City	X		Representative Citizen Groups	
				Citizen Ambassadors	
Responsible Partner for KPI Data Collection			BOEX, UTR		

10.19. Increased environmental awareness

<table>
<tr><th colspan="6">Increased environmental awareness</th></tr>
<tr><td>KPI Description</td><td colspan="5">Awareness of environmental problems is important for creating support for environmental projects and programs. This indicator, therefore, assesses the extent to which the project has used opportunities for increasing environmental awareness and educating about sustainability and the environment.
The extent to which the project has used opportunities for increasing environmental awareness and educating about sustainability and the environment.</td></tr>
<tr><td>KPI Formula</td><td colspan="5">Likert scale:
Not at all – 1 – 2 – 3 – 4 – 5 – very much
6. Not at all: opportunities to increase environmental awareness were not taken into account in the project communication.
7. Poor: opportunities to increase environmental awareness were slightly taken into account in the project communication.
8. Somewhat: opportunities to increase environmental awareness were somewhat taken into account in the project communication, at key moments in the project there was attention for this issue.
9. Good: opportunities to increase environmental awareness were sufficiently taken into account in the project communication, the project utilized many possibilities to address this issue in their communications.
10. Excellent: opportunities to increase environmental awareness were taken into account in the project communication, the project utilized every possibility to address this issue both in online and offline communications.</td></tr>
<tr><td>Measurement procedure</td><td colspan="5">5. Data collection
6. KPI calculation</td></tr>
<tr><td>Unit of Measurement</td><td colspan="2">No Unit</td><td>Threshold/ Target</td><td colspan="2"></td></tr>
<tr><td rowspan="7">Object of assessment</td><td>Building</td><td></td><td rowspan="7">Stakeholders</td><td>DSO</td><td></td></tr>
<tr><td>Set of Buildings</td><td></td><td>TSP</td><td>X</td></tr>
<tr><td>Energy Supply Unit</td><td></td><td>End-Users</td><td>X</td></tr>
<tr><td>Set of Energy Supply Units</td><td></td><td>Governance</td><td>X</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">BOEX, UTR, VEOLIA</td></tr>
</table>

10.20. Increase in Local Renewable Energy production

Increase in Local Renewable Energy production					
KPI Description	The share of renewable energy production in itself gives an idea of the rate of self-consumption of locally produced energy, which is an indicator of the flexibility potential of the local energy system. The indicator should account for the increase of the renewable energy generation due to the intervention. In case biomass is used to generate energy, the transport distance is limited to 100 km. Renewable energy shall include both combustible and non-combustible renewables (ISO/DIS 37120, 2013). Non-combustible renewables include geothermal, solar, wind, hydro, tide and wave energy. For geothermal energy, the energy quantity is the enthalpy of the geothermal heat entering the process. For solar, wind, hydro, tide and wave energy, the quantities entering electricity generation are equal to the electrical energy generated. The combustible renewables and waste (CRW) consist of biomass (fuelwood, vegetal waste, ethanol) and animal products (animal materials/waste and sulphite lyes), municipal waste (waste produced by the residential, commercial and public service sectors that are collected by local authorities for disposal in a central location for the production of heat and/or power) and industrial waste.				
KPI Formula	$$LREG = \frac{ERES_{R\&I} - ERES_{BaU}}{EC}$$ LREG = Annual Local Renewable Electricity Generation ERES = Annual electricity generated by RES EC = Annual Electricity consumption $$LRHG = \frac{HRES_{R\&I} - HRES_{BaU}}{HC}$$ LRHG = Annual Local Renewable Heating/Cooling Generation ERES = Annual Heating/Cooling generated by RES EC = Annual Heating/Cooling consumption				
Measurement procedure	1. Data collection 2. KPI calculation				
Unit of Measurement	%		**Threshold/ Target**		
Object of assessment	Building		**Stakeholders**	DSO	X
	Set of Buildings			TSP	
	Energy Supply Unit	X		End-Users	
	Set of Energy Supply Units	X		Governance	X
	Neighbourhood	X		Citizens	

	City	X		Representative Citizen Groups	
				Citizen Ambassadors	
Responsible Partner for KPI Data Collection			HSB, Rb, AH, IRIS, CSTB,BOEX, STED		

