IRIS

Integrated and Replicable Solutions for Co-Creation in Sustainable Cities

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Intermediate report after one year of measurement

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0.1	12/01/2021	RISE created the first structure of the deliverable
0.2	01/06/2021	RISE modify the structure of the deliverable in collaboration with all partners
0.3		All partners wrote Methodology (chapter2), Revision of KPIs (chapter 3) and data collection overview (Chapter 4) including results (chapter 5)
0.4	01/09/2021	Introduction chapter bin included update and
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Disclaimer

Executive Summary

The present document is the Deliverable D9.6 “Intermediate report after one year of measurement”. The document describes the work carried out within the task 9.5 entitled “Overall evaluation and impact analysis for impact enhancement”. The focus of this task is to provide intermediate results of the demonstration activities in the three Lighthouse (LH) cities and to present the data currently transferred to the IRIS Key Performance Indicators (KPI) tool.

The deliverable D9.6 is based on the work done in the Work Package (WP) 9, in particular the work in task 9.4 and task 9.5 (presented previously in D9.4 and D9.5). In this deliverable, the monitoring framework and established baselines developed in D9.5 are used to collect the data needed for the calculation of the KPIs. The KPIs are in turn used to evaluate the outcome and impact of the implemented measures. The collected data is transferred to the KPI tool, which was created and presented in D9.4. The tool processes and calculates the KPIs and visualizes the results. Data can be transferred to the KPI tool automatically, through a CIP, or manually through a template. A process which is described in this deliverable.

This deliverable was intended to be an intermediate report to provide an initial insight to the results for all measures in the IRIS project. However, due to the lack of data from measures, which in part is due to the Covid-19 pandemic, this report focuses more on providing information about the process of collecting data and transferring it into the KPI tool. This process is collaborative and has been carried out within the IRIS LH cites with support from the technical partners and the WP9 team. Complexity of APIs and the lack of standards have made data extraction and transfer into the KPI tool more difficult. Furthermore, not all measures in IRIS are connected to CIP which means that manual data collection was required and a systematic procedure for this collection needed to be developed and introduced to the partners.

There are several different reasons for lack of data and the resulting exclusion of some measures from this deliverable. A few measures are not yet in operation, while for other data collection have not started or the data transfer to the KPI tool has not been established yet. However, the work done in task 9.5 has provided new knowledge on issues and errors that can occur in the process of transferring data and establishing KPIs. Through dialogues with the project partners, the need to clarify some KPI cards with i.e. units, formulas or use cases has been highlighted. The close cooperation with the project partners has led to continued work on the definitions of the KPIs and what KPIs to include, taking steps in the direction of clearer interpretation and more consistent use. Further adaptation of several KPI-cards was done by the WP9 team. In the process of adjusting KPIs, the effect these adjustments would have on all measures that use them were considered. The process of developing KPIs involves a balance between finding indicators that can be used more generally and indicators that are more specific and thus better capture the purpose of a specific measure.

The improvements of KPIs and lessons learned in task 9.5 will be of great use in the continued work of WP9. Focus will be on transfer of data from all measures into the KPI tool. A continuous dialogue with responsible project partners to ensure this data transfer and discussions on deviation and errors in the initial results will be established.

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List of Abbreviations and Acronyms

Abbreviation	Definition
AC	Alternating Current
APIs	Application Programming Interfaces
AWL	A Working Lab
BAU	Business As Usual
BESS	Battery Energy Storage Systems
BIPV	Building Integrated Photovoltaics
CIM	City Information Model
CIP	City Innovation Platform
CITYkeys	Smart City performance measurement system (Project funded by the European Union HORIZON 2020)
DC	Direct Current
DEMS	District Energy Management System
DER	Distributed Energy Resources
DHCN	District Heating Cooling Network
DoA	Description of Action
DSO	Distribution System Operator
EC2B	Easy to be
EMSs	Smart Energy Management System
EPC	Energy performance contracting
FC	Follower City
GA	Grant Agreement
GDPR	General Data Protection Regulation
GOT	Gothenburg
HEMS	Home Energy Management System
ICT	Information and Communication Technology
IL	IRIS project level
IRR	Internal Rate of Return
IS	Integrated Solution
ISO	International Standards Organization
KPI	Key Performance Indicator
LCL	Lighthouse City Level
LC	Lighthouse City
LH	Lighthouse
lm	Lumen
MaaS	Mobility as a Service

MVP	Minimal Viable Product
NCA	Nice Côte d'Azur
OCPP	Open Charge Point Protocol
PCM	Phase Change Materials
PDS	Public Delegation of Service
POC	Proof of concept
PV	Photovoltaic
RES	Renewable Energy Sources
ROI	Return of Investment
SC	Smart City
SCIS	Smart Cities Information System (Project funded by the European Union HORIZON 2020)
STT	Solution level
TES	Thermal Energy Storage
TSO	Transmission System Operator
TT	Transition Track
UC	Use Case
UNS	University of Nice
UTR	Utrecht
USEF	Universal Smart Energy Framework
USI	Utrecht Sustainability Institute
V2G	Vehicle to Grid
WP	Work Package

1 Introduction

1.1 Scope, objectives and expected impact

The overall aim of Work package (WP) 9 is to monitor and evaluate to which extent the IRIS project has reached the goals and objectives defined for each Lighthouse (LH) city and for the overall project. The monitoring and evaluation work in WP9 will also provide information concerning the performance of the different solutions that are 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 D9.6 *Intermediate report after one year of measurement* is a result of task 9.5 *Overall evaluation and impact analysis for impact enhancement*. The scope of this deliverable is to provide intermediate results of the demonstration activities in the three LH cities and the impact of actions for the IRIS project.

Deliverable D9.6 builds on the work done in WP9, by using the developed framework for monitoring described in D9.5 [1] and the IRIS Key Performance Indicators (KPI) tool that processes the collected data and calculates the KPIs presented in D9.4 [2]. The IRIS KPI tool can be connected through the City Innovation Platform (CIP) to the online systems in each LH city, thereby enabling automatic transfer of the data required for KPIs calculations of the IRIS measures. The tool also allows manual data entry in case the measures are not connected through the CIP.

Deliverable D9.6 gives an initial impression of the impact of the LH cities demonstration activities and presents the data currently transferred to the KPI tool. The KPI tool visualisation of the collected data enables evaluation and comparison of different measures, both at LH city and project level.

1.2 Contributions of partners

Deliverable D9.6 has been authored by Research Institutes of Sweden (RISE), Centre of Research & Technology (CERTH) and Utrecht University (UU). RISE, as the leader in task 9.5 and WP9 leader, has coordinated the activities related to the monitoring and evaluation work. UU, CERTH and RISE have worked on establishing the necessary data to collect for each KPI, in close collaboration with the leaders of the demonstrators of each LH city (Utrecht, Nice and Gothenburg). Furthermore, CERTH and the partners of WP4, the City Innovation Platform (CIP), contributed to establishing the connection of the KPI tool with these platforms.

1.3 Relation to other activities

D9.6 *Intermediate report after one year of measurement* builds on the work done in task 9.3 and task 9.4

D9.6 is relying on data collected from the LH cities of each Transition Track (TT). It is also related to the development of the CIP, as the data from some fields (i.e. building retrofitting, district heating, smart grid and smart mobility) for the LH cites are gathered and stored in the CIP.

There are different reasons why not all measures in the LH cities are included in this deliverable. Some measures are, due to delay in the implementation not in operation yet, some have not started the collecting data or are not connected to the CIP yet. For other measures, the data transfer to the KPI tool has not been established yet. The current version of D9.6 is still submitted with certain gaps but thanks to joint effort from all involved partners, the gaps will be filled soon.

Table 1: List of relation to other activities

Number	Title	Relation (Input/Output)
D4.6 [M30]	Integration of CIP in LH Cities	Output used to connect to the CIP, in each LH city, the monitoring equipment that is required to collect real time, high resolution data.
D5,6,7. 3,4,5,6,7 [M24]	Launch of the activities in each TT in Utrecht, Nice, Gothenburg	Input used for description of the monitoring methodology and listing of all variables to be measured.
D9.2 [M12]	Report on monitoring and evaluation schemes for integrated solutions	Input used for the creation of the data collection and data analysis methodologies.
D9.3 [M12]	Report on data model and management plan for integrated solutions	Input used for the creation of the data collection methodology.
D9.4 [M24]	Establishment of a unified framework for harmonized data gathering, analysis and reporting	Input used for the creation of the data collection methodology.
D9.6: (M38)	Intermediate report after one year of measurement	Output, as the actual performance data collection and reporting will be carried out in this deliverable. Moreover, the KPI tool will be used to calculate and visualize the KPIs in each LH city.
D9.6: (M60)	Report on evaluation and impact analysis for integrated solutions	Output, as the actual performance data collection and reporting will be carried out in this deliverable. Moreover, the KPI tool will be used to calculate and visualize the KPIs in each LH city.

D9.9: (M30)	Second update of the Data Management Plan	Output, the information for all data variables provide the basis for the data input of the data management plan.
D5,6,7. 8	Preliminary report on lighthouse demonstration activities	Input used for description of the monitoring methodology and listing of all variables to be measured. Output in form of update KPI list and first results of KPI
D8.4 – D8.12	Replication plans of follower cities, European level replication guidelines	Output used for monitoring and evaluation of IRIS replicable solutions.

1.4 Structure of the deliverable

The structure of this deliverable is as follows:

Chapter 1: Introduction, where the scope, objectives and expected impact of the report are described. Relation to the other work packages in the IRIS project are given and Demonstrations excluded from this deliverable is listed

Chapter 2: Methodology describes what methods used to obtain the results presented in this report.
Chapter 3: Revision of KPIs includes the modifications made to the original KPI lists, and what data sources are used das well as an overview of all KPIs included in the IRIS project.
Chapter 4: Data collection overview
Chapter 5: Presents the results for the measures that have transferred data in the Lighthouse city Utrecht

Chapter 6: Presents the results for the measures that have transferred data in the lighthouse city Nice
Chapter 7: Presents the results for the measures that have transferred data in the lighthouse city Gothenburg

Chapter 8: Output to other work packages, it specifies how the work described in this report will be used by other work packages in the IRIS project.
Chapter 9: Conclusions, next steps and recommendation

1.5 Demonstrations excluded from deliverable

Unfortunately, not all measures in the LH cities are included in this deliverable. There are different reasons for this, some measures are not yet in operation or have not yet started collecting measurements while for others the data transfer to the KPI tool has not been established yet. The excluded measures for each LH city are listed below, with a brief explanation of the reason behind it.

1.5.1 Utrecht

In total, 21 measures in Utrecht are excluded from this deliverable. A brief explanation to the exclusion is given in Table 2 while more details can be found in the deliverables of the LH city D.5.8 [3].

Table 2: Overview of measures not included in Utrecht with a short explanation to the reason.

Measure Number	Measure title	Explanation
Transition Track 1		
Measure 1	District wide PV	Data in CIP, connection with KPI tool not established
Measure 2	LT district heating	Implementation of measure delayed
Measure 3	HEMS TOON	No results from surveys yet
Measure 4	NZEB refurbishment	Data in CIP, connection with KPI tool not established
Measure 5	Smart (hybrid) e-heating systems	Data in CIP, connection with KPI tool not established
Measure 6	AC/DC home switchboxes	Implementation of measure delayed
Measure 7	Smart DC Street Lighting	Data to CIP pending
Transition Track 2		
Measure 1	Solar V2G charging points for e-cars/e-vans (demand driven)	Implementation of measure delayed
Measure 2	Solar V2G charging point for e-buses	Implementation of measure delayed
Measure 3	Stationary storage in apartment buildings	Implementation of measure delayed
Measure 4	EMSs- Smart Energy Management System	Implementation of measure delayed
Transition Track 4		
Measure 1	Monitoring E-Mobility with LoRa network	No KPIs
Measure 2	Smart Street Lighting with multi-sensoring	No KPIs
Measure 3	3D Utrecht City Innovation Model	No KPIs
Measure 4	Monitoring Grid Flexibility	No KPIs
Measure 5	Fighting Energy Poverty	Data in CIP, connection with KPI tool not established
Transition Track 5		
Measure 1	Community building by change agents	No results from surveys yet
Measure 2	Campaign District School Involvement	No results from surveys yet
Measure 3	Campaign Smart Street Lighting	No results from surveys yet
Measure 4	Co-creation in Local Innovation Hub	No results from surveys yet
Measure 5	XR Experience	No results from surveys yet

1.5.2 Nice

In total 12 measures in Nice are not included in this deliverable. More details on the reasons are given in the deliverables of the LH city D6.8 [4].

Table 3: Overview of measures not included in Nice with a short explanation to the reason.

Measure Number	Measure title	Explanation
Transition Track 1		
Measure 3	Commissioning process from the design of the operation	No results from surveys yet
Measure 4	Dashboard providing real-time energy balance	No data available yet
Transition Track 2		
Measure 1	LEM - Local Energy Management system	No data available yet
Measure 2	DHC Smart District Heating and Cooling optimization algorithm - Phase 1: Monitoring on a part of the network DHC Smart District Heating and Cooling optimization algorithm - Phase 2: Full monitoring (with electric and thermal storage)	No data available yet
Measure 3	Stationary storage deployment in buildings and local electric flexibility management	No data available yet
Transition Track 3		
Measure 1	Dynamic energy management of an EV charging network - Phase 1: baseline EVCI supervision management Dynamic energy management of an EV charging network - Phase 2: V1G and V2G based smart charging services	No data available yet
Measure 2		No data available yet
Transition Track 4		
Measure 1	Sensors data collection in air quality - Phase 1: With legacy air sensors) Sensors data collection in air quality - Phase 2: With microsensors	No data available yet
Measure 2	BIM/CIM data display	No data available yet
Measure 3	Charging infrastructure data for optimal EV-based free-floating car sharing - Phase 1: Connected to phase 1 of measure 3.2	No data available yet

	Charging infrastructure data for optimal EV-based free-floating car sharing - Phase 2: Connected to phase 2 of measure 3.2	
Transition Track 5		
Measure 1	Public awareness campaign on air quality - Phase 1: with IMREDD targetted audience Public awareness campaign on air quality - Phase 2: with public stage media	No results from surveys yet
Measure 3	Citizens individual engagement – IOT invoices	No results from surveys yet

1.5.3 Gothenburg

In total eleven measures in Gothenburg are excluded from this deliverable. A brief explanation to the exclusion is given in the table below while more details can be found in the deliverables of the LH city D.7.8 [5].

Table 4: Overview of measures not included in Gothenburg with a short explanation to the reason.

Measure Number	Measure title	Explanation
Transition Track 1		
Measure 3	Cooling from geo energy without chillers	The cost of the installation increased significantly since the planning phase and the additional fundraising needed delayed the installation of the connection from Brf Viva to the office block. Therefore, this measure is not yet in operation.
Measure 5	Seasonal energy trading (cooling in summer season) with adjacent office block	See Measure 3.
Measure 6	Advanced Energy Management System to achieve peak shaving and minimal environmental impact	No data transferred yet. Info to be included from partners deliverable
Transition Track 2		
Measure 3	Low temperature DH 45/30 system for six buildings	Has no KPIs
Transition Track 5		
Measure 1	Further develop the city’s online	No data transferred yet

	citizensourcing platform "Min Stad"	
Measure 2	Further develop the city's online citizensourcing platform "Min Stad"	No data transferred yet
Measure 3	Further develop the city's online citizensourcing platform "Min Stad"	No data transferred yet
Measure 4	Further develop the city's online citizensourcing platform "Min Stad"	No data transferred yet
Measure 5	Minecraft as a tool for citizen engagement	No data transferred yet
Measure 6	Demonstrate a BIM (Building Information Modeling) based AR/VR app	No data transferred yet
Measure 7	Demonstrate the Personal Energy Threshold (PET)	No data transferred yet

2 Methodology

This chapter describes the methodology used to collect the required data from each measure to enable calculation and evaluation of the KPIs for the IRIs LH cities. Figure 1 shows a schematic overview of the process of selecting KPIs to include in the evaluation and identifying the required data needed from each measure in the different TT and LH cities. It also shows the process of transferring the data, in the right format, into the IRIS KPI tool where the results can be aggregated and visualized. The KPI used in this deliverable are updated versions of the KPI developed in task 9.4.

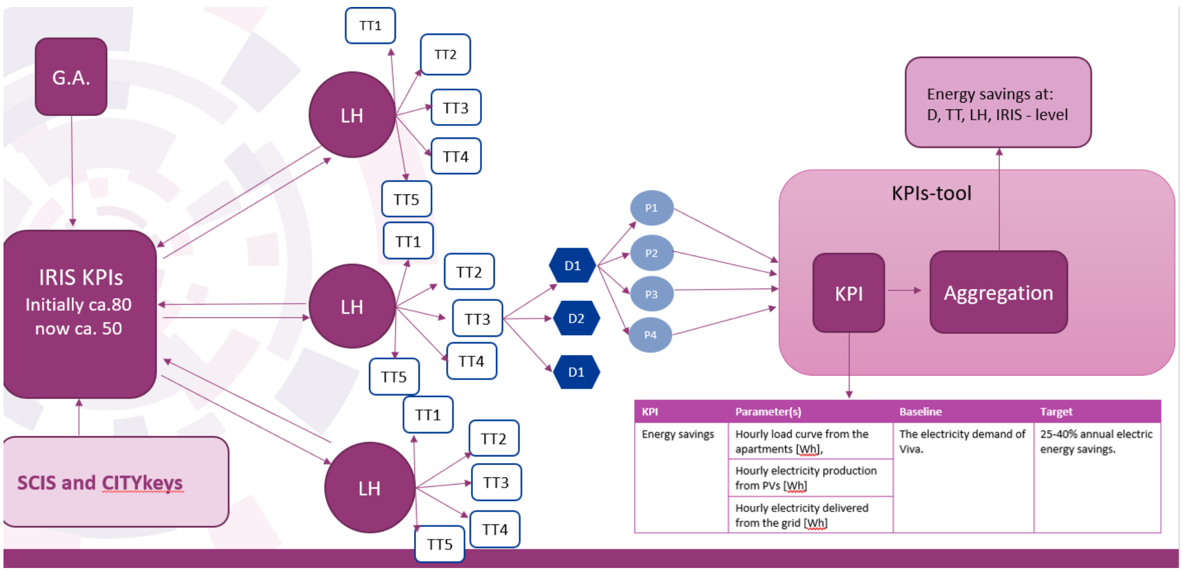


Figure 1: Schematic overview of the process of selecting KPIs to include in the evaluation, identifying the data needed from each measure and transferring it to the KPIs-tool.

The work in T9.5 is based on the monitoring framework developed in T9.4, which was reported in D9.5 [1]. In T9.5 further KPI adjustment and parameter harmonization needed to be done. This was conducted in cooperation with the partners and the process is described in Paragraph 2.2.

The IRIS KPI tool was developed in T9.3 and reported in D9.4 [2]. The basic function of the KPI tool is described in Paragraph 2.1. Since not all measures are connected to the City Information Platform (CIP) an option of manual data entry into the tool was needed. The data collection process is described in Paragraph 2.3

The evaluation and aggregation of KPI is done in the KPI tool and further explained in Paragraph 2.4. To obtain an overview of the status of all the measures, within the different LH cities, an online monitoring timeline was created and continuously updated. This process is described in Paragraph 2.5.

2.1 KPI tool

The project's monitoring operations, as well as the overall evaluation and impact analysis of the initiatives in the LH cities, are aided by the IRIS KPI tool. The IRIS KPI tool is available at http://monitoring.irissmartcities.eu. The tool is a platform which collects monitoring data from a variety of sources and uses it to generate the KPI chosen for each measure. The monitoring data from the IRIS demos is collected in a manual or automated manner.