10.21. Increased system flexibility for energy players/stakeholders

<table>
<tr><th colspan="6">Increased system flexibility for energy players/stakeholders</th></tr>
<tr><td>KPI Description</td><td colspan="5">Additional flexibility capacity gained for energy players/stakeholders. It measures the progress brought by R&I activities relative to the new clusters and functional objectives, assessing the additional electrical power that can be modulated in the selected framework, such as the connection of new RES generation, to enhance an interconnection, to solve congestion, or even all the transmission capacity of a TSO.
This KPI is an indication of the ability of the system to respond to – as well as stabilize and balance – supply and demand in real time, as a measure of the demand side participation in energy markets and in energy efficiency intervention.
Stability refers to the maintaining of voltage and frequency of a given power system within acceptable levels.</td></tr>
<tr><td>KPI Formula</td><td colspan="5">$$\Delta SF = \frac{SF_{R\&I} - SF_{BAU}}{P_{peak}}$$
$\mathcal{SF}is$ the amount of load capacity participating in demand side management [W].
It can also be expressed related to cost as:
$$SFAC = \frac{System\ flexibility}{Cost}$$</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">%, W/€</td><td>Threshold/ Target</td><td colspan="2"></td></tr>
<tr><td rowspan="7">Object of assessment</td><td>Building</td><td></td><td rowspan="7">Stakeholders</td><td>DSO</td><td>x</td></tr>
<tr><td>Set of Buildings</td><td></td><td>TSP</td><td>x</td></tr>
<tr><td>Energy Supply Unit</td><td></td><td>End-Users</td><td></td></tr>
<tr><td>Set of Energy Supply Units</td><td></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">Rb, STED, LOM, EDF, LEM</td></tr>
</table>

10.22. Local community involvement in the implementation phase

<table>
<tr><th colspan="6">Local community involvement in the implementation phase</th></tr>
<tr><td>KPI Description</td><td colspan="5">The extent to which residents/users have been involved in the implementation process.
As residents' beliefs, needs, preferences and expectations towards sustainable living environments have a strong influence on project performance, public involvement during the implementation stage is essential to provide developers with input to ensure that the project will perform as intended. Moreover, a growing body of literature is exemplifying the importance of civil society/community participation in sustainable urban planning and execution, for example by means of smart city projects, to bring together information, knowledge and skills from diverse backgrounds to articulate the often ambiguous targets of smart cities and to create a sense of ownership over the outcomes</td></tr>
<tr><td>KPI Formula</td><td colspan="5">The indicator provides a qualitative measure and is rated on a five-point Likert scale:
No involvement – 1 — 2 — 3 — 4 — 5 — High involvement
1. Not at all: No community involvement.
2. Inform and consult: The more or less completed project is announced to the community either for information only, or for receiving community views. The consultation, however, is mainly seeking community acceptance of the project.
3. Advise: the project implementation is done by a project team. Community actors are invited to ask questions, provide feedback and give advice. Based on this input the planners may alter the project.
4. Partnership: community actors are asked by the project planners to participate in the implementation process. The local community is able to influence the implementation process.
5. Community self-development: the project planners have empowered community actors to manage the project implementation and evaluate the results.</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">No Unit</td><td>Threshold/ Target</td><td colspan="2"></td></tr>
<tr><td rowspan="7">Object of assessment</td><td>Building</td><td></td><td rowspan="7">Stakeholders</td><td>DSO</td><td></td></tr>
<tr><td>Set of Buildings</td><td>X</td><td>TSP</td><td></td></tr>
<tr><td>Energy Supply Unit</td><td></td><td>End-Users</td><td>X</td></tr>
<tr><td>Set of Energy Supply Units</td><td></td><td>Governance</td><td></td></tr>
<tr><td>Neighbourhood</td><td>X</td><td>Citizens</td><td>X</td></tr>
<tr><td>City</td><td>X</td><td>Representative Citizen Groups</td><td>X</td></tr>
<tr><td></td><td></td><td>Citizen Ambassadors</td><td>X</td></tr>
<tr><td colspan="3">Responsible Partner for KPI Data Collection</td><td colspan="3">BOEX, UTR, NCA</td></tr>
</table>