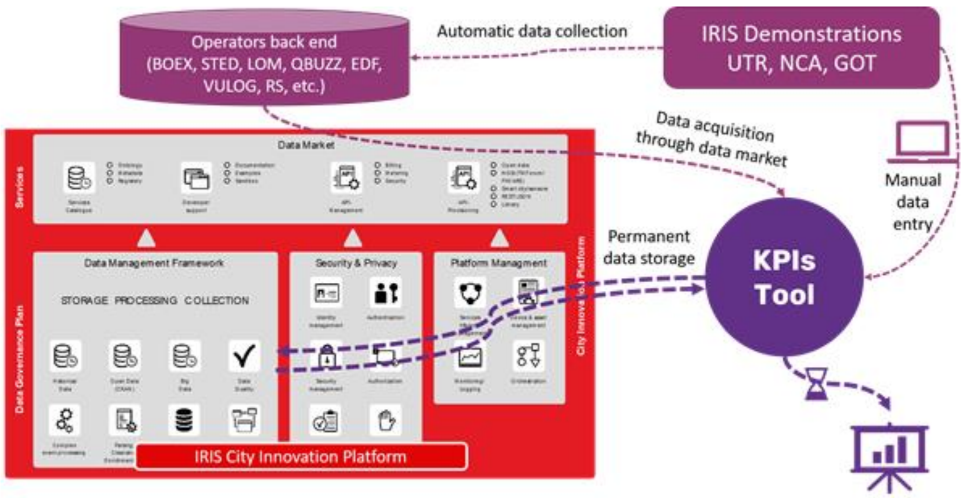


Figure 2: Schematic diagram presenting the connection of the IRIS KPI tool with CIP and LH cities' demonstrations

The tool is being tailored to the preferences and requirements of the KPI data owners and other project participants in an ongoing collaborative process. This technique will ensure that the KPI tool supports the project's monitoring, evaluation, and impact assessment activities successfully.

The KPI tool displays the KPIs at various levels of detail, including measure (demonstrator), Transition Track, LH city, and finally, the IRIS project. The tool's functionality was tailored to the demands and requirements of its users. There are three different kinds of users:

1. **Administration User:** The administrator has complete access to all components, configures and manages them, and takes all technical tasks necessary to ensure the tool's flawless operation. The administrator builds the multiple views, creates dashboards and graphs that exhibit the KPI and picks the chart that is best appropriate for each KPI on the KPI Monitoring Dashboard.

2. **The IRIS partner user:** The IRIS partner user is the tool's typical user. This user can see the KPIs' numerical values for all lighthouse cities as well as performance data (i.e. the numerical values of the variables that are used in the calculation of each KPI). Furthermore, the IRIS partner user can view numerical KPI values at several levels of spatial aggregation (e.g., IRIS project, LH city, Transition Track, Measure, Building / District / System). The restriction is that he cannot edit existing dashboards or panels or create new ones.

3. **General User:** This user category includes everyone who is interested in the IRIS project's outcomes. Without a user account, visitors to http://monitoring.irissmartcities.eu can use the KPI tool, although with reduced capabilities compared to IRIS users.

The following views are available for the **IRIS Overview user:**

IRIS Project View
KPIs at the IRIS level (consolidated)
KPIs per LH city (consolidated at the city level)
KPIs per TT (and city)

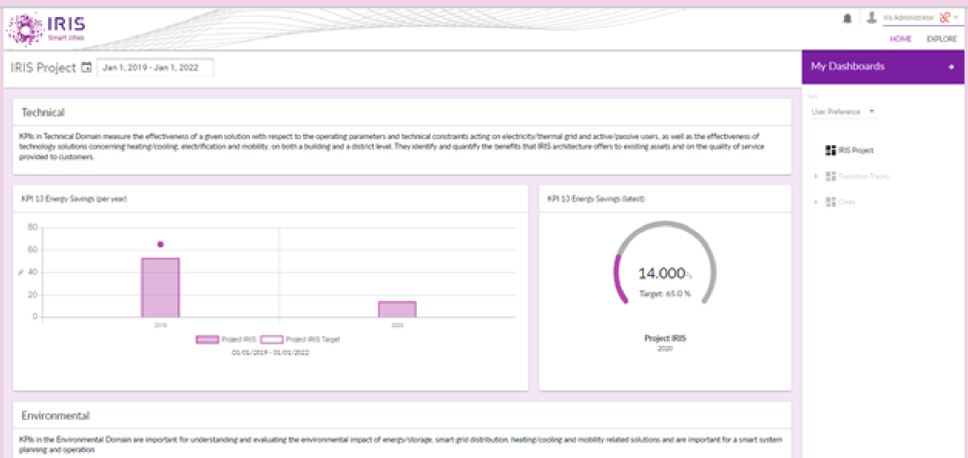


Figure 3 KPIs at the IRIS level

LH City View
KPIs at the city level (consolidated)
KPIs at the TT level (consolidated)

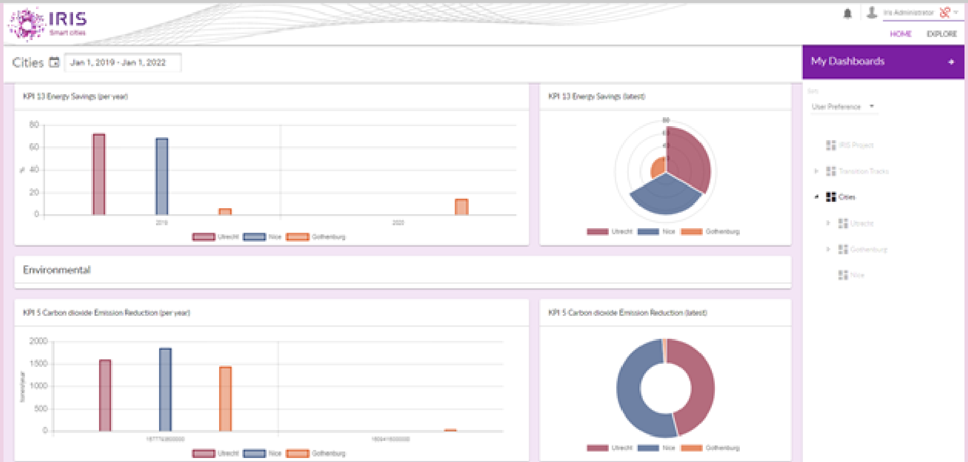


Figure 4 KPIs per City view

Transition Track View

KPIs at the TT level (consolidated)

KPIs at the Measure (Demonstrator) level

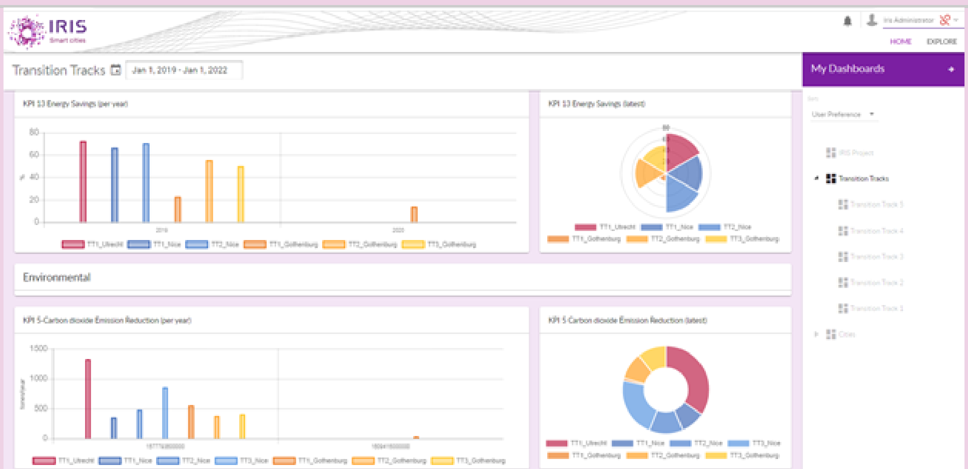


Figure 5 KPIs per TT

Measure View

KPIs of the measure

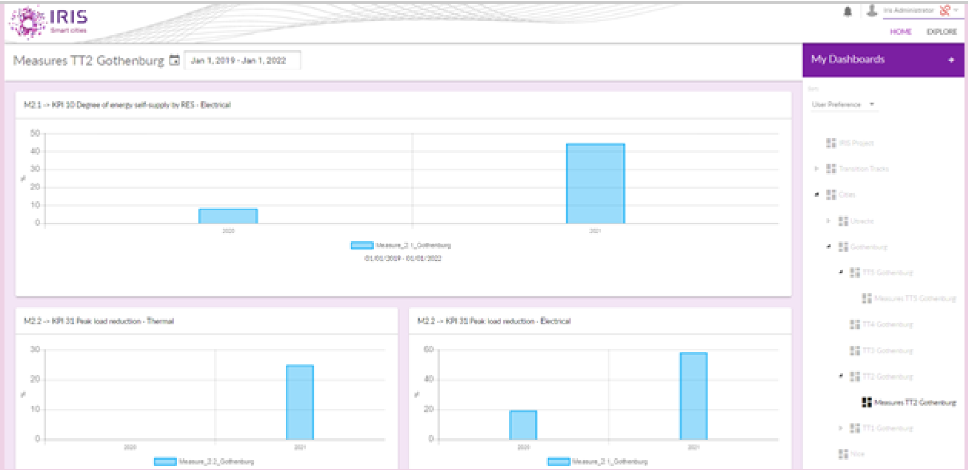


Figure 6 KPI per Measurement

Building / District / System View
KPIs for the Building / District / System
KPI View
Value at IRIS Level
Value at LH City Level
Value at Transition Track Level
Value at Measure Level
Building

Figure 3: Overview of layout of KPI tool

2.2 KPI adjustment and parameter harmonization

The process of assuring that the KPIs are defined in a manner that enables clear interpretation and consistent use has continued in task 9.5, in close dialog with partners, highlighting need to clarify some KPI cards with i.e. units, formulas or use cases. The changes and updates made to KPI cards have been tracked in a changelog to ensure transparency and trackability.

The continuous dialog with responsible partners has also led to further harmonization of parameters used. In some cases, a translation was needed between what is measured by partners and what is stated in the KPI card, and therefore used in the KPI tool. In other cases, the dialog has led to KPIs being removed or added to better capture and evaluate what the measure aims at achieving and the data that is collected.

2.3 Data collection

The process of collecting the data needed for evaluation of the different measures is described in the following paragraphs. The data has been collected from the responsible partners either manually or via connection to CIP.

2.3.1 Manual data collection

To enable manual data collection, two excel templates (Survey Template and Measure Template) have been developed. The “Survey template” is related to 9 KPIs, whose calculation is based on surveys. The ‘’Measure Template’’ is related to all other KPIs. The templates contain all the relative measures at the available aggregation levels (i.e. city, transition track, building). The measurement data providers can define the measure for which they provide measurements by using several drop-down menus. The first step in these menus is to fill in of the user. The options are related to the city, the Transition Track, the measure, the relevant KPI and finally the preferred variable. The drop-down menus are interconnected. Secondly, (step 2) the user inserts the number of people who selected each option in this survey and note in the specific cell that shows the reference time. A new column can be created by completely copying the previous one, then pasting it and changing the preferred options (step 3).

The steps are illustrated in figure 4 below for the Survey Template.

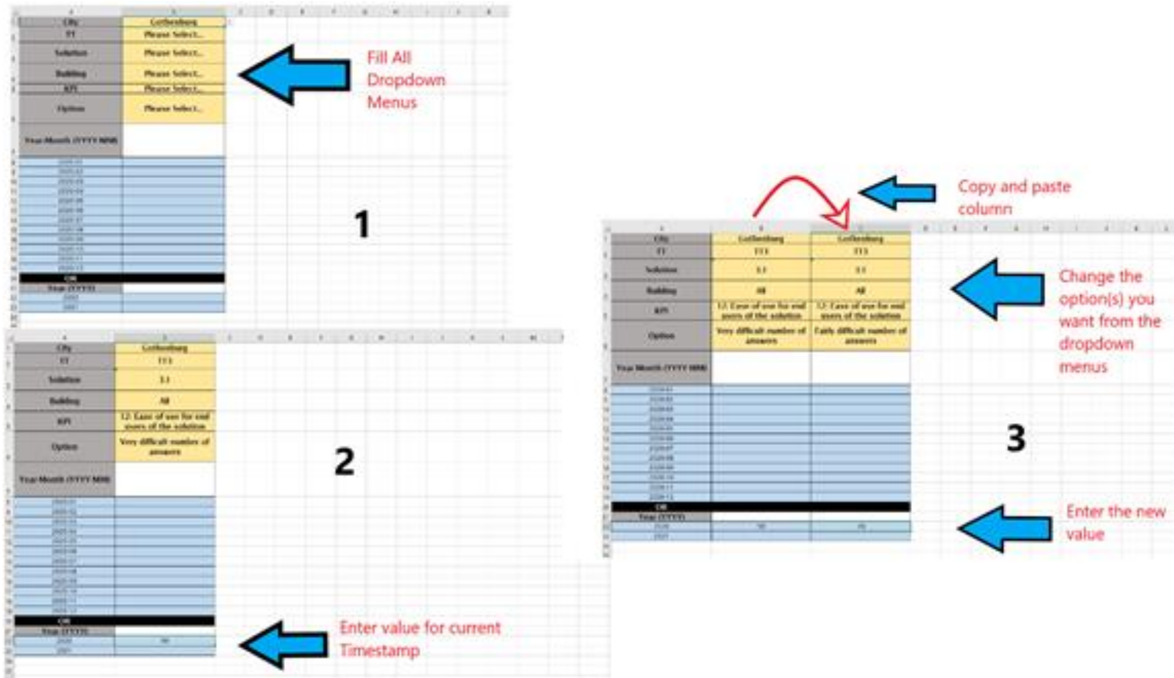


Figure 4: Steps to complete the Survey template

More specifically, the Survey Excel template consists of 6 drop-down menus. The options are related to the city, the Transition Track, the measure, the relevant KPI and finally the preferred variable.

Below is an example of the Survey Excel template. Assume that KPI 12 (Ease of use for end users of the solution) must be completed for Gothenburg City, TT3 and M3.1. From the drop-down menus, the data provider must select these options and in the next step one of the five different variable options. For example, for KPI 12 “Ease of use for end users of the solution”, possible variables are:

- Very difficult number of answers
- Fairly difficult number of answers
- Slightly difficult number of answers
- Fairly easy number of answers
- Very easy number of answers

The final template for the City of Gothenburg, TT3, M3.1 have 5 columns with modified value “Option” and a new data entry for selected timestamp as shown in the figure below.

A	B	C	D	E	F
City	Gothenburg	Gothenburg	Gothenburg	Gothenburg	Gothenburg
TT	TT3	TT3	TT3	TT3	TT3
Solution	3.1	3.1	3.1	3.1	3.1
Building	All	All	All	All	All
KPI	12: Ease of use for end users of the solution	12: Ease of use for end users of the solution	12: Ease of use for end users of the solution	12: Ease of use for end users of the solution	12: Ease of use for end users of the solution
Option	Very difficult number of answers	Fairly difficult number of answers	Slightly difficult number of answers	Fairly easy number of answers	Very easy number of answers
Year-Month (YYYY-MM)					
2020-01					
2020-02					
2020-03					
2020-11					
2020-12					
OR					
Year (YYYY)					
2020	0	10	20	60	50
2021	0	0	30	50	60

Figure 5: Example of a complete survey template

The measure excel template is divided into three sheets. The first sheet is referred to City Level, the second to the building level and the third to the solution level. The user can select the desired sheet as shown at the bottom of the excel file.

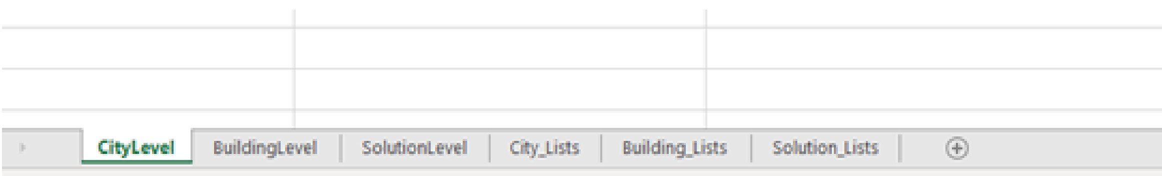
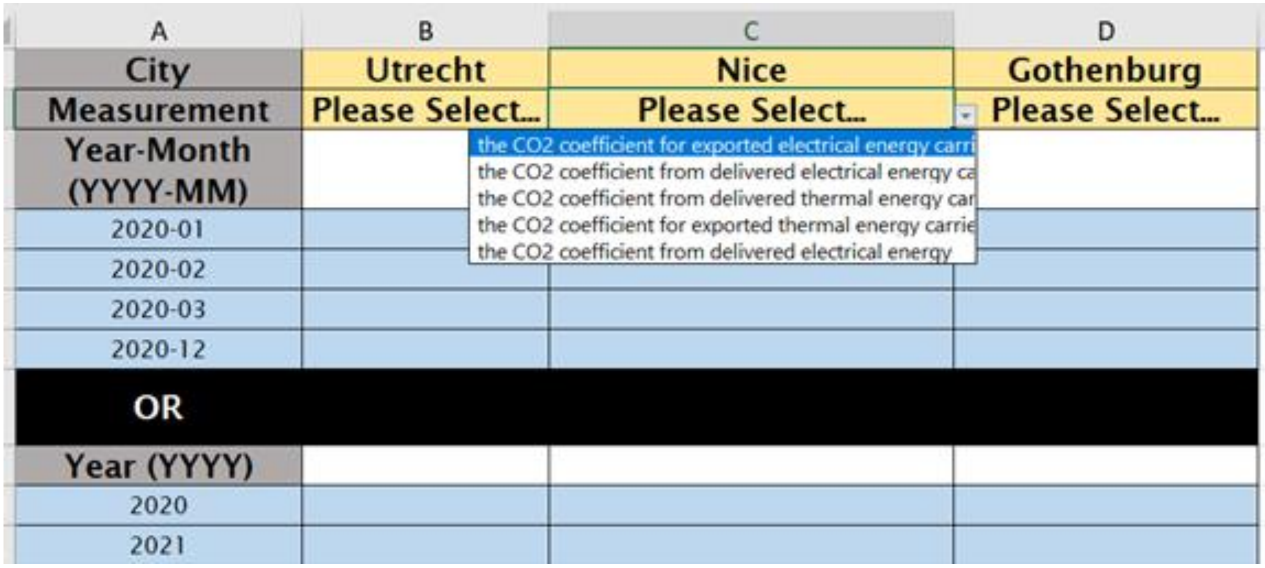


Figure 6: Different sheet Levels of Measure Template

In each sheet, after selecting the desired variables from the menu, the user enters the measurements next to the respective dates (depending on whether the data is monthly or annual). New column can be created in the same way as mentioned in the previous paragraph.

<u>City Level Sheet</u>

There are two drop-down menus on this sheet. One for the selection of the city and another for the selection of the measure. An example of the City level sheet is shown in the figure below.

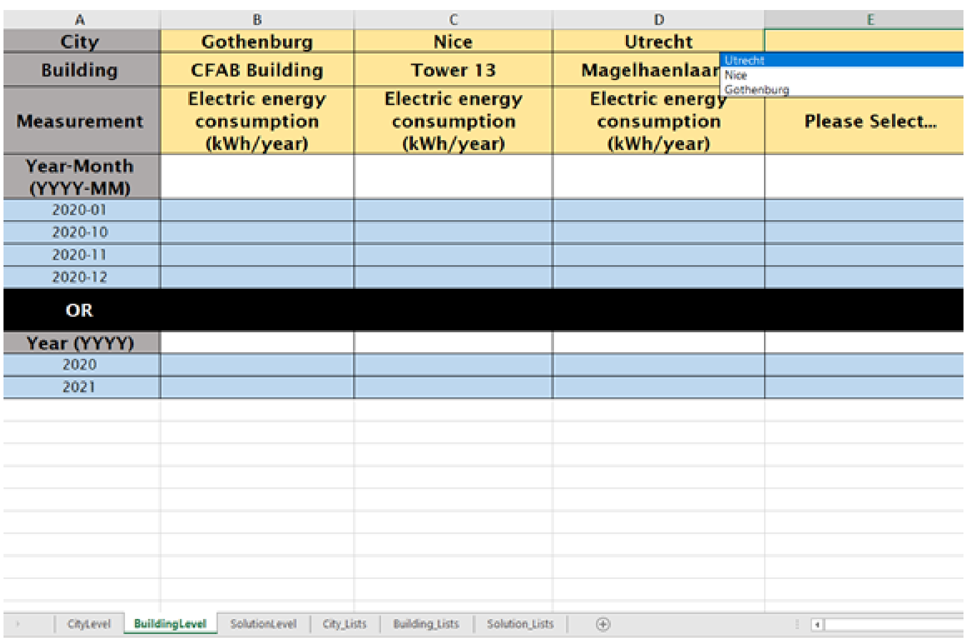


A	B	C	D
City	Utrecht	Nice	Gothenburg
Measurement	Please Select...	Please Select...	Please Select...
Year-Month (YYYY-MM)			
2020-01			
2020-02			
2020-03			
2020-12			
OR			
Year (YYYY)			
2020			
2021			

Figure 7: City Level Sheet Template of a Measure Template

<u>Building sheet</u>

In this sheet there are options for the city, the building and the measure. The figure below is an example of a building level sheet.