10.23. Local community involvement in the planning phase

<table>
<tr><th colspan="6">Local community involvement in the planning phase</th></tr>
<tr><td>KPI Description</td><td colspan="5">The extent to which residents/users have been involved in the planning process.
As residents' beliefs, needs, preferences and expectations towards sustainable living environments have a strong influence on project performance, public involvement during the planning stage is essential to provide developers with input to ensure that the project will perform as intended. Moreover, a growing body of literature is exemplifying the importance of civil society/community participation in sustainable urban planning and execution, for example by means of smart city projects, to bring together information, knowledge and skills from diverse backgrounds to articulate the often ambiguous targets of smart cities and to create a sense of ownership over the outcomes</td></tr>
<tr><td>KPI Formula</td><td colspan="5">The indicator provides a qualitative measure and is rated on a five-point Likert scale:
No involvement – 1 — 2 — 3 — 4 — 5 — High involvement
6. Not at all: No community involvement.
7. Inform and consult: The more or less completed plant project is announced to the community either for information only, or for receiving community views. The consultation, however, is mainly seeking community acceptance of the project.
8. Advise: the project planning is done by a project team. Community actors are invited to ask questions, provide feedback and give advice. Based on this input the planners may alter the project.
9. Partnership: community actors are asked by the project planners to participate in the planning process. The local community is able to influence the planning process.
10. Community self-development: the project planners have empowered community actors to manage the project planning and evaluate the results.</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">No Unit</td><td>Threshold/ Target</td><td colspan="2"></td></tr>
<tr><td rowspan="7">Object of assessment</td><td>Building</td><td></td><td rowspan="7">Stakeholders</td><td>DSO</td><td></td></tr>
<tr><td>Set of Buildings</td><td>X</td><td>TSP</td><td></td></tr>
<tr><td>Energy Supply Unit</td><td></td><td>End-Users</td><td>X</td></tr>
<tr><td>Set of Energy Supply Units</td><td></td><td>Governance</td><td></td></tr>
<tr><td>Neighbourhood</td><td>X</td><td>Citizens</td><td>X</td></tr>
<tr><td>City</td><td>X</td><td>Representative Citizen Groups</td><td>X</td></tr>
<tr><td></td><td></td><td>Citizen Ambassadors</td><td>X</td></tr>
<tr><td colspan="3">Responsible Partner for KPI Data Collection</td><td colspan="3">UTR, NCA, BOEX</td></tr>
</table>

10.24. NOx emission

<table>
<tr><th colspan="6">NO_x emission</th></tr>
<tr><td>KPI Description</td><td colspan="5">Nitrogen oxides (NO and NO2) are major air pollutants, which can have significant impacts on human health and the environment (ISO/DIS 37120, 2013). NO contributes to ozone layer depletion and, when exposed to oxygen, can transform into NO2. NO2 contributes to the formation of photochemical smog and at raised levels can increase the likelihood of respiratory problems. Nitrogen dioxide inflames the lining of the lungs, and it can reduce immunity to lung infections. This can cause problems such as wheezing, coughing, colds, flu and bronchitis. Increased levels of nitrogen dioxide can have significant impacts on people with asthma because it can cause more frequent and more intense attacks. NO2 chemically transforms into nitric acid and contributes to acid rain. Nitric acid can corrode metals, fade fabrics, and degrade rubber. When deposited, it can also contribute to lake acidification and can damage trees and crops, resulting in substantial losses.
Percentage reduction in NOx emissions (NO and NO2) achieved by the project.</td></tr>
<tr><td>KPI Formula</td><td colspan="5">$$percentage\ change\ in\ NOx\ emissions = \left(\frac{NOx\ emissions\ \left(\frac{t}{yr}\right)\ after\ project}{NOx\ emissions\ \left(\frac{t}{yr}\right)\ before\ project} \times 100 \right)$$
NOx emissions can be derived from energy use if not directly available. The level of NOx emissions is varying depending mainly on the energy generation technology and type of fuel.
It would be most convenient to use an average ratio number specific to the combustion process and fuel (e.g. Energy production from coal or diesel combustion engines).
$$\boldsymbol{Energy\ produced \times NOx_{ratio}\ (kWh \times NOx/kWh)}$$</td></tr>
<tr><td>Measurement procedure</td><td colspan="5">3. Data collection
4. 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="8">Object of assessment</td><td>Building</td><td></td><td rowspan="8">Stakeholders</td><td>DSO</td><td>X</td></tr>
<tr><td>Set of Buildings</td><td></td><td>TSP</td><td>X</td></tr>
<tr><td>Energy Supply Unit</td><td></td><td>End-Users</td><td>X</td></tr>
<tr><td>Set of Energy Supply Units</td><td></td><td>Governance</td><td>X</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">LOM, UTR</td></tr>
</table>