A	B	C	D	E
City	Gothenburg	Nice	Utrecht	
Building	CFAB Building	Tower 13	Magelhaenlaan	
Measurement	Electric energy consumption (kWh/year)	Electric energy consumption (kWh/year)	Electric energy consumption (kWh/year)	Please Select...
Year-Month (YYYY-MM)				
2020-01				
2020-10				
2020-11				
2020-12				
OR				
Year (YYYY)				
2020				
2021				

Figure 8: Building Level Sheet of a Measure Template

Solution Level

There are five drop-down menus on this sheet, the figure below illustrates an example of a solution level sheet.

In solution level, options are available about city, transition track (TT), solution, building and measure

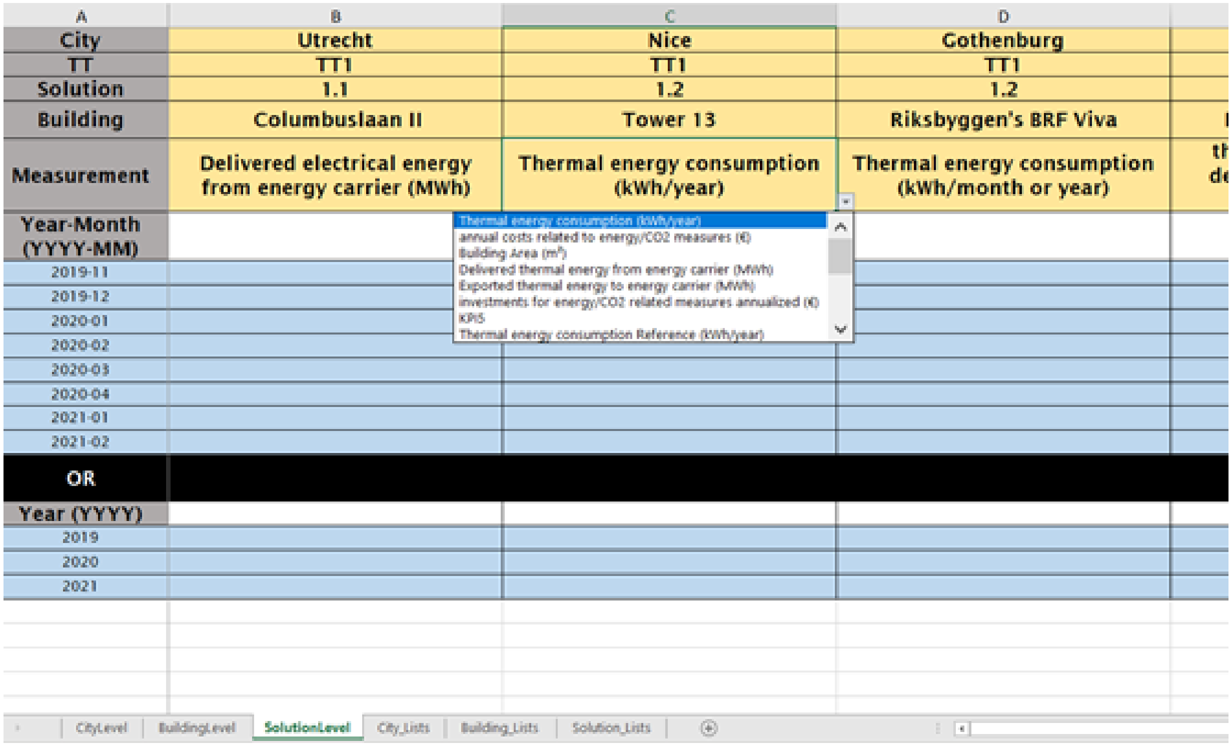
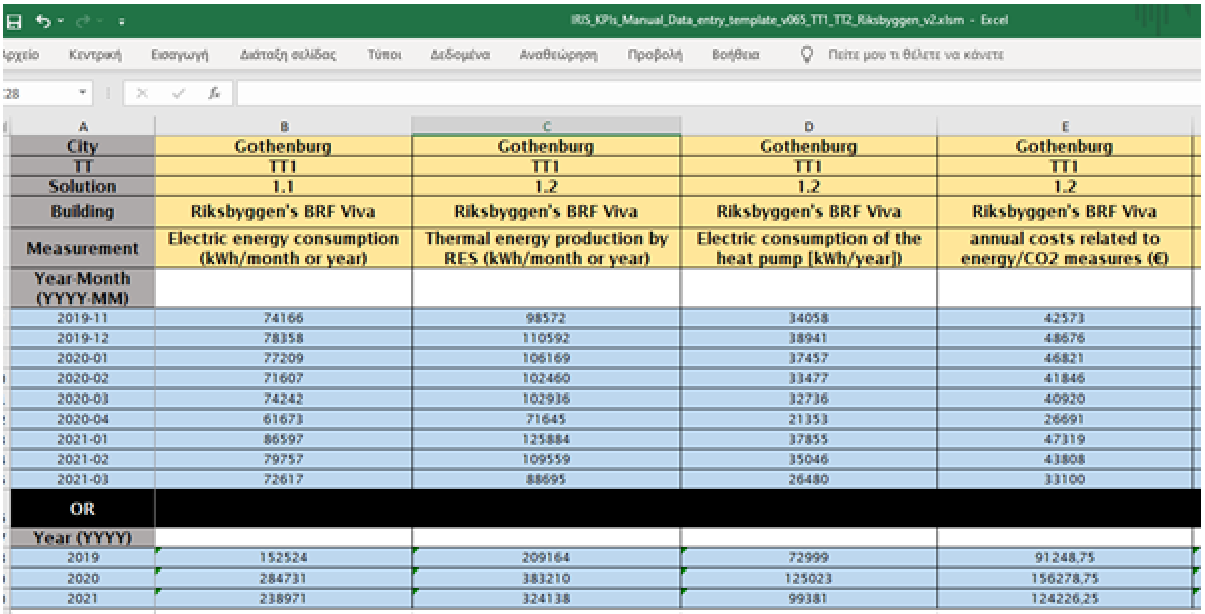


Figure 9: Solution Level Sheet of a Measure Template

An example of a filled solution level template is shown in the figure below. In this, there are values for both monthly and annual data.



A	B	C	D	E
City	Gothenburg	Gothenburg	Gothenburg	Gothenburg
TT	TT1	TT1	TT1	TT1
Solution	1.1	1.2	1.2	1.2
Building	Riksbyggen's BRF Viva	Riksbyggen's BRF Viva	Riksbyggen's BRF Viva	Riksbyggen's BRF Viva
Measurement	Electric energy consumption (kWh/month or year)	Thermal energy production by RES (kWh/month or year)	Electric consumption of the heat pump [kWh/year])	annual costs related to energy/CO2 measures (€)
Year-Month (YYYY-MM)				
2019-11	74166	98572	34058	42573
2019-12	78358	110592	38941	48676
2020-01	77209	106169	37457	46821
2020-02	71607	102460	33477	41846
2020-03	74242	102936	32736	40920
2020-04	61673	71645	21353	26691
2021-01	86597	125884	37855	47319
2021-02	79757	109559	35046	43808
2021-03	72617	88695	26480	33100
OR				
Year (YYYY)				
2019	152524	209164	72999	91248,75
2020	284731	383210	125023	156278,75
2021	238971	324138	99381	124226,25

Figure 12: A filled example of a Measure template

Gathering data from partners

Dialog with responsible partners was needed to explain and ensure understanding of the layout, functionality and formats used in the template. Furthermore, the process of how and when data was going to be transferred from the partners to the KPI tool needed to be explained. This dialog was achieved through meetings and the first actual transfer of data through the template served as trial. Through the dialog with responsible partners and the trial of manual data transfer valuable feed-back on the template and minor errors in it, was obtained.

Validator development

In the process of manually collecting data, there is a possibility of errors in the way the data provider fills in the measure template. For that reason, a validation tool has been developed to ensure an error-free competed template. All measure templates must be checked with the validator, before being sent to the partners responsible for data processing in the KPI tool. The validator tool is used for the measure templates only and not for the survey templates. Validator main page is shown in figure 10. The user could click the ''choose a file'' button, upload a file and click ''validate'' to check a file for errors.

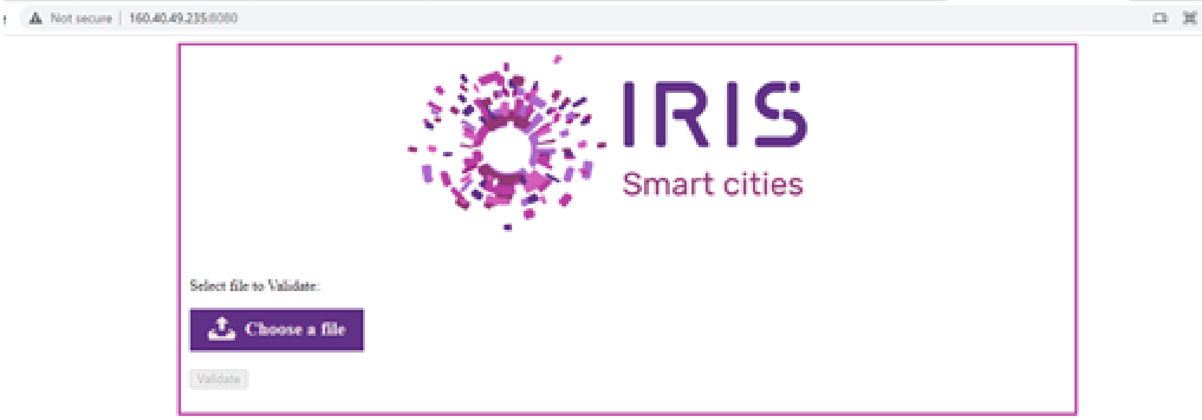


Figure 10: Main page of the validator deployment tool

In the next screen, the validator will determine if the uploaded file is correct or if changes need to be made.

The changes needed can be of two types. First type is the **Error** and second the **Warning**.

- **Errors** could appear in the data cells if one of them contains characters or other symbols that are not numbers. Errors could also occur if the date values are in any form other than "YYYY-MM" or "YYYY / MM".
- **Warnings** could appear in the data cells if there is an empty cell. Moreover, a warning message will appear if there are dates that appear more than once in date cells.

If a template file contains errors, it must be corrected and validated until there are no errors. However, warnings are changes that do not need to be corrected but are recommended to be checked.

The following figures show a rejected file (Figure 11) and an approved file (Figure 12) by the validator.

Figure 11: Rejected file by the validator

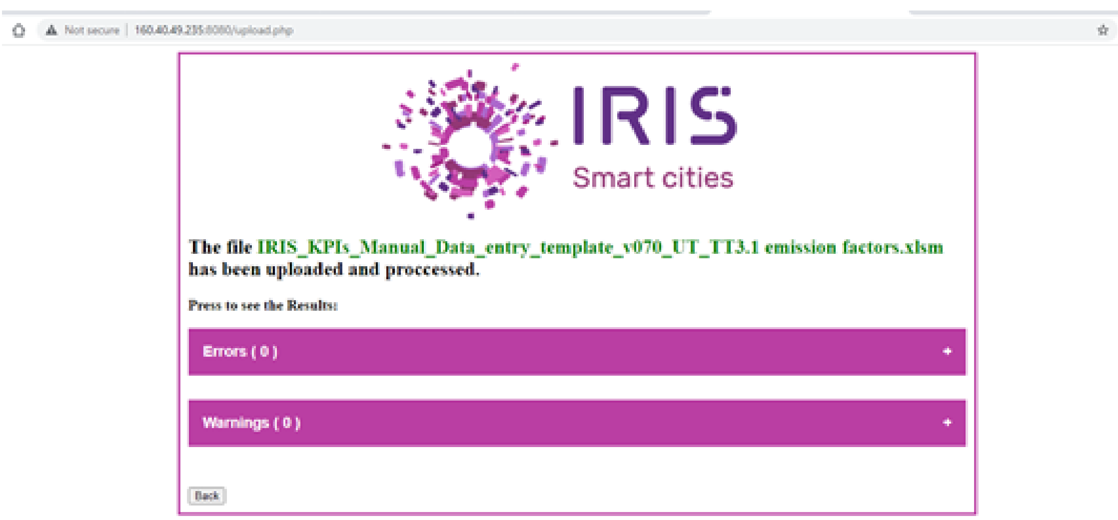


Figure 12: Approved file by the validator

2.3.2 Data collection via CIP

For CIP data collection, an automated way for data gathering has been developed, so the KPI tool to be connected to specific CIP endpoints throughout the RESTful API. This automation calls and receives the measurements needed for KPI calculations. Each API endpoint gives a response in json format which is then parsed through the automation tool for the necessary transformation so it can be stored in the database. The aggregation of the time for each measurement can be adjusted on a monthly or annual basis.

Data from low-level entities refers to data measured or extracted at the level of Buildings, Districts, or Systems. Such information can range from energy measurements to expenses to replies gleaned via structured/Likert-scale questionnaires.

Below is an example of a call in CIP's RESTful API through Postman software. The answer is in json format.

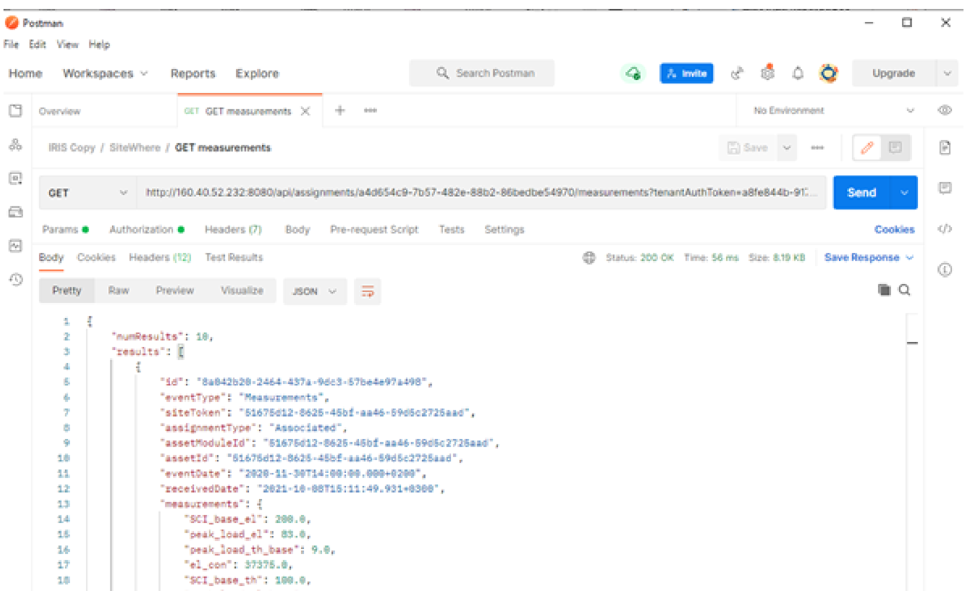


Figure 13: Example of API endpoint call by Postman software

2.4 Data evaluation

The data collected and included in the KPI tool was used to also calculate the KPIs manually. This calculation allowed for an initial evaluation of the accuracy of the data and identification of potential errors in the KPI tool. When different results are obtained from the manual calculation and the KPI tool they will be checked and controlled with the responsible partner for the demonstration. This will be an ongoing process to ensure accurate results and correct interpretation. The time period when the data was collected needs to be considered when evaluating and analyzing it. The Covid-19 pandemic might have affected the energy use and travel patterns, as more people have worked from home. Additionally, it needs to be considered if the weather was normal or if it differed considerably in terms of, for instance, temperature or hours of sunshine.

2.5 Keeping track of progress

To be able to continually keep an updated overview of the data collection progress, a measure tracker sheet for each LH city was created in the IRIS Demo measure tracker. This monitoring sheet was developed to compile information on measures such as title, which month monitoring started, contact person and if the measure is connected to CIP or if the data will be transferred manually to the KPI tool. Moreover, in the IRIS Demo measure tracker colors, shown in Table 5, were used to indicate the data collection progress for each measure.

Table 5: Colours used in the measure tracker to indicate status of data collection for different measures

Data collected by partner, transferred to KPI tool and included in D9.6
Data collected by partner, transferred to the KPI tool under progress
Data collected by partner, transferred to KPI tool not started
Monitoring not started
No KPIs

Parts of the information included in these monitoring sheets were extracted and included in Chapter 4 to provide an updated overview of the data collection progress.

3 Revision of KPIs

3.1 Update of KPI cards

Paragraph 2.1.1 of report D9.5 [1] describes the iterative process of how the description and calculation of KPIs was updated to obtain a workable situation with the data obtained from the demonstrators and to provide meaningful results.

After submission of D9.5 the KPI tool was set up with the KPI formulas and provided with data from the demonstrators to calculate results. During the process of working with real data, new problems or inconsistencies occurred, such as:

- Non harmonious use of units, eg. Tonnes vs Kg, kWh vs MWh etc.
- In some cases, KPIs calculated as a percentage give meaningless results (always 100% or 0% when baseline is 0)
- Inconsistencies in the name / description of the KPI and what is being calculated.
- Unclarity on how to calculate KPI

Because of the above reasons further adaptation of several KPI-cards was done by the WP9 team. In each case with a close look on what the effect of these adjustments would be on all demonstrators where these KPIs were calculated. These adaptations included:

- Harmonization of units
- Homogenization of the calculation method of comparable KPIs
- Changing KPI output to absolute numbers, instead of percentage
- Addition of use cases to clarify the utilization and calculation of the KPI
- Adjustment of the KPI description

This resulted in a new document with updated KPI-cards for the KPIs listed in the table below**Σφάλμα! Το αρχείο προέλευσης της αναφοράς δεν βρέθηκε.**. In order to make sure that all main adaptations to KPIs are clearly registered, this document commences with a changelog, which is illustrated in Appendix 1.

Table 6: Modified KPIs compared to D9.5

KPI #	KPI name
5	Carbon dioxide emission reduction
6	Carbon monoxide emission reduction
10	Degree of energy self-supply by RES
15	Fine particulate matter emission reduction
20	Increase in Local Renewable Energy production

21	Increased system flexibility for energy players/stakeholders
24	Nitrogen oxide emission reduction
34	Reduced energy cost for customers
35	Reduced energy curtailment of RES and DER
37	Reduction in annual final energy consumption by street lighting
38	Reduction in car ownership among tenants
39	Increased km by tenants and employees in the district
42	Storage capacity installed
45	User engagement
47	Quality of open data
53	Storage Energy Losses

3.2 Harmonization of parameters

To ensure consistent use of KPIs in the evaluation of different measures and avoid misunderstanding, the parameters measured and used to establish the KPIs were harmonized. This work is closely connected to the update of the KPI cards in general and the work with homogenization of the calculation method of comparable KPIs in particular. The harmonization work was done as part of the dialog with partners in the process of collecting data, see section 2.2.

In the subsequent result sections 5-7, the parameters that are being measured and used to establish the KPIs are included for each measure.

In some cases, it was necessary to translate the parameters used by the partners to the corresponding parameters used in the KPI cards. One such example is shown below. In this case, the partners parameters are equal to the ones used in the KPI card, they are only named differently.

Table 7: Example of translation of parameters needed for harmonization and smooth transfer to the KPI

Parameters used by partner	Parameters in KPI card
Very dissatisfied, number of answers	Very difficult, number of answers
Dissatisfied, number of answers	Fairly difficult number of answers
Neutral, number of answers	Slightly difficult number of answers
Satisfied, number of answers	Fairly easy number of answers
Very satisfied, number of answers	Very easy number of answers

3.3 Update of included KPIs for the LHC

In the following sections the new, removed or modified KPIs are listed for each LH city.

3.3.1 Utrecht

Below is a table of the new, modified or removed KPIs for the measures in Utrecht with a comment to explain the reason for the change.