10.25. Number of connected urban objects

Number of connected urban objects					
KPI Description	Number of connected urban objects in the City innovation platform.				
KPI Formula	Number of objects connected				
Measurement procedure	1. Data collection 2. KPI calculation				
Unit of Measurement	No Unit		**Threshold/ Target**		
Object of assessment	Building		**Stakeholders**	DSO	
	Set of Buildings			TSP	
	Energy Supply Unit			End-Users	X
	Set of Energy Supply Units			Governance	X
	Neighbourhood	X		Citizens	X
	City	X		Representative Citizen Groups	X
				Citizen Ambassadors	X
Responsible Partner for KPI Data Collection			NCA		

10.26. Number of e-charging stations deployed in the area

Number of e-charging stations deployed in the area					
KPI Description	Charging infrastructure development is critical for the promotion of electromobility and the deployment of electric vehicles. This indicator will assess the level of service with regards to charging capabilities offered by measuring the number of electric vehicles charging stations deployed in the area.				
KPI Formula	Total stations deployed/area; * 100				
Measurement procedure	1. Data collection 2. KPI calculation				
Unit of Measurement	Stations/km2, %		**Threshold/ Target**		
Object of assessment	Building		**Stakeholders**	DSO	X
	Set of Buildings			TSP	X
	Energy Supply Unit			End-Users	X
	Set of Energy Supply Units			Governance	X
	Neighbourhood	X		Citizens	
	City	X		Representative Citizen Groups	
				Citizen Ambassadors	
Responsible Partner for KPI Data Collection			VULOG		

10.27. Number of efficient vehicles deployed in the area

Number of efficient vehicles deployed in the area					
KPI Description	A car-sharing system needs a critical number (mass) of vehicles in order to be useful for the users. This indicator will assess the level of service offered by measuring the number of efficient vehicles in the area.				
KPI Formula	Vehicles deployed / area				
Measurement procedure	1. Data collection 2. KPI calculation				
Unit of Measurement	Veh/km2		**Threshold/ Target**		
Object of assessment	Building		**Stakeholders**	DSO	
	Set of Buildings			TSP	X
	Energy Supply Unit			End-Users	X
	Set of Energy Supply Units			Governance	X
	Neighbourhood	X		Citizens	
	City	X		Representative Citizen Groups	
				Citizen Ambassadors	
Responsible Partner for KPI Data Collection			VULOG		

10.28. Number of Free Floating subscribers

Number of Free Floating subscribers					
KPI Description	The successful implementation of a free-floating car-sharing system mostly depends on the use of the vehicles, which is highly related to the service subscribers. This indicator will assess the increase in the number of subscribers to the free-floating car-sharing service.				
KPI Formula	Number of final users involved				
Measurement procedure	1. Data collection				
Unit of Measurement	#		**Threshold/ Target**		
Object of assessment	Building	X	**Stakeholders**	DSO	
	Set of Buildings	X		TSP	X
	Energy Supply Unit			End-Users	
	Set of Energy Supply Units			Governance	X
	Neighbourhood	X		Citizens	
	City	X		Representative Citizen Groups	
				Citizen Ambassadors	
Responsible Partner for KPI Data Collection			VULOG		

10.29. Open data-based solutions

Open data-based solutions					
KPI Description	To gain insight of the use of open data, mapping the applications developed based on the open data is vital. This KPI is intended to give a statement about the ease of use of open data from external developers.				
KPI Formula	Number of services based on open data.				
Measurement procedure	Manual monitoring/ research in CIP databases.				
Unit of Measurement	Number / (month, year)		**Threshold/ Target**		
Object of assessment	Building		**Stakeholders**	DSO	X
	Set of Buildings			TSP	X
	Energy Supply Unit			End-Users	
	Set of Energy Supply Units			Governance	X
	Neighbourhood			Citizens	
	City	X		Representative Citizen Groups	
				Citizen Ambassadors	
Responsible Partner for KPI Data Collection			NCA, METRY, CIVITY		

10.30. Participatory governance

<table>
<tr><th colspan="6">Participatory governance</th></tr>
<tr><td>KPI Description</td><td colspan="5">Participatory governance focuses on deepening democratic engagement through the participation of citizens in the processes of governance with the state. The idea is that citizens should play a more direct role in public decision-making or at least engage more deeply with political issues (Gaventa 2006). A more active engagement of citizens into urban governance and decision making is one of the main aims of the European Innovation Partnership on Smart Cities and Communities (EIP SCC). In its Strategic Implementation Plan (SIP), the EIP SCC specifically highlights the potential of new online services for participatory governance:
“If smartly mobilized, the effect of citizen’s behaviour, choices, creativity and entrepreneurship could be enormous, offering huge untapped potential. ICTs play a vital role in this – particularly as the Internet, not least through smartphones, becomes all-pervasive – as well as the willingness to be open towards new citizen-driven initiatives that might not fit with the current administrative system.”(EIP SCC 2012. 12)
Several online platforms for a stronger engagement of citizens into decision making have been developed in recent years (e.g. ONTOPICA, GRANICUS, ACCELA, WE THINQ). This indicator looks at the degree of success of these platforms.</td></tr>
<tr><td>KPI Formula</td><td colspan="5">The indicator is calculated as the sum of users actively engaged in relevant projects of the city during a year (numerator) divided by the total number of inhabitants of the city (denominator), multiplied by 100%
Theoretically the sum of users could equal the total population, so the scale is evenly distributed in steps of 10%.
<table><tr><th colspan="2">Normalisation</th></tr><tr><td>Improvement</td><td>Score</td></tr><tr><td>0-10%</td><td>1</td></tr><tr><td>10-20%</td><td>2</td></tr><tr><td>20-30%</td><td>3</td></tr><tr><td>30-40%</td><td>4</td></tr><tr><td>40-50%</td><td>5</td></tr><tr><td>50-60%</td><td>6</td></tr><tr><td>60-70%</td><td>7</td></tr><tr><td>70-80%</td><td>8</td></tr><tr><td>80-90%</td><td>9</td></tr><tr><td>90-100%</td><td>10</td></tr></table></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="3">Object of assessment</td><td>Building</td><td></td><td rowspan="3">Stakeholders</td><td>DSO</td><td></td></tr>
<tr><td>Set of Buildings</td><td></td><td>TSP</td><td>X</td></tr>
<tr><td>Energy Supply Unit</td><td></td><td>End-Users</td><td>X</td></tr>
</table>

	Set of Energy Supply Units			Governance	X
	Neighbourhood	X		Citizens	
	City	X		Representative Citizen Groups	
				Citizen Ambassadors	
Responsible Partner for KPI Data Collection			GOT		

10.31. Peak load reduction

Peak load reduction					
KPI Description	Compare the peak demand before the aggregator implementation (baseline) with the peak demand after the aggregator implementation (per final consumer, per feeder, per network). E.g. Peak load is the maximum power consumption of a building or a group of buildings to provide certain comfort levels. With the correct application of ICT systems, the peak load can be reduced on a high extent and therefore the dimension of the supply system. In SCIS, the indicator is used to analyse the maximum power demand of a system in comparison with the average power.				
KPI Formula	$PL_{REDUCTION} = \left(1 - \frac{P_{peak,R\&I}}{P_{BaU}}\right) * 100$				
Measurement procedure	1. Data collection 2. KPI calculation				
Unit of Measurement	%		**Threshold/ Target**		
Object of assessment	Building	X	**Stakeholders**	DSO	X
	Set of Buildings	X		TSP	X
	Energy Supply Unit			End-Users	
	Set of Energy Supply Units			Governance	
	Neighbourhood	X		Citizens	
	City	X		Representative Citizen Groups	
				Citizen Ambassadors	
Responsible Partner for KPI Data Collection			CSTB, CAH, VEOLIA, UNS, EDF, NEXITY, Rb, AH, METRY		

10.32. People reached

People reached					
KPI Description	A Smart City project is usually most successful if the entire target group of a service participates. For example, if all electrical car owners join in optimizing their battery use to improve the energy system efficiency of the district. In addition, a high score on people reached can be seen as a signal of increased community engagement due to the project. The effort the project will make towards reaching the full extent of its target group can vary and with it the size of the target audience. Therefore, this effort and target audience have to be clearly defined before assessing the indicator. Percentage of people in the target group that have been reached and/or are activated by the project				
KPI Formula	(number of citizens reached/total number of citizens considered as the total target group of the project) * 100%				
Measurement procedure	3. Data collection 4. KPI calculation				
Unit of Measurement	%		**Threshold/ Target**		
Object of assessment	Building		**Stakeholders**	DSO	
	Set of Buildings			TSP	X
	Energy Supply Unit			End-Users	X
	Set of Energy Supply Units			Governance	X
	Neighbourhood	X		Citizens	
	City	X		Representative Citizen Groups	
				Citizen Ambassadors	
Responsible Partner for KPI Data Collection			BOEX, UTR, NCA, VEOLIA		