Table 8: The changes of KPIs included in the evaluation of measures in Utrecht

TT.M	KPI	New	Modify	Remove	Comment
1.1, 1.6, 1.7, 3.1, 3.2	Carbon dioxide Emission Reduction		**X**		Updated KPI formula
3.1	Storage capacity installed		**X**		Updated KPI formula
3.1, 3.2	Fine particulate matter emission		**X**		Updated KPI formula
3.1, 3.2	Carbon monoxide emission reduction		**X**		Updated KPI formula
3.1, 3.2	NOx emission reduction		**X**		Updated KPI formula
5.6	Citizen engagement and Self- Maintenance	**X**			This is a new measure that was added to the IRIS project

3.3.2 Nice

Below is a table of the new, modified or removed KPIs for the measures in Nice with a comment to explain the reason for the change.

Table 9:The changes of KPIs included in the evaluation of measures in Nice

TT.M	KPI	New	Modify	Remove	Comment
2.1	Energy Savings			**X**	
2.1	Carbon dioxide Emission Reduction			**X**	The measure doesn't affect Carbon dioxide Emission Reduction

2.1	Battery degradation rate		**X**		Updated KPI formula
2.1	Reduced energy cost for costumers		**X**		Updated KPI formula
2.1	Peak load reduction			**X**	
2.1	Degree of energy self-supply by RES			**X**	Already calculated in TT M1
2.1	Increased system flexibility for energy players		**X**		Updated KPI formula
2.1	Reduced energy cost for costumers		**X**		Updated KPI formula
2.1	Storage capacity installed		**X**		Updated KPI formula
2.2	Storage capacity installed		**X**		Updated KPI formula
2.2	Energy Savings		**X**		Updated KPI formula
2.2	Reduced energy cost for costumers		**X**		Updated KPI formula

2.2	Degree of energy self-supply by RES		**X**		Updated KPI formula
3.1	Storage capacity installed		**X**		Updated KPI formula
3.1	Carbon dioxide Emission Reduction			**X**	The measure doesn't affect Carbon dioxide Emission Reduction
3.1	Increased system flexibility for energy players		**X**		Updated KPI formula
3.1	Number of e-charging stations deployed in the area		**X**		Updated KPI formula

3.3.3 Gothenburg

Below is a table of the new, modified or removed KPIs for the measures in Gothenburg with a comment to explain the reason for the change.

Table 10: The changes of KPIs included in the evaluation of measures in Gothenburg.

TT.M	KPI	New	Modify	Remove	Comment
1.1	Energy savings			**X**	The measure should result in production of electricity from PVs, so no energy savings and therefore this KPI is removed.
1.1	Carbon dioxide Emission Reduction		**X**		Updated KPI formula
1.2	Carbon dioxide Emission Reduction		**X**		Updated KPI formula
1.3	Carbon dioxide Emission Reduction		**X**		Updated KPI formula
1.4	Peak load reduction			**X**	Meters have not been installed in such a way that it will be possible to evaluate

TT.M	KPI	New	Modify	Remove	Comment
					the effect on peak load reduction for the measure.
1.4	Carbon dioxide Emission Reduction			**X**	Not possible to evaluate this measure at the level of detail needed to capture possible CO2 emission reduction since it would require momentary information regarding heat production units in the district heating grid. (Furthermore, the EMS (M1.6) will optimize the operation of the installations of Brf Viva to achieve lower costs, not CO2 emissions. Although it can be assumed that lower cost also is associated with lower emissions.)
1.4	CO_2 reduction cost efficiency			**X**	See explanation above.
1.4	Storage capacity installed		**X**		Updated KPI formula
1.5	Carbon dioxide Emission Reduction			**X**	Measure 1.5 and 1.3 are connected and to avoid double accounting this KPI is only included for 1.3.
1.5	CO_2 reduction cost efficiency			**X**	See comment above.
1.5	Energy savings			**X**	The KPI is removed since the aim of the measure is energy trading not energy savings
1.5	Peak load reduction			**X**	The KPI is removed since peak load reduction is not the aim of the measure
1.5	Reduced energy cost for customers		**X**		Updated KPI formula
1.6	Carbon dioxide emission reduction			**X**	The KPI is removed since this measure does not aim at or lead to reduction of CO2 emission.
1.6	Degree of energy self-supply by RES			**X**	This KPI is removed as the measure does not include renewable energy production
1.6	Peak load reduction			**X**	The KPI is removed since peak load reduction is not the aim of the measure
1.6	Increased system flexibility for energy stakeholders		**X**		Updated KPI formula
1.7	Carbon dioxide Emission Reduction		**X**		Updated KPI formula
2.1	Storage capacity installed		**X**		Updated KPI formula
2.2	Storage capacity installed		**X**		Updated KPI formula
2.2	Storage energy losses	**X**			Added KPI

TT.M	KPI	New	Modify	Remove	Comment
2.4	Battery degradation rate			**X**	If evaluation of battery degradation rate will be included it will be given by the provider of the batteries. Instead of measured data, which would be needed for a KPI calculation, there might just be a number, estimate or statement on the degradation of the batteries.
2.4	Storage capacity installed		**X**		Updated KPI formula
3.1	Carbon dioxide Emission Reduction		**X**		Updated KPI formula
3.1	Energy savings			**X**	The KPI is removed as the measure is not focused on energy savings.
3.1	Improved access to vehicle sharing solutions			**X**	The KPI was removed as it didn't fit the measure since it is new building
3.1	Reduction in car ownership among tenants		**X**		Updated KPI formula
3.1	Reduction in driven km by tenants		**X**		Updated KPI formula
3.2	Carbon dioxide Emission Reduction		**X**		Updated KPI formula
3.2	Energy savings			**X**	The KPI is removed as the measure is not focused on energy savings.
3.2	Reduction in car ownership among tenants		**X**		Updated KPI formula
4.1	Quality of open data		**X**		Updated KPI formula
4.2	Quality of open data		**X**		Updated KPI formula
5.1	User engagement		**X**		Updated KPI formula

3.4 Lessons learned on KPI revisions

The work performed by WP9 in the past period of the IRIS project has confirmed again the lessons previously learnt regarding KPI revisions which are described in paragraph 3.4 of D9.5 [1].

Further on, it is important to repeat that, even though it seems that KPIs can be chosen and defined at an early stage of a project, they should always be possible to modify those during the project period. Progressive insight, changes in the demonstrators or the emergence of interesting new indicators will require flexibility in the methods of monitoring and evaluation. When modifications are made, a detailed record of them should be kept, to make sure that any unforeseen side-effects can be dealt with.

3.5 Aggregation of KPIs

In paragraph 4.2 of D9.2 [6], possible aggregation of KPIs from different measures to transition track and Lighthouse city level are presented for each city. As certain KPIs and measures were updated in the process described in 2.2 these tables required revision. This chapter presents the updated tables. It shows the KPIs of each transition track and their position in the IRIS-KPI-House (figure below) for each city. It is not possible or relevant to aggregate all KPIs that are used for different measures to TT, LHC and IRIS project level. The idea with the KPI house and these aggregation tables is to provide an overview of the KPIs that will be aggregated and to what level this will be done.

The measures in the following tables are numbered as presented in the measure tracker, to understand what each measure means, it is recommended to have Annex 2 present while analysing these tables.

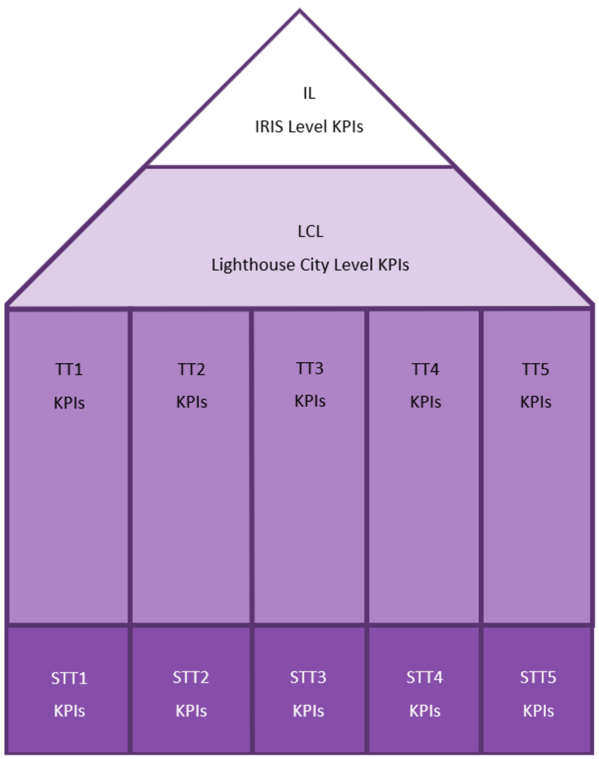


Figure 14: IRIS KPI-house illustrating how KPIs are aggregated from the solution level and up. The KPIs presented in the bottom part of the house, at solution level (STT1 – STT5) are, if possible, aggregated to transition track level (TT1-5) or higher to lighthouse city level or even to the top level, that is the entire IRIS project level.

3.5.1 Utrecht

3.5.1.1 TT1 Smart renewables and closed-loop energy positive districts

TT#1 level KPIs Carbon dioxide Emission Reduction Energy savings CO2 reduction cost efficiency Reduced energy cost for consumers						
Measure 1	**Measure 2**	**Measure 3**	**Measure 4**	**Measure 5**	**Measure 6**	**Measure 7**
Carbon dioxide Emission Reduction		Increased awareness of energy usage			Carbon dioxide Emission Reduction	Carbon dioxide Emission Reduction
Degree of energy self-supply by RES					Energy savings	Energy savings
Increase in Local Renewable Energy production					CO2 reduction cost efficiency	Reduction in annual final energy consumption by street lighting

Figure 15: KPIs of Utrecht TT1 with the associated solutions and their position in the IRIS KPI-house

3.5.1.2 *TT2:* Smart Energy Management and Storage for Energy Grid Flexibility

TT#2 level KPIs Peak load reduction Storage capacity installed			
Measure 1	**Measure 2**	**Measure 3**	**Measure 4**
		Storage capacity installed	

Figure 16: KPIs of Utrecht TT2 with the associated solutions and their position in the IRIS KPI-house

3.5.1.3 TT 3 Smart e-Mobility Sector

TT#3 level KPIs NOx emission reduction Fine particulate matter emission Carbon monoxide emission reduction Carbon dioxide Emission Reduction	
Measure 1	**Measure 2**
NOx emission reduction	NOx emission reduction
Fine particulate matter emission	Fine particulate matter emission
Carbon monoxide emission reduction	Carbon monoxide emission reduction
Carbon dioxide Emission Reduction	Carbon dioxide Emission Reduction
Access to vehicle sharing solutions for city travel	
Yearly km driven in e-car sharing system	

Figure 17: KPIs of Utrecht TT3 with the associated solutions and their position in the IRIS KPI-house

3.5.1.4 TT 5 Citizen Engagement

TT#5 level KPIs None				
Measure 1	**Measure 2**	**Measure 3**	**Measure 4**	**Measure 5**
Increased environmental awareness	People reached	Ease of use for end-users	Local community involvement in development process	Ease of use for end-users
People reached		Advantages for end-users		
Local community involvement in planning/ implementation phase		Local community involvement in planning/ implementation phase		

Figure 18: KPIs of Utrecht TT5 with the associated solutions and their position in the IRIS KPI-house

3.5.2 Nice

3.5.2.1 TT1 Smart renewables and closed-loop energy positive districts

TT#1 Level KPIs Energy Savings Carbon dioxide Emission Reduction Increase in Local Renewable Energy production Degree of energy self-supply by RES Storage capacity installed Battery Degradation Rate Increased awareness of energy usage Ease of use for end users of the solution			
Measure 1	**Measure 2**	**Measure 3**	**Measure 4**
Energy Savings	Energy Savings	Data loss prevention	Energy Savings
Carbon dioxide Emission Reduction	Carbon dioxide Emission Reduction	Increased awareness of energy usage	Carbon dioxide Emission Reduction
Increase in Local Renewable Energy production	C02 reduction cost efficiency		Increase Environmental awareness
Degree of energy self-supply by RES			Ease of use for end users of the solution
Storage capacity installed			User engagement
C02 reduction cost efficiency			

Figure 19: KPIs of NCA TT1 with the associated solutions and their position in the IRIS KPI-house

3.5.2.2 TT2 Smart Energy Management and Storage for Energy Grid Flexibility

TT#2 Level KPIs Increased system flexibility for energy players stakeholders Peak load reduction Storage capacity installed Battery Degradation Rate Reduced energy cost for costumers Investment costRatio of valorized PV RES Degree of energy self-supply by RES Energy Savings Carbon dioxide Emission Reduction		
Measure 1	**Measure 2**	**Measure 3**
Increased system flexibility for energy players stakeholders	Degree of energy self-supply by RES	Storage capacity installed
Peak load reduction	Energy Savings	Battery Degradation Rate
Storage capacity installed	Carbon dioxide Emission Reduction	Increased system flexibility for energy players stakeholders
Battery Degradation Rate	Peak load reduction	Investment cost
Reduced energy cost for costumers	Reduced energy cost for costumers	
Investment cost		
Ratio of valorized PV RES		

Figure 20: KPIs of NCA TT2 with the associated solutions and their position in the IRIS KPI-house

3.5.2.3 TT3 Smart e-Mobility Sector

TT#3 Level KPIs None	
Measure 1	**Measure 2**
Increased system flexibility for energy players stakeholders	Access to vehicle sharing solutions for city travel
Peak load reduction	Number of efficient vehicles deployed in the area
Storage capacity installed	Number of Free-Floating subscribers
Number of e-charging stations deployed in the area	
Reduced energy cost for costumers	

Figure 21: KPIs of NCA TT3 with the associated solutions and their position in the IRIS KPI-house

3.5.2.4 TT4 City Innovation Platform (CIP)

TT#4 Level KPIs Quality of open data Open data-based solutions		
Measure 1	**Measure 2**	**Measure 3**
Number of connected urban objects	Quality of open data	Open data-based solutions
Usage of open data	Quality of CIP	Quality of open data
Quality of open data	Usage of the dashboard	
Open data-based solutions	Usage of open data	
Share of RES in ICT power supply	Quality of open data	

Figure 22: KPIs of NCA TT4 with the associated solutions and their position in the IRIS KPI-house

3.5.2.5 TT5 Citizen Engagement

TT#5 Level KPIs People reached		
Measure 1	**Measure 2**	**Measure 3**
People reached	People reached	People reached
Increased environmental awareness	Increased environmental awareness	User engagement
	Increase awareness of energy usage	
	Increase consciousness of citizens	

Figure 23:KPIs of NCA TT5 with the associated solutions and their position in the IRIS KPI-house

3.5.3 Gothenburg

3.5.3.1 TT1 Smart renewables and closed-loop energy positive districts

TT#1 level KPIs Carbon dioxide Emission Reduction Degree of energy self-supply by RES						
Measure 1	**Measure 2**	**Measure 3**	**Measure 4**	**Measure 5**	**Measure 6**	**Measure 7**
Carbon dioxide Emission Reduction	Carbon dioxide Emission Reduction	Carbon dioxide Emission Reduction	Storage capacity installed	Reduced energy cost for consumers	Increased system flexibility for energy stakeholders	Carbon dioxide Emission Reduction
Degree of energy self-supply by RES	CO2 reduction cost efficiency	CO2 reduction cost efficiency			Reduced energy cost for consumers	CO2 reduction cost efficiency
	Degree of energy self-supply by RES	Degree of energy self-supply by RES				Degree of energy self-supply by RES
						Increase in local renewable energy production

Figure 24: KPIs of Gothenburg TT1 with the associated solutions and their position in the IRIS KPI-house

3.5.3.2 TT2: Smart Energy Management and Storage for Energy Grid Flexibility

TT#2 level KPIs Storage capacity installed Peak load reduction			
Measure 1	**Measure 2**	**Measure 3**	**Measure 4**
Degree of energy self-supply by RES	Peak load reduction		Peak load reduction
Peak load reduction	Storage capacity installed		Storage capacity installed
Storage capacity installed	Storage energy losses		

Figure 25: KPIs of Gothenburg TT2 with the associated solutions and their position in the IRIS KPI-house

3.5.3.3 TT 3 Smart e-Mobility Sector

TT#3 level KPIs Carbon dioxide Emission Reduction Energy savings Reduction in driven km by tenants and employees in the district	
Measure 1	**Measure 2**
Carbon dioxide Emission Reduction	Carbon dioxide Emission Reduction
Ease of use for end users of the solution	Ease of use for end users of the solution
Reduction in driven km by tenants and employees in the district	Improved access to vehicle sharing solutions
Reduction in car ownership among tenants	Reduction in driven km by tenants and employees in the district
Yearly km driven in e-care sharing system	Yearly km driven in e-care sharing system

Figure 26: KPIs of Gothenburg TT3 with the associated solutions and their position in the IRIS KPI-house

3.5.3.4 TT4: City Innovation Platform (CIP)

TT#4 level KPIs Open data-based solutions Quality of open data	
Measure 1	**Measure 2**
Advantages for end-users	Open data-based solutions
Ease of use for end-users of the solution	Quality of open data
Open data-based solutions	
Quality of open data	
Usage of open source software	

Figure 27: KPIs of Gothenburg TT4 with the associated solutions and their position in the IRIS KPI-house

3.5.3.5 TT 5: Citizen engagement and co-creation

TT#5 level KPIs Local community involvement in the planning phase Increase environmental awareness			
Measure 1-4	**Measure 5**	**Measure 6**	**Measure 7**
Local community involvement in the planning phase	Local community involvement in the planning phase	Increase environmental awerness	Increase environmental awerness
User engagement		Ease of use for end-users of the solution	

Figure 28: KPIs of Gothenburg TT5 with the associated solutions and their position in the IRIS KPI-house

4 Data collection overview

4.1 Utrecht

Table 11: Data collection overview for Utrecht

Measure Number	Measure title	Start of monitoring	Connected to the CIP	Data transfer to KPI-tool
Transition Track 1				
Measure 1	District wide PV	M42	Via HEMS TOON	via CIP
Measure 2	LT district heating	M52	Via HEMS TOON	via CIP
Measure 3	HEMS TOON	M27	Yes	via CIP
Measure 4	NZEB refurbishment	M42	Via HEMS TOON	via CIP
Measure 5	Smart (hybrid) e-heating systems	M42	Via HEMS TOON	via CIP
Measure 6	AC/DC home switchboxes	M41	Planned month (M41)	via CIP
Measure 7	Smart DC Street Lighting	M38	Planned month (M38)	Manual
Transition Track 2				
Measure 1	Solar V2G charging points for e-cars/e-vans (demand driven)	M20	Yes	
Measure 2	Solar V2G charging point for e-buses	Before M1		Manual due to confidentiality
Measure 3	Stationary storage in apartment buildings	M39	Planned month (M39)	
Measure 4	EMSs- Smart Energy Management System	M39	Planned month (M39)	
Transition Track 3				
Measure 1	V2G e-cars (demand driven)	M20		Manual (yearly for KPIs)

Measure 2	V2G e-buses	Before M1		Manual (yearly for KPIs)
Transition Track 4				
Measure 1	Monitoring E-Mobility with LoRa network	M27	Yes	
Measure 2	Smart Street Lighting with multi-sensoring	M38	Planned month (M38)	
Measure 3	3D Utrecht City Innovation Model			
Measure 4	Monitoring Grid Flexibility			
Measure 5	Fighting Energy Poverty			
Transition Track 5				
Measure 1	Community building by change agents	M22		Manual (survey)
Measure 2	Campaign District School Involvement	M13		Manual (based upon attendees)
Measure 3	Campaign Smart Street Lighting	M8		Manual (survey)
Measure 4	Co-creation in Local Innovation Hub	M1		Manual (survey)
Measure 5	XR Experience	M33		Manual (survey)

4.2 Nice

Table 12: Data collection overview for Nice

Measure Number	Measure title	Start of monitoring	Connected to the CIP	Data transfer to KPI-tool (if not connected to the CIP)
Transition Track 1				
Measure 1	Collective self-consumption at building scale (Palazzo Meridia)	M44	planned M44	Via CIP