10.33. Platform downtime

Platform downtime					
KPI Description	To run a stable platform, monitoring is required to fix bugs and quickly improve the software environments.				
KPI Formula	Downtime per timeframe.				
Measurement procedure	The CIP will keep detailed usage statistics.				
Unit of Measurement	Minutes / (selected timeframe)		**Threshold/ Target**		
Object of assessment	Building		**Stakeholders**	DSO	X
	Set of Buildings			TSP	X
	Energy Supply Unit			End-Users	
	Set of Energy Supply Units			Governance	X
	Neighbourhood			Citizens	
	City	X		Representative Citizen Groups	
				Citizen Ambassadors	
Responsible Partner for KPI Data Collection			CIVITY, NCA, GOT		

10.34. Reduced energy cost for costumers

Reduced energy cost for costumers					
KPI Description	This KPI is intended to assess the economic benefits of a scheduling strategy for prosumers coordinated by an aggregator. The KPI will measure the cost of the energy traded by an aggregator, both as a baseline and when ICT are implemented, e.g. the effect of shifting the demand to consume from the grid when the electricity price is lower.				
KPI Formula	$$COST_{REDUCTION} = \frac{COST_{R\&I} - COST_{BaU}}{COST_{BaU}}$$ COST = the electricity price at a given period of time				
Measurement procedure	1. Data collection 2. KPI calculation				
Unit of Measurement	%		**Threshold/ Target**		
Object of assessment	Building	X	**Stakeholders**	DSO	X
	Set of Buildings	X		TSP	X
	Energy Supply Unit	X		End-Users	X
	Set of Energy Supply Units	X		Governance	
	Neighbourhood	X		Citizens	
	City	X		Representative Citizen Groups	
				Citizen Ambassadors	
Responsible Partner for KPI Data Collection			Rb, EDF		

10.35. Reduced energy curtailment of RES and DER

Reduced energy curtailment of RES and DER					
KPI Description	Reduction of energy curtailment due to technical and operational problems. The integration of ICT will have an impact on producers, as the time for curtailment will be reduced, and the operative range will be wider. This indicator can be measured as the percentage of GWh electricity curtailment from DER reduction of R&I solution compared to BaU for a period of time, i.e. a year.				
KPI Formula	$$Reduction\ of\ EnI = \frac{EnI_{baseline} - EnI_{R\&I}}{EnI_{baseline}} \cdot 100$$ EnI = Energy not Injected				
Measurement procedure	1. Calculation/determination of baseline 2. Data collection 3. KPI calculation				
Unit of Measurement	%		**Threshold/ Target**		
Object of assessment	Building		**Stakeholders**	DSO	X
	Set of Buildings			TSP	X
	Energy Supply Unit	X		End-Users	
	Set of Energy Supply Units	X		Governance	
	Neighbourhood	X		Citizens	
	City	X		Representative Citizen Groups	
				Citizen Ambassadors	
Responsible Partner for KPI Data Collection			LOM, EDF		

10.37. Reduction in annual final energy consumption by street lighting

Reduction in annual final energy consumption by street lighting					
KPI Description	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				
KPI Formula	$$ES_E = 1 - \frac{TE_C}{ER_E}$$ 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)].				
Measurement procedure	1. Data collection 2. KPI calculation				
Unit of Measurement	%		**Threshold/ Target**		
Object of assessment	Building	X	**Stakeholders**	DSO	X
	Set of Buildings	X		TSP	X
	Energy Supply Unit			End-Users	X
	Set of Energy Supply Units			Governance	X
	Neighbourhood	X		Citizens	
	City	X		Representative Citizen Groups	
				Citizen Ambassadors	
Responsible Partner for KPI Data Collection			STED		