	Collective self-consumption at building scale (UNS-IMREDD)	M40	planned M40	Via CIP
Measure 2	Optimization of heating load curve	M31	Yes	Via CIP
Measure 1	LEM - Local Energy Management system	M40	Planned M40	Via CIP
Measure 3	Commissioning process from the design of the operation	M31	No	Manual
Measure 4	Dashboard providing real-time energy balance	M39	No	Manual
Transition Track 2				
Measure 2	DHC Smart District Heating and Cooling optimization algorithm - Phase 1: Monitoring on a part of the network	M33	Planned M43	Via CIP
	DHC Smart District Heating and Cooling optimization algorithm - Phase 2: Full monitoring (with electric and thermal storage)	M43	Planned M43	Via CIP
Measure 3	Stationary storage deployment in buildings and local electric flexibility management	M40	Planned M43	Via CIP
Transition Track 3				
Measure 1	Dynamic energy management of an EV charging network - Phase 1: baseline EVCI supervision management	M40	Planned M40	Via CIP
	Dynamic energy management of an EV charging network - Phase 2: V1G and V2G based smart charging services	M43	Planned M43	Via CIP
Measure 2	Free floating EV car sharing system - Phase 1: smart management of EV charging to optimize shared vehicles use rate	M40	Planned M40	Via CIP
	Free floating EV car sharing system - Phase 2: Smart charging of V1G and V2G vehicles for EVCI to contribute to grid flexibility services	M43	Planned M43	Via CIP
Transition Track 4				

Measure 1	Sensors data collection in air quality - Phase 1: With legacy air sensors)	M31	Yes	Via CIP
	Sensors data collection in air quality - Phase 2: With microsensors	M43	Planned in M46	Via CIP
Measure 2	BIM/CIM data display	M31	Planned in M43	Via CIP
Measure 3	Charging infrastructure data for optimal EV-based free-floating car sharing - Phase 1: Connected to phase 1 of measure 3.2	M40	Planned in M40	Via CIP
	Charging infrastructure data for optimal EV-based free-floating car sharing - Phase 2: Connected to phase 2 of measure 3.2	M43	Planned M43	Via CIP
Measure 4	Data interoperability with energy cloud	M40	Planned M40	Via CIP
Transition Track 5				
Measure 1	Public awareness campaign on air quality - Phase 1: with IMREDD targeted audience	M31	No	Manual
	Public awareness campaign on air quality - Phase 2: with public stage media	M40	No	Manual
Measure 2	Public awareness campaign Energy – School & Collège; Youth & Family - Phase 1: with youth and family	M27	No	Manual
	Public awareness campaign Energy – School & Collège; Youth & Family - Phase 2 : for the school	M43	No	Manual
Measure 3	Citizens individual engagement – IOT invoices	M40		

4.3 Gothenburg

Table 13: Data collection overview for Gothenburg

Measure Number	Measure title	Start of monitoring	Connected to the CIP	Data transfer to KPI-tool
Transition Track 1				
Measure 1	At least 200 kWh electricity storage in 2nd life batteries powered by 140 kW PV	M21	No	Manual
Measure 2	Heating from geo energy with heat pumps (2-300 m deep boreholes)	M21	No	Manual

Measure 3	Cooling from geo energy without chillers	M50	No	Manual
Measure 4	Local energy storages consisting of water buffer tanks, structural storage and long-term storage in boreholes	M21	No	Manual
Measure 5	Seasonal energy trading (cooling in summer season) with adjacent office block	M50	No	Manual
Measure 6	Advanced Energy Management System to achieve peak shaving and minimal environmental impact	M43	No	Manual
Measure 7	Building Integrated Photovoltaics (BIPV) in façade	M1	No	Manual
Transition Track 2				
Measure 1	350 V DC building microgrid utilizing 140 kW rooftop PV installations and 200 kWh battery storage	M24	No	Manual
Measure 2	1700 kWh PCM (Phase Change Material) cooling storage	M35	No	Manual
Measure 3	Low temperature DH 45/30 system for six buildings	M21	No	Manual
Measure 4	Integration and evaluation of a 200kWh energy storage	M21	No	Manual
Transition Track 3				
Measure 1	EC2B, version for accommodation (Riksbyggen's BRF Viva)	M21	No	Manual
Measure 2	EC2B, version for workplaces (Johanneberg campus area)	M40	No	Manual
Transition Track 4				
Measure 1	CIM - City Information Model	M30	No	Manual
Measure 2	Energy Cloud	M43	No	Manual
Transition Track 5				
Measure 1	Further develop the city's online citizensourcing platform "Min Stad"	M33	No	Manual
Measure 2	Further develop the city's online citizensourcing platform "Min Stad"	M33	No	Manual
Measure 3	Further develop the city's online citizensourcing platform "Min Stad"	M33	No	Manual
Measure 4	Further develop the city's online citizensourcing platform "Min Stad"	M33	No	Manual
Measure 5	Minecraft as a tool for citizen engagement	M33	No	Manual
Measure 6	Demonstrate a BIM (Building Information Modeling) based AR/VR app	M36	No	Manual
Measure 7	Demonstrate the Personal Energy Threshold (PET)	M10	No	Manual

5 Results Utrecht

The KPI tool currently only presents results from measure 3.1 and 3.2. Therefore, this chapter only shows a brief explanation of these measures and its results. The reason why other measures are not yet represented in the KPI tool is shown in Table 2.**Σφάλμα! Το αρχείο προέλευσης της αναφοράς δεν β ρέθηκε.**

5.1 TT3 Intelligent mobility solutions

5.1.1 Monitoring plan for measure 3.1: V2G e-cars

The Mobility as a Service (MaaS) "We Drive Solar" car-sharing system started its demonstration in the LH demo district Kanaleneiland-Zuid. The first car was placed at the local innovation hub Krachtstation. Despite the efforts taken with local partners, and citizen engagement activities to investigate demand for car-sharing services, the demand for V2G e-cars did not increase in the selected area, while significant demand was visible in other areas of Utrecht. Because of these reasons the demonstration area for this measure was increased to the whole city of Utrecht.

Figure 29: Picture of the car-sharing system

LomboXnet is monitoring the driven km by all e-cars as part of their monitoring system, as well as the number of shared e-cars in the district. For calculation of the emission reductions, the same conversion factors are used as the ones in the DoA.

Data transfer of the variables into the KPI tool takes place by means of the manual data entry template.

Table 14: Summary-list of KPIs and related parameters for Measure 3.1 V2G e-cars

KPI	Parameter(s)	Data source	Baseline	GA-Target
NOx emission reduction	Number of kilometres driven by the car-sharing fleet	LomboXnet monitoring system	same amount of km/year driven by comparable fossil fuel cars	1 ton in 5 years
	NOx emission factors for EVs	DoA		
	NOx emission factors for comparable fossil fuel cars	DoA		
Fine particulate matter emission (FPM)	Number of kilometres driven by the car-sharing fleet	LomboXnet monitoring system	same amount of km/year driven by comparable fossil fuel cars	0,02 ton in 5 years
	FPM emission factors for EVs	DoA		
	FPM emission factors for comparable fossil fuel cars	DoA		
Carbon monoxide emission reduction	Number of kilometres driven by the car-sharing fleet	LomboXnet monitoring system	same amount of km/year driven by comparable fossil fuel cars	3 ton in 5 years
	CO emission factors for EVs	DoA		
	CO emission factors for comparable fossil fuel cars	DoA		
Carbon dioxide Emission Reduction	Number of kilometres driven by the car-sharing fleet	LomboXnet monitoring system	same amount of km/year driven by comparable fossil fuel cars	308 ton in 5 years
	CO_2 emission factors for EVs	DoA		
	CO_2 emission factors for comparable fossil fuel cars	DoA		
Access to vehicle sharing solutions for city travel	Number of vehicles available for sharing	LomboXnet monitoring system	Number of shared cars at start of project	18 cars
	Number of inhabitants of target area	Municipality https://allecijfers.nl/gemeente/utrecht/		
Yearly km driven in e-car sharing system	Number of kilometres driven by the car-sharing fleet	LomboXnet monitoring system	Amount of km by shared cars at present	270,000 km per year

5.1.1.1 Data input for Measure 3.1

Table 15: Data input for Measure 3.1 V2G e-cars

Parameter(s)	2020	2021
Number of kilometres driven by the car-sharing fleet	833.159	670.979
NOx emission factors for EVs	0	
NOx emission factors for comparable fossil fuel cars	0.6 E-6 Tonnes/km	
FPM emission factors for EVs	0	
FPM emission factors for comparable fossil fuel cars	0.018 E-6 Tonnes/km	
CO emission factors for EVs	0	
CO emission factors for comparable fossil fuel cars	2.5 E-6 Tonnes/km	
CO_2 emission factors for EVs	63.3 E-6 Tonnes/km	
CO_2 emission factors for comparable fossil fuel cars	224 E-6 Tonnes/km	
Number of vehicles available for sharing	66	109
Number of inhabitants of target area* 1000	357	359

5.1.1.2 Results from Measure 3.1

Table 16: KPIs results for Measure 3.1 V2G e-cars

KPI	2020	2021	GA- Target
NOx emission reduction	.500	.403	1 ton in 5 years
Fine particulate matter emission (FPM)	.0150	.0121	0,02 ton in 5 years
Carbon monoxide emission reduction	2.08	1.68	3 ton in 5 years
Carbon dioxide Emission Reduction	134	108	308 ton in 5 years
Access to vehicle sharing solutions for city travel	66	109	18 cars
Yearly km driven in e-car sharing system	833.159	670.979	270,000 km per year

5.1.2 Monitoring plan for measure 3.2: V2G e-buses

IRIS partner QBuzz is relocating its bus depot from the Europalaan in Utrecht to Westraven, a district just south of the IRIS district in Kanaleneiland-Zuid, and at the Remiseweg, across the Amsterdam-Rijn channel from Westraven. Smart charging of the buses will be tested, but V2G e-buses and chargers are not available. QBuzz will investigate the options for V2G charging at its new bus-depot with the objective to demonstrate and optimize smart charging.

The buses feature detailed monitoring and data storage equipment is based on the ViriCiti platform, these monitors in the buses and in the chargers many parameters including voltage, currents, state of charge, energy charged, accelerator usage and other parameters. Total amount of km's driven by the busses are obtained from this platform and, together with the emission factors, transferred to the KPI tool by means of the manual data entry template.

Table 17: Summary-list of KPIs and related parameters for Measure 3.2 V2G e-buses

KPI	Parameter(s)	Data source	Baseline	GA-Target
NOx emission reduction	Number of kilometres driven by E-buses	ViriCity monitoring system	same amount of km/year driven by comparable fossil fuel buses	22 ton in 5 years
	NOx emission factors for E-buses	DoA		
	NOx emission factors for comparable fossil fuel buses	DoA		
Fine particulate matter emission	Number of kilometres driven by E-buses	ViriCity monitoring system	same amount of km/year driven by comparable fossil fuel buses	0,26 ton in 5 years
	FPM emission factors for E-buses	DoA		
	FPM emission factors for comparable fossil fuel buses	DoA		
Carbon monoxide emission reduction	Number of kilometres driven by E-buses	ViriCity monitoring system	same amount of km/year driven by comparable fossil fuel buses	1,6 ton in 5 years
	CO emission factors for E-buses	DoA		
	CO emission factors for comparable fossil fuel buses	DoA		
Carbon dioxide Emission Reduction	Number of kilometres driven by E-buses	ViriCity monitoring system	same amount of km/year driven by comparable fossil fuel buses	4785 ton in 5 years

	CO_2 emission factors for E-buses	DoA		
	CO_2 emission factors for comparable fossil fuel buses	DoA		

5.1.2.1 Data input for Measure 3.2

Table 18: Data input for Measure 3.2 V2G e-buses

Parameter(s)	2020	2021
Number of kilometres driven by E-busses	833.159	670.979
NOx emission factors for E-busses	0	
NOx emission factors for comparable fossil fuel cars	5.400E-06 Tonnes/km	
FPM emission factors for E-busses	0	
FPM emission factors for comparable fossil fuel cars	6.400E-08 Tonnes/km	
CO emission factors for E-busses	0	
CO emission factors for comparable fossil fuel cars	2.000E-06 Tonnes/km	
CO_2 emission factors for E-busses	3.692E-04 Tonnes/km	
CO_2 emission factors for comparable fossil fuel cars	1.196E-03 Tonnes/km	

5.1.2.1 Results from Measure 3.2

Table 19: KPIs results for Measure 3.2 V2G e-busses

KPI	2020	2021	GA- Target
NOx emission reduction	7.59	7.30	22 ton in 5 years
Fine particulate matter emission (FPM)	0.09	0.09	0,26 ton in 5 years
Carbon monoxide emission reduction	2.81	2.71	1.6 ton in 5 years
Carbon dioxide Emission Reduction	1162	1118	4785 ton in 5 years

5.1.3 Results of the KPIs for TT3

The figures in this paragraph show the calculation results of the KPIs of measure 3.1 and 3.2. Note that results from 2021 only include the results till July 2021 and are expected to be higher for the complete year. FPM emission reduction for measure 3.1 is not visible in the graph, since it is much smaller than the one of measure 3.2 (0.015 and 0.012 tonnes for 2020 and 2021)

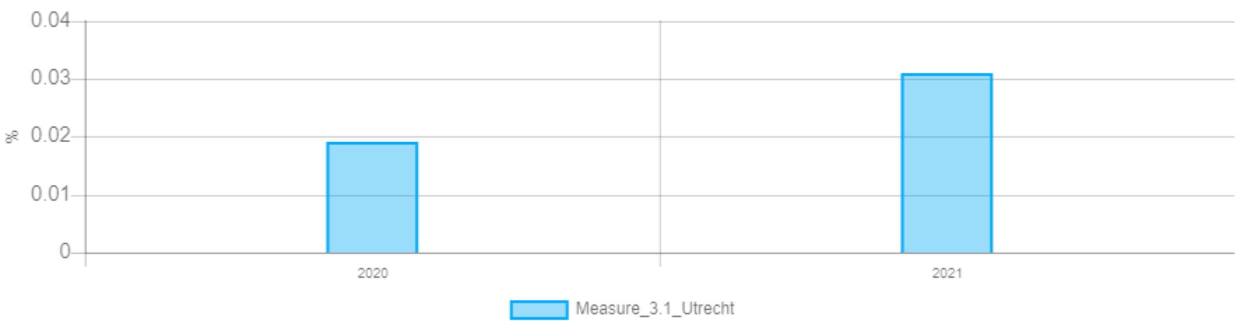


Figure 30: Access to vehicle sharing solutions for city travel (KPI 2) of Measure 3.1 in Utrecht

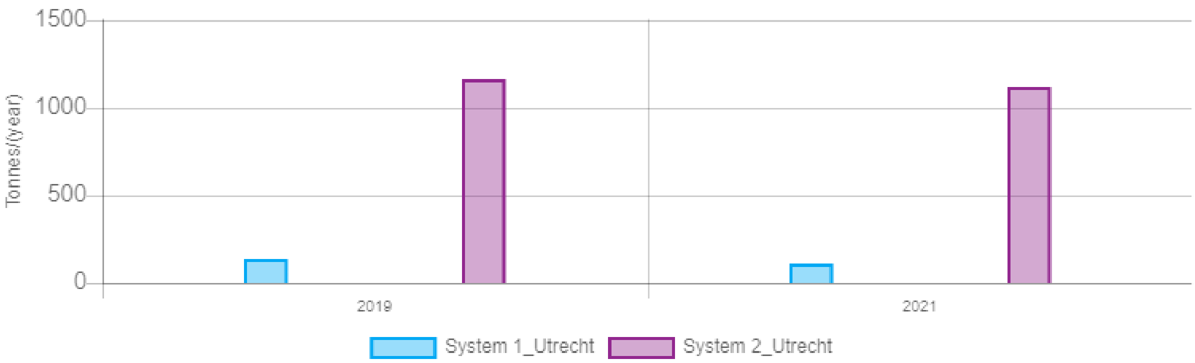


Figure 31: Carbon Dioxide emission reduction (KPI 5) of Measure 3.1 and 3.2 in Utrecht

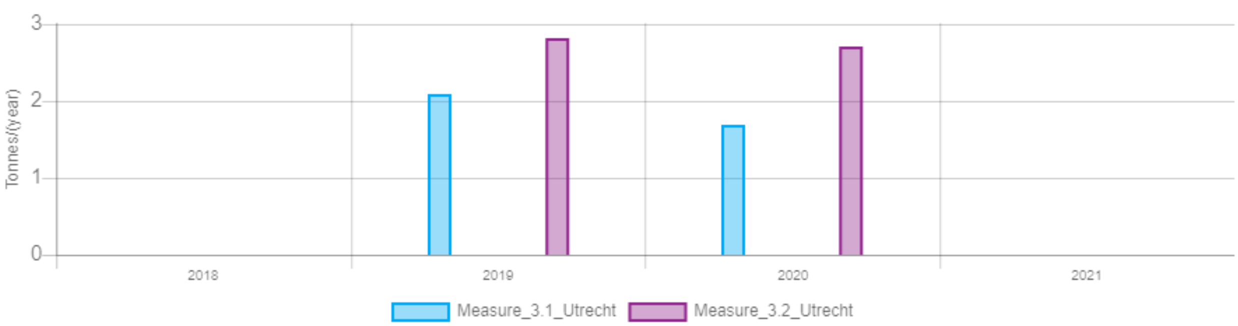


Figure 32: Carbon Monoxide emission reduction (KPI 6) of Measure 3.1 and 3.2 in Utrecht

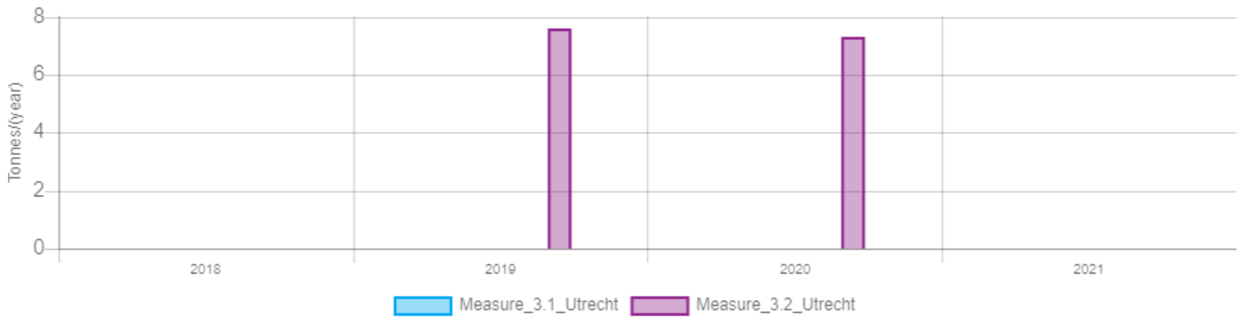


Figure 33: Fine Particulate matter emission reduction (KPI 15) of Measure 3.1 and 3.2 in Utrecht

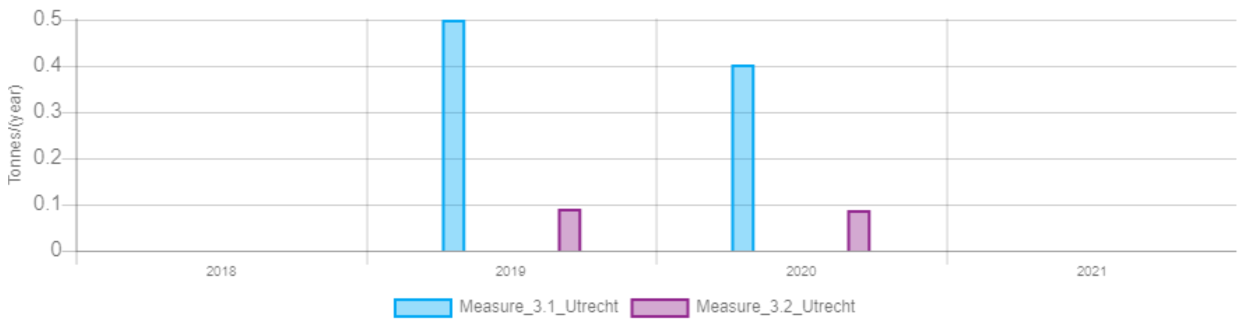


Figure 34: Nitrogen oxide emission reduction (KPI 24) of Measure 3.1 and 3.2 in Utrecht

6 Results Nice

6.1.1 TT1 Renewables and energy positive districts

The data provided in the following paragraphs are extracted from deliverable D6.3: Launch of T.T.1 activities on Smart renewables and near zero energy district (Nice). More detailed information about these integrated solutions can be found in this source.

6.1.2 Measure 1.1: Collective self-consumption at building scale

Collective self-consumption at building scale is a new concept for commercial and residential customers in France, while only a small number of projects have been done in Europe so far. This concept will be tested in Nice Meridia on two positive energy buildings under construction.

The main objective of this use case is to assess the benefits and analyse the barriers (legal, financial, technical) that prevent the development of the collective self-consumption market at building scale. One sub-objective will be to experiment with different technologies to increase the ratio of PV self-consumption.

Monitoring plan aims at calculating KPIs above mentioned.

KPIs deal with services provided by the battery. For PALAZZO MERIDIA and IMREDD buildings, battery storage system is foreseen to increase natural self-consumption of the building (communal parts of the building for PALAZZO MERIDIA). Therefore, the monitoring plan is based mainly on electrical power measurements located at convenient places.

Furthermore, it is appropriate to measure the real battery efficiency (auxiliary consumption, non-ideal inverter and non-ideal discharge/charge behaviour) but also to evaluate KPIs for the whole building.

The metering system will be made of electric meters (electronic), measuring voltage and current at 10-minute timestep (10 min averaged power). In addition, electric meters for the total building electricity demand (measured at the electrical transformer every 10-minute timestep) and energy meters for the total building heat and cool demand (measured at the DHC (District Heating Cooling) network substation on a monthly basis) will complete the monitoring plan.

Table 20 : Summary-list of KPIs and related parameters for Measure 1.1 Collective self-consumption at building scale

KPI	Parameter(s)	Data source	Baseline	GA- Target
Carbon dioxide Emission Reduction (t CO2)	Delivered electrical energy from energy carrier (MWh)	Digital smart electricity meter	there is no prior state as buildings are new. The baseline will use reference data, i.e. values stipulated by	24
	Exported electrical energy	Digital smart electricity meter		

	to energy carrier (MWh)		national regulations	
Energy Savings (%)	Electric energy consumption Reference (kWh/year)	Digital smart electricity meter	there is no prior state as buildings are new. The baseline will use reference data, i.e. values stipulated by national regulations	340
	Electric energy consumption by RES (kWh/month or year)	Digital smart electricity meter		
Increase in local renewable energy production (%)	Electric energy production by RES Baseline (kWh/month or year)	Digital smart electricity meter	there is no prior state as buildings are new. The baseline will use reference data, i.e. values stipulated by national regulations	360
	Electric energy production by RES (kWh/month or year)	Digital smart electricity meter		
	Electric energy consumption by RES (kWh/month or year)	Digital smart electricity meter		
Degree of energy self-supply by RES	Electric energy production by RES (kWh/month or year)	Digital smart electricity meter	there is no prior state as buildings are new. The baseline will use reference data, i.e. values stipulated by national regulations	80%
	Electric energy consumption by RES (kWh/month or year)	Digital smart electricity meter		

6.1.2.1 Data input for Measure 1.1

Table 21: Data input for Measure 1.1 Collective self-consumption at building scale

Parameter(s)	2021	
	Imredd	Palazzo
Delivered electrical energy from energy carrier (MWh)	77.436	
Exported electrical energy to energy carrier (MWh)	31.37	
Electric energy consumption Reference (kWh/year)	46.066	706.616
Electric energy consumption by RES (kWh/month or year)		706.616
Electric energy production by RES Baseline (kWh/month or year)	1098.71	303.116
Electric energy production by RES (kWh/month or year)	1098.71	303.116

6.1.2.2 Results from Measure 1.1

Table 22: KPIs results for Measure 1.1 Collective self-consumption at building scale

KPI	2020	2021	GA- Target
Carbon dioxide Emission Reduction (t CO2)			24
Energy Savings (%)			340
Increase in local renewable energy production (%)			360
Degree of energy self-supply by RES			80%

Preliminary Results

IMREDD

- **PV production analysis:**

According to the preliminary study that was realized before the construction phase, the theorical production was estimated to 201 MWh/year. From the 01/01/2021 to the 30/08/2021, the real energy production from the photovoltaic installation at IMREDD is currently equals to 138,9 MWh representing 69,1% of the theorical annual production.

PALAZZO MERIDIA

The photovoltaic system of the PALAZZO building produces local and decarbonized electricity since March 2021 reaching 313 580 kWh at the end of September.

Table 23: Preliminary results for Measure 1.1 Collective self-consumption at building scale

Month	Energy production (kWh)
March	14 993
April	No measurement
May	39 035
June	51 004
July	53 395
August	71 866
September	83 287

In August power exportation from common area occurs each day. In term of cumulative energy total production of PV is the same order of magnitude as common area demand which is about 10 MWh. It means battery has a clear potential to increase self-consumption. For this month self-consumption was about 40%.

It is also interesting to note that maximum of power demand is weakly affected by self-consumption (-3 kW / 31kW) because maximum power demand is when PV production is low.

6.1.3 Measure 1.2: Optimization of heating load curve

Renovation of existing buildings is generally limited to the refurbishment of the resources of production or insulation of buildings. Heating control remains centralized, according to a single heating scheme for the entire building, which depends only on the outside air temperature and on an internal room measurement. Some houses are overheated while others are underheated, leading to overconsumption (overheating, opened-windows, etc.) and discomfort.

As part of the renovation of existing buildings, the aim of Measure 2 is to integrate a smart control system within the district heating distribution, giving the possibility to adjust heat supply to the individual demand in each apartment according to their sun/wind exposures but also considering accurate indoor temperature.

Each substation is already equipped with a thermal counter which permits to define the historical heating consumption (consumption in MWh). Historical data are based on winter 2018/2019 (from 25/10/2018 to 14/05/2019).

Table 24: *Summary-list of KPIs and related parameters for Measure 1.2 Optimization of heating load curve*

KPI	Parameter(s)	Data source	Baseline	GA- Target
Energy savings	Thermal energy consumption (kWh/year)	Existing smart meter	Heating energy for previous year(s) (e.g. 2018) times CO_2 factor for natural gas	
	Thermal energy consumption Reference (kWh/year)			

6.1.3.1 Data input for Measure1.2

Table 25 : Data input for Measure1.2 Optimization of heating load curve

Parameter(s)	2020	2021
Thermal energy consumption (kWh/year)		
Thermal energy consumption Reference (kWh/year)		

6.1.3.2 Results from Measure 1.2

Table 26: KPIs results for Measure1.2 Optimization of heating load curve

KPI	2020	2021	GA- Target
Energy savings			

6.1.4 Results of the KPIs for TT1

The following figure shows the calculation results of the KPI 13 (Thermal Energy Savings) of measure 1.2 in Nice for two buildings. As can be shown in this, differences could be observed in these two buildings (Tower 13, Tower 14). While the Thermal Energy Savings in Tower 13 are 56.91%, in Tower 14 the same measure is 31.74%

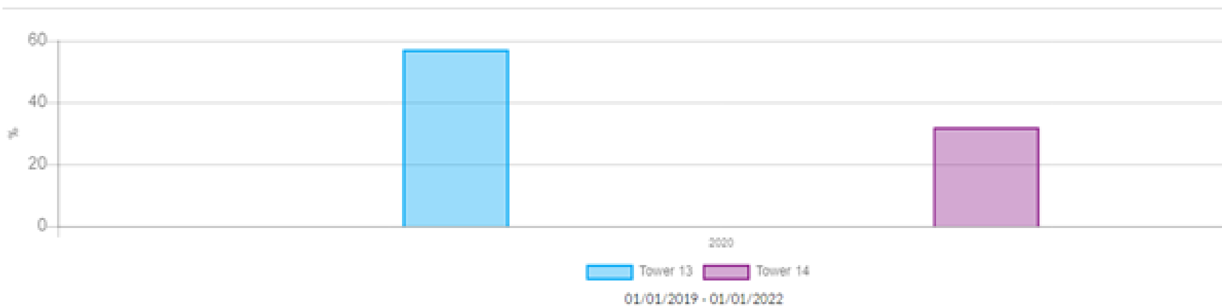


Figure 35: Thermal Energy Savings of Buildings in Nice

7 Results Gothenburg

In this chapter the included measures per transition track (TT) for LH city Gothenburg are shortly described. The reason why other measures are not yet represented in the KPI tool is shown in Table 4.

The parameters related to the KPIs and the manually calculated results are presented in tables. Furthermore, the results from the KPI tool are presented per transition track and KPI. The control evaluation and analysis of the results are not completed at this stage due to the delay of data transfer and lack of time to analyze but it will be performed when more data is available. As stated in section 2.4, evaluation of data will be an ongoing process to ensure accurate results and correct interpretation, also considering factors such as weather and the changing behaviors due to the pandemic.

7.1 TT1 Renewables and energy positive districts

7.1.1 Measure 1.1: 200 kWh electricity storage in 2nd life batteries powered by 140 kW PV

Next to Chalmers campus Johanneberg in Gothenburg, Riksbyggen has built a new housing cooperative, Viva, with a total of 132 apartments, see Figure 36. Measures 1.1-1.6, 2.4 and 3.1 are connected to Viva.

In measure 1.1 the re-usefulness of vehicle batteries in stationary applications, together with solar PVs, are explored. Electricity is generated by PVs at the roof of four of the six buildings in Viva. This electricity is either used directly in Viva or stored in the batteries to be used later. The batteries are taken from their mobile service in buses, when roughly 80% of original capacity remains, and given a second life in a stationary application. This leads to an improved efficiency in the use of resources as well as a reduced environmental impact.

Figure 36: The housing cooperation Brf Viva as seen from Johanneberg Science Park

The monitoring of this measure is carried out in close cooperation with the utility company Göteborg Energi who has access to most of the data through their work with the overall energy management system of Viva, see measure 1.6. They are also part of IRIS and another cooperative research project dealing specifically with advanced energy management.

Table 27: Summary-list of KPIs and related parameters for Measure 1.1 200 kWh electricity storage in 2nd life batteries powered by 140 kW PV

KPI	Parameter(s)	Data source	Baseline	Target
Carbon dioxide Emission Reduction	Electric energy production by RES [kWh/month (year)]	Smart meters	Baseline is the load curve from the apartments, unassisted by either batteries or PVs, times the carbon intensity with hourly resolution on the imported electricity.	15-20%, or 10 metric tonnes.
	The CO_2 coefficient of energy used in base case [t CO2/kWh]	National emission factor for Sweden		
Degree of energy self-supply by RES	Electric energy production by RES [kWh/month (year)]	Smart meter	Zero percent self-supply.	Brf Viva's degree of self-supply for **electrical** energy is expected to vary between 10% and 60%.
	Electric energy consumption [kWh/month (year)]	Smart meter		

7.1.1.1 Data input for Measure 1.1

Table 28: Data input for Measure 1.1 200 kWh electricity storage in 2nd life batteries powered by 140 kW PV

Parameter(s)	2019	2020	2021
Electric energy production by RES [kWh/year]	51718	137873	50682
Electric energy consumption [kWh/year]	393937	696197	349016
The CO_2 coefficient of electricity used in base case [t CO2/MWh] (national emission factor for Sweden)	0,023		

7.1.1.2 Results from Measure 1.1

Table 29: KPIs results for Measure 1.1 200 kWh electricity storage in 2nd life batteries powered by 140 kW PV

KPI	2019	2020	2021	GA- Target
Carbon dioxide Emission Reduction [t/year]	1,19	3,17	1,17	15-20%, or 10 metric tonnes.
Degree of energy self-supply by RES	13,1%	19,8%	14,5%	Brf Viva's degree of self-supply for **electrical** energy is expected to vary between 10% and 60%.

Note that in 2019 and 2021 data from measurements are included for only the seven last and five first months, respectively. This explains the lower values on emission reduction for these years. However, the values are clearly lower than the set target, if the target was set for this measure alone. Discussion will be had with the responsible project partner. The degree of energy self-supply is in line with set target, although at the lower end.

7.1.2 Measure 1.2: Heating from geo energy with heat pumps

This measure introduces heating of Viva by heat pumps drawing geothermal energy from deep boreholes.

Heat pumps are used to raise the temperature of the water coming up from the holes to 45 degrees. This is then led from the main energy central to 3 sub-centrals where heat exchangers bring the heat into the radiator system. Each sub-central also brings the temperatures up to 60 degrees for hot tap water. The geo energy system is also designed to provide hot water during the coldest days of the year.

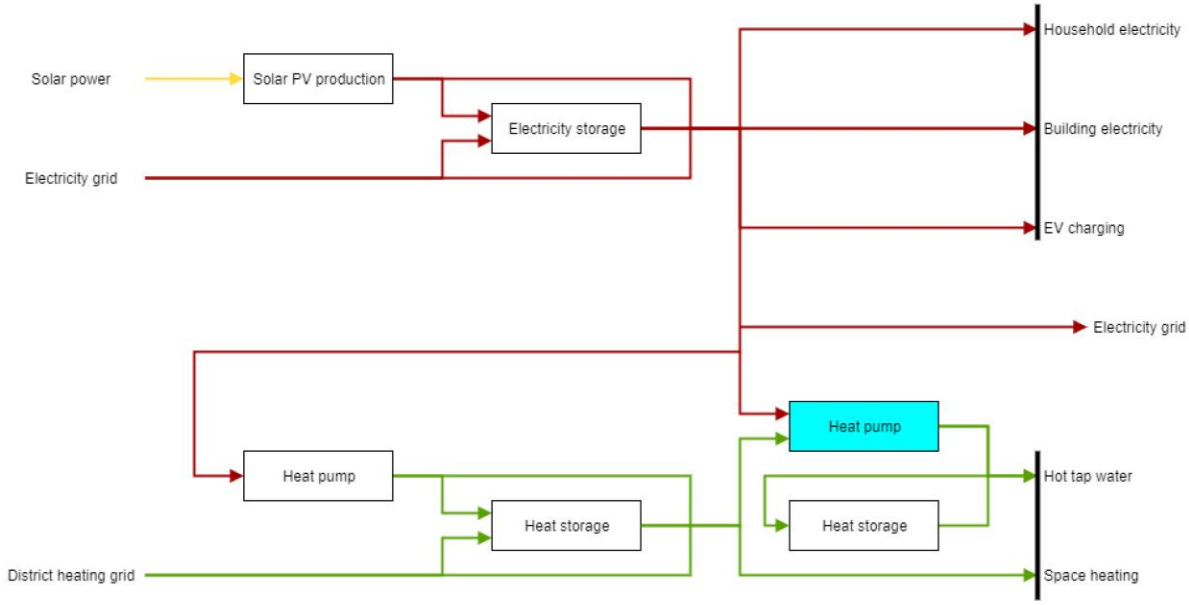


Figure 37: The overall schematic of the energy system in Viva. Note the Heat pump, marked in teal, which is where the heat from the geothermal energy enters the system.

Table 30 : Summary-list of KPIs and related parameters for Measure 1.2 Heating from geo energy with heat pumps

KPI	Parameter(s)	Data source	Baseline	Target
Degree of energy self-supply by RES	Thermal energy production by RES [kWh/month](year)	Smart meter	Zero self-supply.	Varying between 0% and 100% for **thermal** energy.[1]
	Thermal energy consumption [kWh/month(year)]	Smart meters		
Carbon dioxide Emission Reduction	Thermal energy production by RES [kWh/month(year)]	Smart meters	0% reduction	90% reduction.
	The CO2 coefficient of baseline heat production [t CO2/MWh]	Emission factor for the district heating grid in Gothenburg		
	Electricity consumption of the heat pump [kWh/month (year)]	Smart meter		
	The CO2 coefficient of baseline electricity production [t CO2/MWh]	Generalised value for Sweden		
CO_2 reduction cost efficiency	Yearly carbon dioxide Emission Reduction [tonnes/year]	Calculation, from separate KPI	N/A	400 €/tonne CO_2 e*y
	Annualized investment cost for energy/CO2 related measures [€]	Calculation		
	Running costs related to energy/CO2 measures [€/year]	Calculation		

[1] More self-supply is not always better. Remember that DH in Sweden is largely comprised of waste heat, and thus has a very low carbon intensity. It is in many cases more beneficial from an emissions point of view to use DH.

7.1.2.1 Data input for Measure 1.2

Table 31: Data input for Measure 1.2 Heating from geo energy with heat pumps

Parameter(s)	2019	2020	2021
Thermal energy production by RES [kWh/year]	364975	712206	424972
Thermal energy consumption [kWh/year]	390538	783832	475526
The CO2 coefficient of baseline heat production [t CO2/MWh] (emission factor for the district heating grid in Gothenburg)	0,074		
Electricity consumption of the heat pump [kWh/year]	120873	217709	127641
The CO2 coefficient of baseline electricity production [t CO2/MWh] (National emission factor for Sweden)	0,023		

7.1.2.2 Results from measure 1.2

Table 32: KPIs results for Measure 1.2 Heating from geo energy with heat pumps

KPI	2019	2020	2021	GA- Target
Carbon dioxide Emission Reduction [t/year]	24,2	47,7	28,5	90% reduction.
Degree of energy self-supply by RES	93%	91%	89%	Varying between 0% and 100% for **thermal** energy.[2]

Note that in 2019 and 2021 data from measurements are included for only the seven last and five first months, respectively. This explains the lower value of the KPI Carbon dioxide emission reduction for these years. The target is set as percentage, so the absolute numbers need to be discussed with the project partner to know if the results are in line with it. The degree of self-supply by RES of Brf Viva is on the higher end of the expected range, which means that the emission reduction should be reaching the target. Discussions will be had with the project partner regarding absolute numbers for the target and the assumptions on emission factors that were used to establish it.

[2] More self-supply is not always better. Remember that DH in Sweden is largely comprised of waste heat, and thus has a very low carbon intensity. It is in many cases more beneficial from an emissions point of view to use DH.

7.1.3 Measure 1.4: Local energy storages consisting of water buffer tanks, structural storage and long-term storage in boreholes

This measure incorporates a couple of different thermal energy storages into the overall energy system of Viva. There are accumulator tanks in four places in Viva. In the main energy centre, that services the entire group of buildings, there are 2 tanks to relieve the heat exchangers from turning on and off too often. Each of these tanks holds 2000 litres which brings a storage capacity of 160 kWh, working with a temperature difference of 30 degrees. Additionally, there are 9 tanks in each of the 3 sub-centres, that store hot tap water. Each of these tanks holds 500 litres which brings a storage capacity of 810 kWh, working with a temperature difference of 52 degrees. The total thermal energy storage in the accumulator tanks is 970 kWh. In addition, the thermal inertia of Viva's concrete building structure effectively acts as a short-term passively controlled energy storage. Once measure 1.3 and 1.5 are in operation long-term storage in boreholes can be considered.

The monitoring of this measure will be carried out by Riksbyggen in close cooperation with the utility company Göteborg Energi who has access to most of the data through their work with the overall energy management system, see measure 1.6.

Table 33: Summary-list of KPIs and related parameters for Measure 1.4 Local energy storages consisting of water buffer tanks, structural storage and long-term storage in boreholes

KPI	Parameter(s)	Data source	Baseline	Target
Storage capacity installed	Storage capacity installed [kWh]	N/A	The baseline is 0 kWh.	970 kWh in tanks. N/A for boreholes and structure.

7.1.3.1 Data input for Measure 1.4

Table 34: Data input for Measure 1.4 Local energy storages consisting of water buffer tanks, structural storage and long-term storage in boreholes

Parameter(s)	2020	2021
Storage capacity installed [kWh]	970	

7.1.3.2 Results from Measure 1.4

Table 35:KPIs results for Measure 1.4 Local energy storages consisting of water buffer tanks, structural storage and long-term storage in boreholes

KPI	2019	2020	2021	GA- Target
Storage capacity installed [kWh]		970		970 kWh in tanks. N/A for boreholes and structure.

Based on the values obtained from the project partner it appears that this measure has achieved the set target.

7.1.4 Measure 1.7 Building Integrated Photovoltaics (BIPV) in façade

The real estate company HSB has its Living Lab placed at campus Johanneberg. The Living Lab is the home for 50 students but at the same time a research, test and demonstration environment.

In IRIS, HSB Living Lab contributes with a demonstration and evaluation of so-called BIPV, Building Integrated Photo Voltaics. This demonstrator focuses on the situation at the end of the service life of the façade and roof materials. The installation was designed based on budget, available space, HSBs wishes and aspects of research. There were 5 BIPV facilities with two different solar cell technologies on three façade sides and one BIPV plant on the roof. In the figures below the installed solar panels and their orientation on the building can be seen.