10.38. Reduction in car ownership among tenants

Reduction in car ownership among tenants					
KPI Description	Number of care ownership among tenants before and after moving in to the demonstration area				
KPI Formula	Survey among tenants				
Measurement procedure	1. Data collection 2. KPI calculation				
Unit of Measurement	%		**Threshold/ Target**		
Object of assessment	Building		**Stakeholders**	DSO	
	Set of Buildings	X		TSP	
	Energy Supply Unit			End-Users	X
	Set of Energy Supply Units			Governance	X
	Neighbourhood	X		Citizens	X
	City			Representative Citizen Groups	
				Citizen Ambassadors	
Responsible Partner for KPI Data Collection			TRIV		

10.39. Reduction in driven km by tenants and employees in the district

Reduction in driven km by tenants and employees in the district					
KPI Description	Kilometers driven by the tenants and employees in the district before and after moving in to the demonstration area.				
KPI Formula	Survey among tenants and employees				
Measurement procedure	1. Data collection 2. KPI calculation				
Unit of Measurement	%		**Threshold/ Target**		
Object of assessment	Building	X	**Stakeholders**	DSO	X
	Set of Buildings	X		TSP	X
	Energy Supply Unit			End-Users	X
	Set of Energy Supply Units			Governance	X
	Neighbourhood	X		Citizens	X
	City	X		Representative Citizen Groups	
				Citizen Ambassadors	
Responsible Partner for KPI Data Collection			TRIV		

10.41. Share of RES in ICT power supply

Share of RES in ICT power supply					
KPI Description	Share of renewable energy sources in the power supply for Information and Communication Technologies				
KPI Formula	Share of RES power supply/ total power supply				
Measurement procedure	1. Data collection 2. KPI calculation				
Unit of Measurement	%		**Threshold/ Target**		
Object of assessment	Building		**Stakeholders**	DSO	X
	Set of Buildings			TSP	X
	Energy Supply Unit	X		End-Users	X
	Set of Energy Supply Units	X		Governance	X
	Neighbourhood	X		Citizens	X
	City	X		Representative Citizen Groups	
				Citizen Ambassadors	
Responsible Partner for KPI Data Collection	GOT, METRY				

10.42. Storage capacity installed

Storage Capacity installed					
KPI Description	Viewing the need for an increase in the RES penetration in the energy mix, energy storage is essential due to the fuzziness in the generation using RES. The smart storage capacity includes all the energy storage technologies integrated in the city smart grid containing electricity, heating and mobility. This KPI presents the impact of the project in the use of smart energy storage systems.				
KPI Formula	$Storage\ capacity\ installed = \frac{SCI_{R\&I} - SCI_{baseline}}{SCI_{baseline}} \cdot 100$				
Measurement procedure	1. Data collection 2. KPI calculation				
Unit of Measurement	%		**Threshold/ Target**		
Object of assessment	Building		**Stakeholders**	DSO	X
	Set of Buildings			TSP	X
	Energy Supply Unit			End-Users	
	Set of Energy Supply Units	X		Governance	
	Neighbourhood	X		Citizens	
	City	X		Representative Citizen Groups	
				Citizen Ambassadors	
Responsible Partner for KPI Data Collection	UTR, NCA, GOT				

10.43. Trialability

Trialability					
KPI Description	An innovative smart city solution that can be experimented with in the local context (e.g. 'living lab') before full implementation, will represent less uncertainty for the potential adopter. Moreover, testing at the local context allows for further fine-tuning of a solution itself, or of the local context to the solution, to increase its performance. The possibilities for such testing define, to some extent, the solution's potential for diffusion and it is thus presumed that smart city solutions benefit from a higher level of trialability. This indicator therefore assesses the extent to which the solution can be experimented with (Rogers, 1995) NB. It is not the question whether or not the project team has experimented with the innovation in the project in question. It is merely an indication whether or not the innovation's characteristics allow for small-scale trials, before adopters might choose to implement it on a larger scale.				
KPI Formula	The indicator provides a qualitative measure and is rated on a five point Likert scale: No possibility for experimentation – 1 — 2 — 3 — 4 — 5 —Very high possibilities for experimentation. 1. No possibility: The solution cannot be experimented with on a limited basis in the local context. Implementation on a limited basis is either technically unfeasible or would require too much extra resources (time, money, expertise). 2. Limited possibilities: The solution has very low opportunities for experimentation at the local level, as it would be very difficult to implement the innovation on a limited basis only, or would require substantial extra resources (time, money, expertise). 3. Moderate possibilities: The solution has a moderate opportunity for experimentation at the local level. It would be difficult to implement the innovation on a limited basis only but would be possible with some extra resources (time, money, expertise). 4. High possibilities: The solution has a high opportunity as it can be quite easily implemented on a limited basis at the local context, with limited resources (time, money, expertise). 5. Very high possibilities: The solution can easily be experimented with on a limited basis at the local context, without requiring extra resources (time, money, expertise).				
Measurement procedure	1. Data collection 2. KPI calculation				
Unit of Measurement	No unit		**Threshold/ Target**		
Object of assessment	Building	X	**Stakeholders**	DSO	X
	Set of Buildings	X		TSP	X
	Energy Supply Unit	X		End-Users	X
	Set of Energy Supply Units	X		Governance	X

	Neighbourhood	X		Citizens	X
	City	X		Representative Citizen Groups	X
				Citizen Ambassadors	X
Responsible Partner for KPI Data Collection			UTR, NCA, GOT		

10.44. Usage of open source software

Usage of open source software					
KPI Description	The use of open source software means less possibilities of vendor lock-in and more space for communities to develop together smart city solutions. It also lowers the software costs. This KPI is intended to give a statement about how easy it is to connect systems.				
KPI Formula	How easy is it to connect systems				
Measurement procedure	Survey				
Unit of Measurement	Likert scale (no unit)		**Threshold/ Target**		
Object of assessment	Building		**Stakeholders**	DSO	
	Set of Buildings			TSP	X
	Energy Supply Unit			End-Users	
	Set of Energy Supply Units			Governance	X
	Neighbourhood			Citizens	
	City	X		Representative Citizen Groups	
				Citizen Ambassadors	
Responsible Partner for KPI Data Collection			UTR, NCA, GOT		

10.45. User engagement

User engagement					
KPI Description	The implementation of ICT solutions can also be related to the involvement of the users in the control over the energy use in the building. A variety of measures can be implemented, from the installation of metering systems to give the user feedback, to the involvement of the user in the management of their energy consumption. In case that these measures can be allocated to an energy demand reduction, this indicator will be shown.				
KPI Formula	• Number of final users involved • Number of people with increased capacity				
Measurement procedure	1. Data collection				
Unit of Measurement	#		**Threshold/ Target**		
Object of assessment	Building	X	**Stakeholders**	DSO	
	Set of Buildings	X		TSP	X
	Energy Supply Unit			End-Users	X
	Set of Energy Supply Units			Governance	X
	Neighbourhood	X		Citizens	
	City	X		Representative Citizen Groups	
				Citizen Ambassadors	
Responsible Partner for KPI Data Collection			UTR, NCA, GOT		

10.46. Yearly km driven in e-car sharing systems

Yearly km made through the e-car sharing system					
KPI Description	The key element of a car-sharing system is the usage of the system, not only in terms of users but in terms of kilometres. This indicator will assess the number of kilometres done using the car-sharing service				
KPI Formula	Number of kilometres done by the car-sharing fleet				
Measurement procedure	1. Data collection				
Unit of Measurement	km		**Threshold/ Target**		
Object of assessment	Building	X	**Stakeholders**	DSO	
	Set of Buildings	X		TSP	
	Energy Supply Unit			End-Users	X
	Set of Energy Supply Units			Governance	
	Neighbourhood	X		Citizens	
	City	X		Representative Citizen Groups	
				Citizen Ambassadors	
Responsible Partner for KPI Data Collection			UTR, NCA, GOT		

10.47. Quality of open data

Quality of open data					
KPI Description	The quality of open data is better if is standardized. Processes get easier when data standards are applied. The DCAT standard allows municipal employees to produce data in a standardized way.				
KPI Formula	Percentage of data that uses DCAT standards.				
Measurement procedure	Manual monitoring/ research to calculate the number of standardized datasets.				
Unit of Measurement	%		**Threshold/ Target**		
Object of assessment	Building		**Stakeholders**	DSO	
	Set of Buildings			TSP	
	Energy Supply Unit			End-Users	
	Set of Energy Supply Units			Governance	X
	Neighbourhood			Citizens	
	City	X		Representative Citizen Groups	
				Citizen Ambassadors	
Responsible Partner for KPI Data Collection	UTR, NCA, GOT				