In the full-scale housing lab HSB Living Lab, much was already achieved when IRIS begun, albeit only shortly before, and so the measure included is a retrofit of façade-integrated photovoltaic panels. These panels were installed in multiple directions for evaluation purposes, including an economic comparison of using PVs as a façade material.

This demonstrator has shown that PVs on façades can be an excellent idea. An important factor here is that the PV panels are used as the primary rainscreen for the building, which means that it replaces another façade material, and the investment is not simply an added cost but an alternative cost. With the long service life of the panels and the continuous values electricity it generates, life cycle costs are quite encouraging.

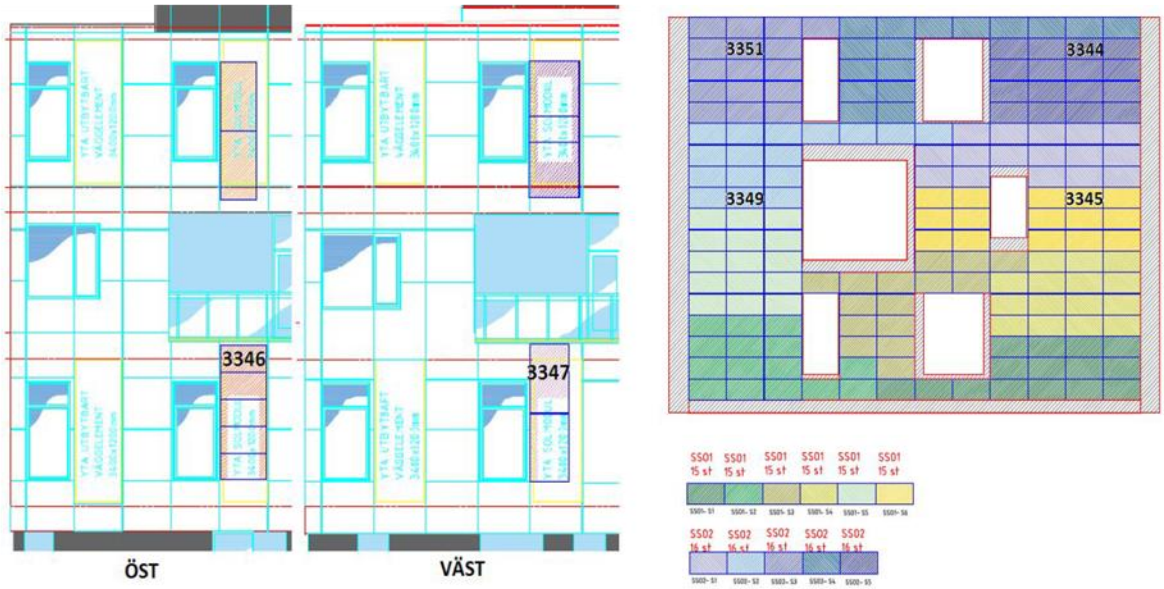


Figure 38: Solar panels (A-Si and mono-Si) at the façade east(öst)/west(väst) on the left and solar panel (A-Si) at the façade south on the righ).

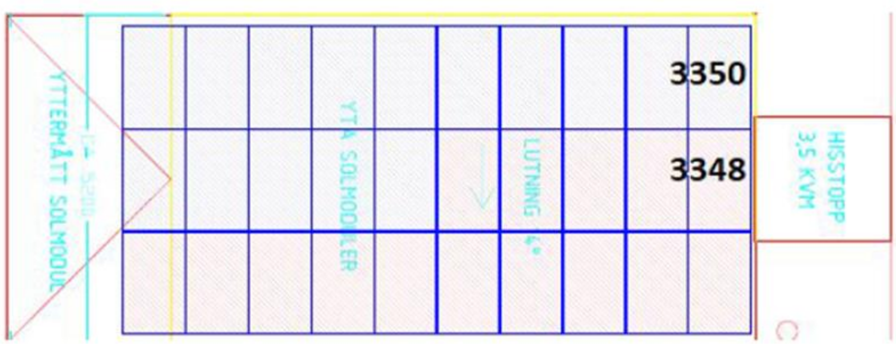


Figure 39: Solar panels (Mono-Si) on the roof.

Monitoring of this measure is conducted continuously until 2025. Energy production will be evaluated from different perspectives, such as: 1. Production compared to different weather conditions such as solar radiation/temperature. 2. Eventual decreased production caused by the age of the system. The monitoring is done by HSB.

The KPIs that have been selected to assess the success and suitability of this measure are summarized in the table below.

Table 36: Summary-list of KPIs and related parameters for Measure 1.7 Building Integrated Photovoltaics (BIPV) in façade.

KPI	Parameter(s)	Data source	Baseline	Target
Increase in local renewable energy production	Electric energy production by RES [kWh/month or year]	Smart Meter	0 MWh per average year	14 MWh
Degree of energy self-supply by RES	Electric energy production by RES [kWh/month or year]	Smart Meter	0 %	19 % of electricity used in the building
	Electric energy consumption [kWh/month (year]	Smart Meter		
Carbon dioxide emission reduction	Electric energy production by RES [kWh/month or year]	Smart Meter	0 tonnes	0,525 tonnes CO_2 reduction
	Electric energy consumption [kWh/month (year]	Smart Meter		
	The CO2 coefficient of baseline electricity production [g CO2/kWh]	National emission factor for Sweden		
	The CO2 coefficient of PV electricity production [g CO2/kWh]	Set to zero		
CO_2 reduction cost efficiency	Annualized investment cost for energy/CO2 related measures [€/year]	Calculation	N/A	N/A
	Yearly carbon dioxide Emission Reduction [tonnes/year]	Calculation, from separate KPI		
	Running costs related to energy/CO2 measures [€/year]	Calculation		

7.1.4.1 Data input for Measure 1.7

Table 37: Data input for Measure 1.7 Building Integrated Photovoltaics (BIPV) in façade

Parameter(s)	2019	2020	2021
Electric energy production by RES [kWh/month or year]	12303	11564	5446
Electric energy consumption [kWh/month (year]	84147	105616	52118
The CO2 coefficient of baseline electricity production [t CO2/MWh] (National emission factor for Sweden)	0,023		
The CO2 coefficient of PV electricity production [t CO2/MWh]	0		
Annualized investment cost for energy/CO2 related measures [€/y]	2100	2100	2100
Running costs related to energy/CO2 measures [€/year]	200	200	200

7.1.4.2 Results from measure 1.7

Table 38: KPIs results for Measure 1.7 Building Integrated Photovoltaics (BIPV) in façade

KPI	2019	2020	2021	GA- Target
Degree of energy self-supply by RES	15%	11%	10%	19 % of electricity used in the building
Carbon dioxide emission reduction [t/year]	0,28	0,27	0,13	0,525 tonnes CO_2 reduction
CO2 reduction cost efficiency [€/t]	8128	8648	18362	
Increase in local renewable energy production [MWh]	12,3	11,6	5,4	14 MWh

Note that only five months of data are included for 2021 which explains the KPI values differing this year compared to the other two years.

The evaluation has been made based on national emission factors and the general assumptions made in the KPI card for KPI 5 "Carbon dioxide emission reduction". However, the partner wishes to include other emission factors for the grid electricity and PV electricity production. The input from the project partner will be considered in the upcoming work and if reliable sources for the emission factors can be provided, they will be included in the evaluation. Furthermore, the emission cost efficiency is rather high so the assumptions and units for the costs will be checked with the project partner. The KPIs Degree of energy self-supply by RES and Increase in local renewable energy production don't quite reach their set targets and a discussion with the project partner regarding expected developments are going to be had.

7.1.5 Results of the KPIs for TT1

The figures in this paragraph shows the calculation results of the KPIs of measure 1.1-1.7 as they are displayed in the KPI-tool.

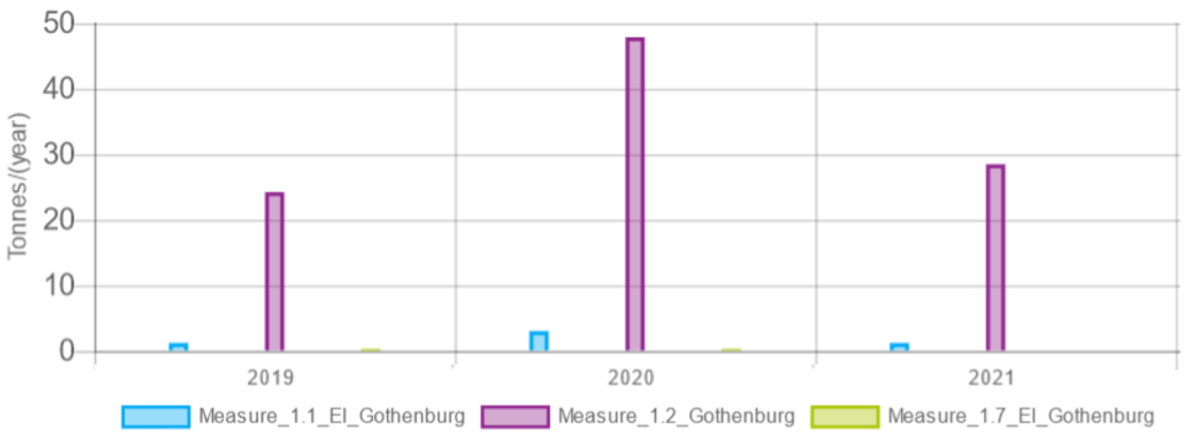


Figure 40: KPI Carbon dioxide Emission Reduction (KPI5) of Measure 1.1, 1.2, and 1.7 in Gothenburg

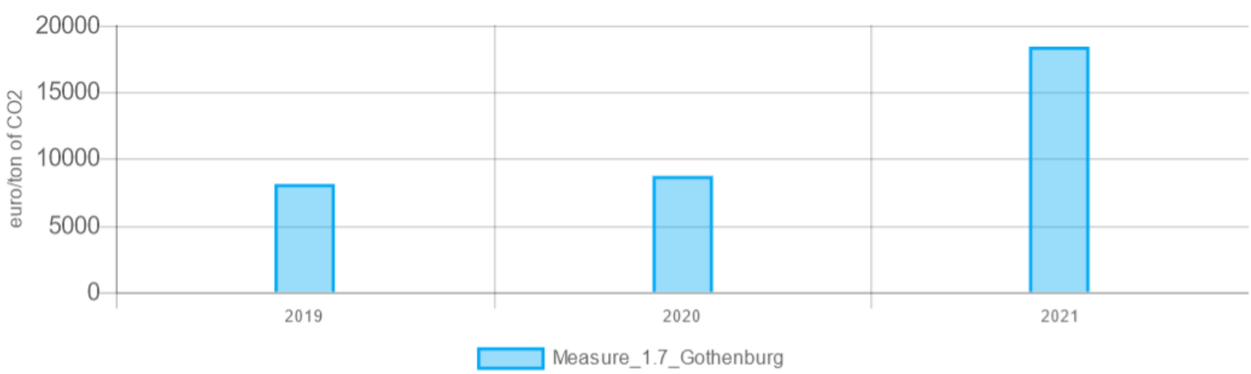


Figure 41: KPI CO2 Reduction Cost Efficiency (KP7) of Measure 1.2, and 1.3 in Gothenburg

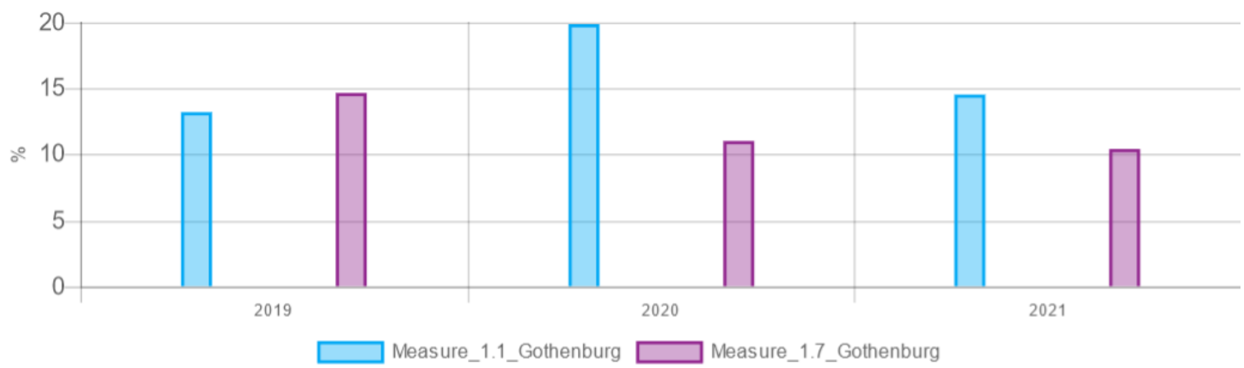


Figure 42: Degree of energy self-supply by RES (KPI10)- Electrical of Measure 1.1, and 1.7 in Gothenburg

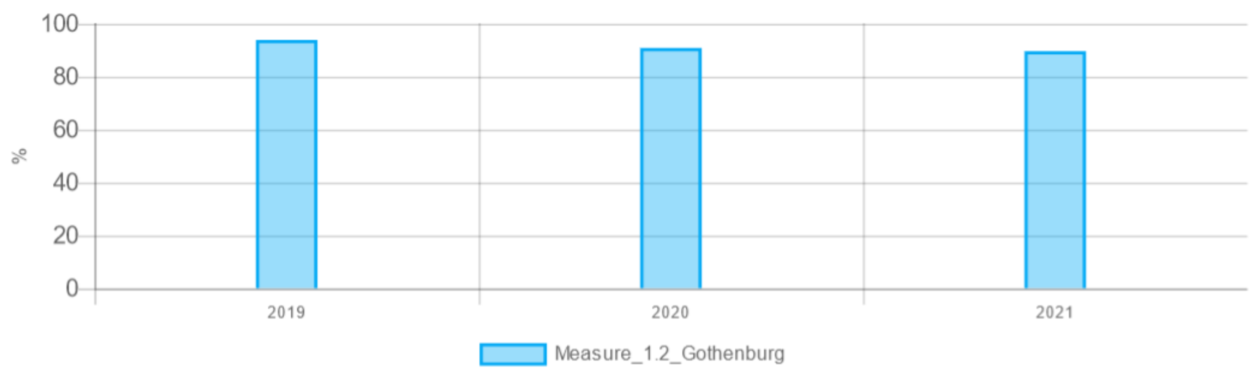


Figure 43: Degree of energy self-supply by RES (KPI10)- Thermal of Measure 1.2 in Gothenburg

7.2 TT2 Flexible energy management and storage

7.2.1 Measure 2.1 a 350 V DC building microgrid utilizing 140 kW rooftop PV installations and 200 kWh battery storage

Real estate company Akademiska Hus will demonstrate how a DC system can give advantages when local electricity is produced with (PV) and stored in battery systems. The measure is in Akademiska Hus new building called "A Working Lab" (AWL), which is an office building of approximately 12 000 m², and an innovations arena. The DC/battery/PV project is incorporated in AWL, and the PV is located both on the roof of AWL and on a nearby building SB3.

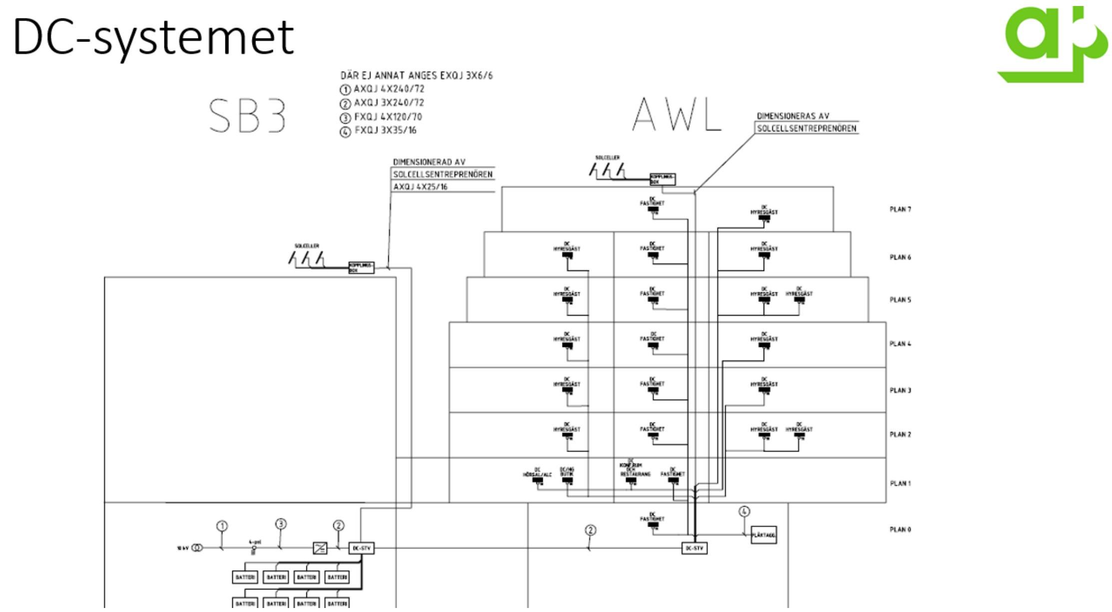


Figure 44: DC/ solar panel and battery system in the AWL building

The measurement system built in AWL building will be used for the evaluation. The data will be stored in the measurement computer and be used in reports for IRIS and Akademiska Hus.

The KPIs that have been selected to assess the success and suitability of this measure are summarized in the table below.

Table 39: Summary-list of KPIs and related parameters for Measure 2.1 a 350 V DC building microgrid utilizing 140 kW rooftop PV installations and 200 kWh battery storage

KPI	Parameter(s)	Data source	Baseline	Target
Peak Load reduction	Peak power [kW]	Smart meter	Consumed electricity in the building minus the used PV electricity.	80% peak power reducti on
	Peak power baseline [kW]	Smart meter	The consumed electricity at present, which is the power that would have been bought without the battery and dc systems.	
Storage Capacity Installed	Storage capacity installed [kWh]	Smart meter	0 kWh	200 kWh
Degree of energy self-supply by RES	Electric energy production by RES [kWh/month or year]	Smart meter	0 kWh	10%
	Electric energy consumption [kWh/month or year]	Smart meter		

7.2.1.1 Data input for Measure 2.1

Table 40: Data input for Measure 2.1 a 350 V DC building microgrid utilizing 140 kW rooftop PV installations and 200 kWh battery storage

Parameter(s)	2020		2021							
	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	jul	Aug
Electric energy production by RES [kWh/month]	3343	2590	2583	3695	11317	26647	22228	26846	26074	21378
Electric energy consumption [kWh/month]	37375	36403	36164	34730	37281	41076	39233	41283	44556	42281
Peak power [kW]	83	105	115	110	80	30	25	25	25	40
Peak power baseline [kW]	113	120	130	130	140	140	145	135	125	130
Storage capacity installed [kWh]	200									

7.2.1.2 Results from Measure 2.1

Table 41: KPIs results for Measure 2.1 a 350 V DC building microgrid utilizing 140 kW rooftop PV installations and 200 kWh battery storage

KPIs	2020		2021								Target
	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	jul	Aug	
Degree of energy self-supply by RES [%]	9%	7%	7%	11%	30%	65%	57%	65%	59%	51%	10%
Peak Load reduction [%]	27%	13%	12%	15%	43%	79%	83%	81%	80%	69%	80% peak power reduction
Storage Capacity Installed	200										200 kWh

The KPIs of measure 2.1 are given monthly instead of annually since not enough data has been collected from measurements yet. The storage capacity installed seem to be in line with the target, the peak load reduction a little below, while the degree of energy self-supply by RES is above target. The set targets will be discussed with the project partner to understand if and why peak load reduction and degree of self-supply are not fulfilled to the same extent.

7.2.2 Measure 2.2: 200 kWh PCM (Phase Change Material) cooling storage

The purpose of PCM Cooling Storage is to reduce the peak cooling power demand by storing cooling energy in Phase Change Materials (PCM) in a Thermal Energy Storage (TES). The PCM storage is loaded from Chalmers campus cooling system KB0. It is discharged to AWL KB11 return pipe system.

In this measure, the energy efficiency in cooling storage in a PCM material will be measured. Efficiency is measured in storage loses and in investment cost. The PCM will be evaluated and compared with a cooling machine. When all data is available, a life cycle cost calculation will be performed.

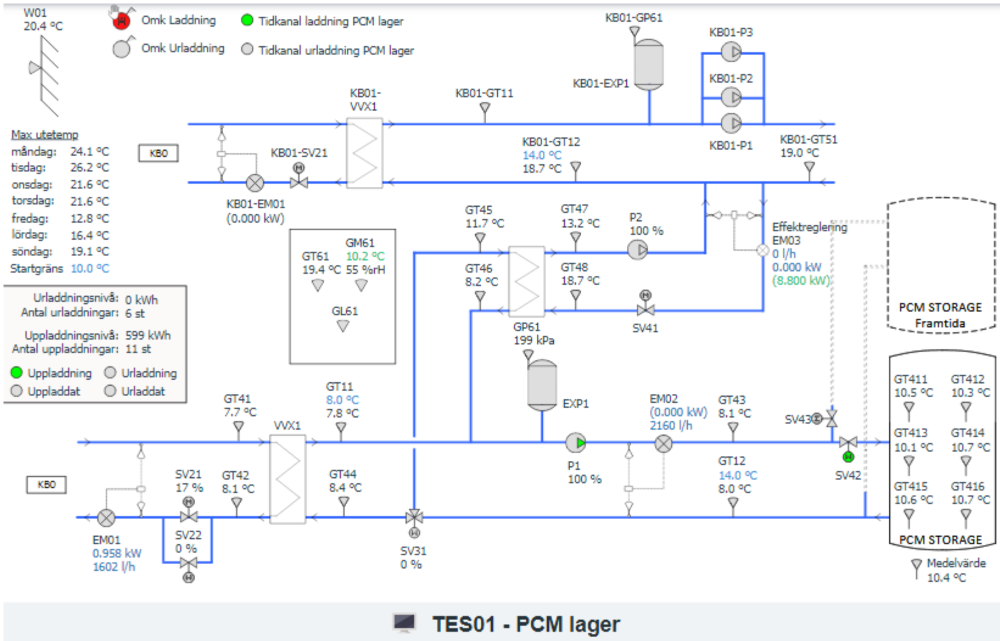


Figure 45: Principle of PCM storage

The measurement system built in the AWL building will be used for the evaluation. The data will be stored in the measurement computer and the calculations will be in reports for IRIS and Akademiska Hus.

The KPIs that have been selected to assess the success and suitability of this measure are summarized in the table below:

Table 42: Summary-list of KPIs and related parameters for Measure 2.2 200 kWh PCM (Phase Change Material) cooling storage

KPI	Parameter(s)	Data source	Baseline	Target
Peak Load reduction	Peak power [kW]	Smart meter	0 kWh	
	Peak power baseline [KW]			
Storage Capacity Installed	Storage capacity installed [kWh]			Target for step 1: 200 kWh/50 kW for 4 h Target for step 1+2: 800 kWh/150 kW for 4 h
Storage energy losses	Energy output [kWh] (from PCM)	Smart meter	Losses from eq. water storage	
	Energy input [kWh] (to PCM)	Smart meter		

7.2.2.1 Data input for Measure 2.2

Table 43: Data input for Measure 2.2 200 kWh PCM (Phase Change Material) cooling storage

Parameter(s)	2020		2021							
	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
Peak power [kW]	9	9	9	9	8	8	90	101	222	58
Peak power baseline [KW]	9	9	9	9	17	26	125	136	257	93
Storage capacity installed [kWh]	100									
Energy output [kWh] (from PCM)	500	583	532	587	1050	1635	1482	788	742	149
Energy input [kWh] (to PCM)	600	870	739	771	1348	2010	1781	841	445	215

7.2.2.2 Results from measure 2.2

Table 44: KPIs results for Measure 2.2 200 kWh PCM (Phase Change Material) cooling storage

KPIs	2020		2021								Target
	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	
Peak Load reduction	0%	0%	0%	0%	53%	69%	28%	26%	14%	38%	
Storage Capacity Installed	100										Target for step 1: 200 kWh/50 kW for 4 h Target for step 1+2: 800 kWh/150 kW for 4 h
Storage energy losses	17%	33%	28%	24%	22%	19%	17%	6%	-67%	31%	

As demonstrated in the results, the KPI “storage energy losses” has an unreasonable value for July in 2021. This is likely due to an error in the data whichit will be checked with the project partner. The target for storage capacity installed will also be checked. Peak load reduction has no set target but assumptions behind the baseline and the quality of data from measurements will be checked with responsible partner.

7.2.3 Measure 2.4: Integration and evaluation of a 200kWh energy storage

This measure explores the re-usefulness of vehicle batteries in stationary applications.

The battery storage in Viva consists of 14 lithium-ion batteries that have previously been used to power buses in public transport in Gothenburg. These batteries enable a larger portion of the electricity generated in Viva to be used at the site. Furthermore, this stationary application is an example of the type of extended service life that vehicle manufacturers are seeking to improve the value and overall sustainability performance of their products. An overview of the batteries' life can be seen in the figure below.

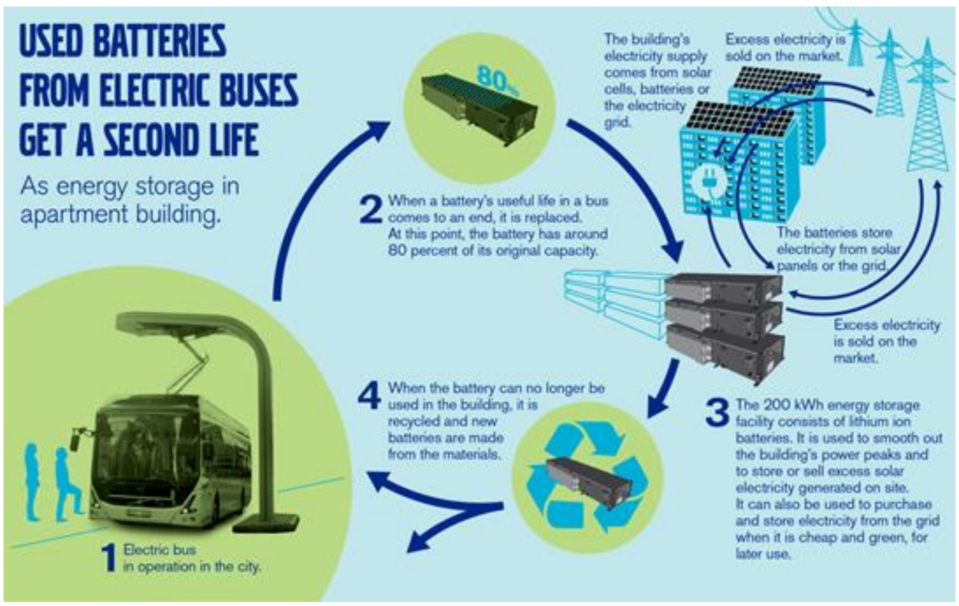


Figure 46: The circularity of the batteries

The monitoring will be carried out by Riksbyggen in close cooperation with the utility company Göteborg Energi. The selected KPIs to assess the success and suitability of this measure are summarized in the table below.

Table 45:Summary-list of KPIs and related parameters for Measure 2.4 Integration and evaluation of a 200kWh energy storage

KPI	Parameter(s)	Data source	Baseline	Target
Peak Load Reduction	Peak power [kW]	Smart meters	Consumed electricity in the building minus the used PV electricity, which is what should have been bought without the battery.	25%
	Peak power baseline [kW]	Smart meter	Consumed electricity in the building, i.e. bouth electricity plus the electricity from PV and battery.	
Storage Capacity Installed	Storage capacity in the batteries [kWh]	Battery specifications from supplier and/or smart meters.	0 kWh	200 kWh

7.2.3.1 Data input for Measure 2.4

Table 46: Data input for Measure 2.4 Integration and evaluation of a 200kWh energy storage

						2020								2021		
Parameter(s)	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dev	Jan	Feb	Mar	Apr	May
Peak power [kW]	160	151	138	128	96	79	99	115	124	158	163	195	198	161	148	121
Peak power baseline [kW]	166	167	144	144	130	105	111	113	125	157	160	196	194	214	143	119
Storage capacity installed [kWh]																

7.2.3.2 Results from Measure 2.4

Table 47: KPIs results for Measure 2.4 Integration and evaluation of a 200kWh energy storage

	2020										2021				
KPI	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dev	Jan	Feb	Mar	Apr	May
Peak Load reduction	3%	10%	4%	11%	26%	24%	11%	-2%	1%	-0,1 %	-2%	0,2%	-2%	25%	-3%	-2%
Storage capacity installed [kWh]																

Note that value of the KPI peak load reduction takes negative numbers for six months indicating an increase in peak load used compared to the baseline. This will be discussed with the project partner. The baseline is based on the actual electricity consumption while the peak power is the electricity consumption minus the power used from battery/and or PVs (i.e. own production) which indicates that there is some error in the measurement or in extraction of data.

7.2.4 Results of the KPIs for TT2

The figures in this paragraph shows the calculation results of the KPIs of measure 2.1-2.4 as they are displayed in the KPI-tool.

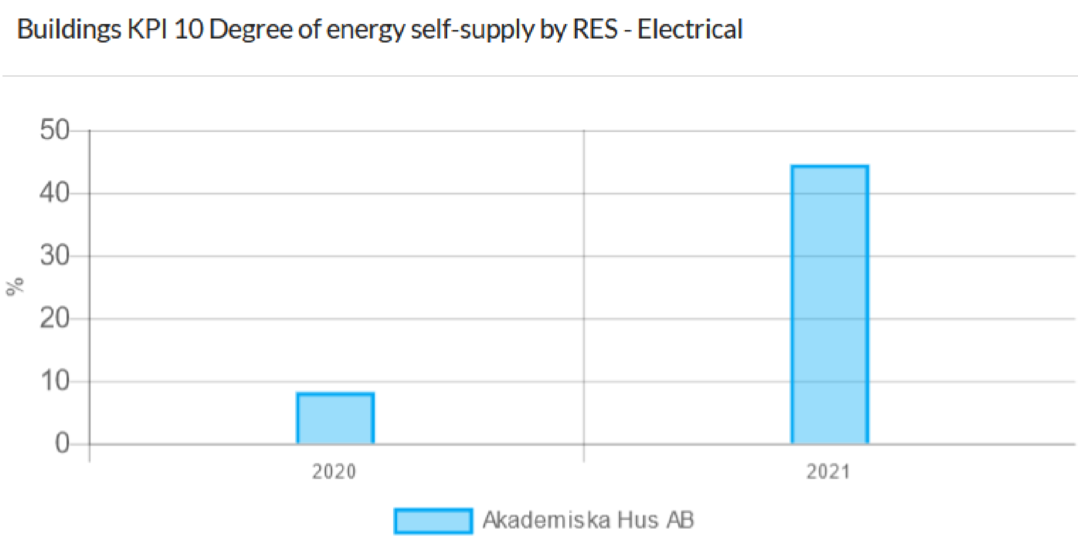


Figure 47: Degree of energy self-supply by RES (KPI 10)- Electrical of Measure 2.1 in Gothenburg

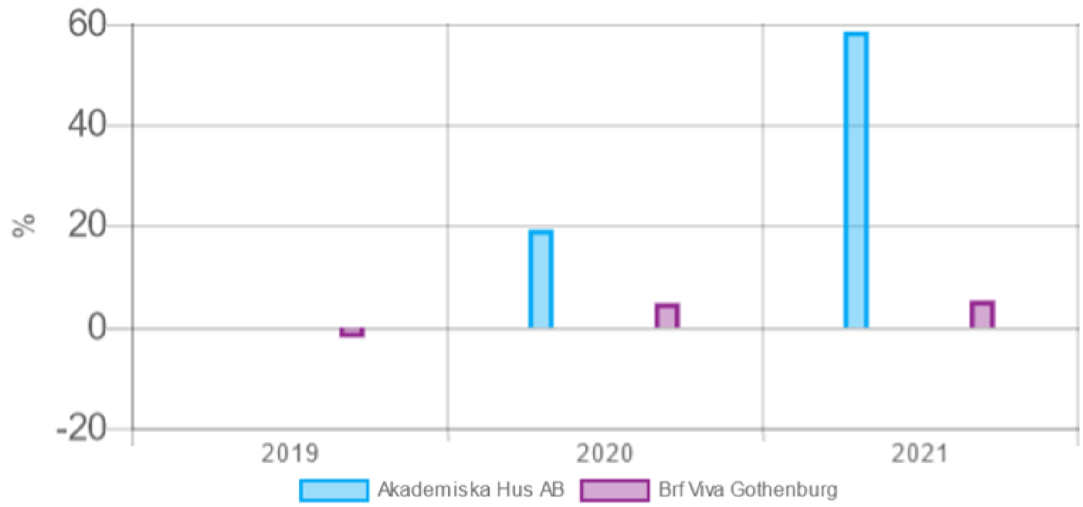


Figure 48: Peak load reduction (KPI 31) Electrical of Measure 2.1 and 2.4 in Gothenburg

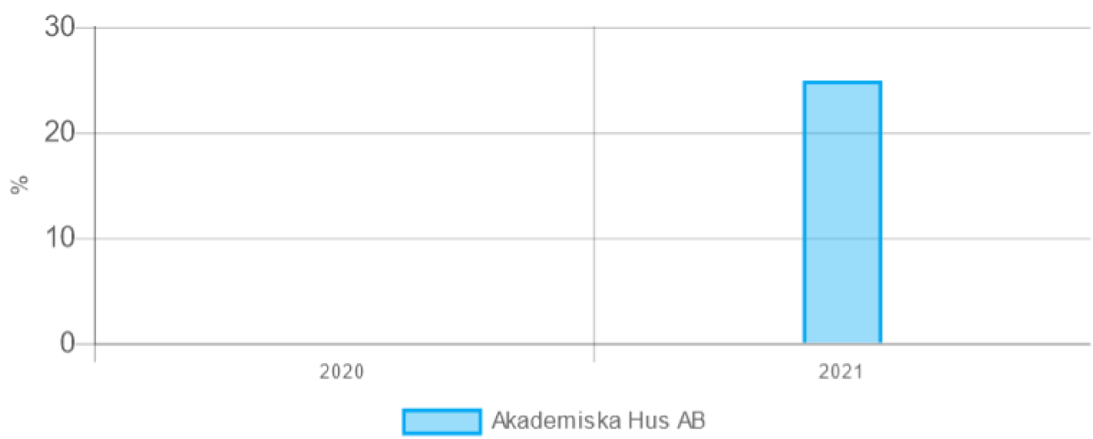


Figure 49: Peak load reduction (KPI 31) Thermal of Measure 2.2 in Gothenburg

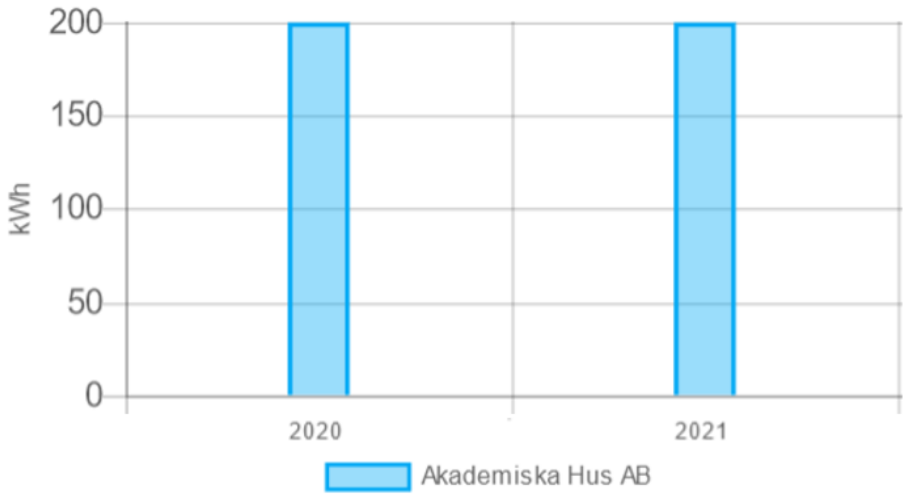


Figure 50: Storage capacity installed (KPI 42) Electrical of Measure 2.1

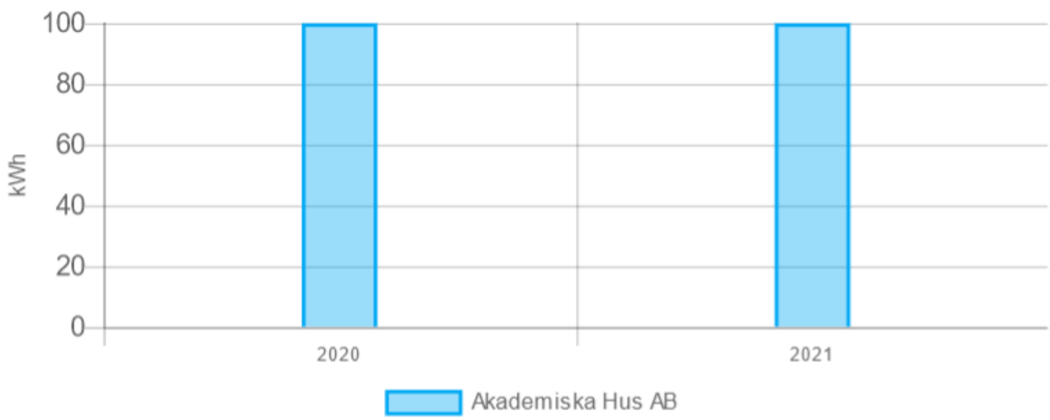


Figure 51: Storage capacity installed (KPI 42) Thermal of Measure 2.2 in Gothenburg

7.3 TT3 Intelligent mobility solutions

7.3.1 Measure 3.1: EC2B for tenants in Brf Viva

The Mobility as a Service (MaaS) concept "Easy to be" (EC2B) offers customers an attractive alternative to owning their own car, allowing easy access to a variety of transport modes (e-cars, e-bikes, public transport etc) in connection to where customers live or work. In demonstrator #1 EC2B is implemented for tenants in the 132 apartments in Brf Viva in Gothenburg, where no private car parking is available.

Residents will have exclusive access to 3 electric cars (to start with Renault Zoe), 1 light e-vehicle "Zbee", 3 electric cargo bikes and 4 electric bikes, as well as charging infrastructure for all types of e-vehicles (55 recharging polls for e-bikes, 6 for e-cars and 2 for light e-vehicles). Demonstrator was implemented in December 2018. To access the e-bikes and light e-vehicles, an electronic key cabinet has been installed which is opened using the EC2B app. The EC2B app was launched in February 2019.

Figure 52: E-cars being charged in car port at Brf Viva

Figure 53: Some of the shared electric bikes in Brf Viva, including both ordinary e-bikes and cargo bikes. Helmets can also be borrowed

Trivector is responsible for providing data for this measure.

The KPIs that have been selected to assess the success and suitability of this measure are summarized in the table below.

Table 48: Summary-list of KPIs and related parameters for Measure 3.1 EC2B for tenants in Brf Viva

KPI	Parameter(s)	Data source	Baseline	Target
Carbon dioxide Emission Reduction	Km driven by tenants before implementing the measure (km/year or month)	Travel survey	Calculated based on travel survey data from equivalent area and register data on CO_2 -emissions from Swedish vehicles	1040 tonnes reduction in 5 years
	Km driven by tenants in conventional cars after implementation (km/year or month)	Travel survey		
	Km driven in e-car sharing system after implementation (km/year or month)	Data from car sharing provider(s)		
	the CO2 coefficient for conventional vehicle (t CO2/km)	Data from car sharing provider		
	the CO2 coefficient for electric vehicle (t CO2/km)	Based on assumption by project partner		
Ease of use for end users of the solution	Very difficult (number of answers)	Questionnaire	No MaaS solution available to users	
	Fairly difficult (number of answers)			
	Slightly difficult (number of answers)			
	Fairly easy (number of answers)			
	Very easy (number of answers)			
Reduction in car ownership among tenants	number of cars owned before moving to the demonstration area	Register data	Average number of cars/household in area Guldheden = 0,39, statistics from SCB	
	number of cars owned after moving to the demonstration area	Register data		
Reduction in driven km by tenants	Km driven by tenants before implementing the measure (km/year or month)	Travel survey	Calculated based on travel survey data from equivalent area	1360500 km/year car mile reduction among tenants and employees in the district
	Km driven by tenants after implementing the measure (km/year or month)	Travel survey		

Yearly km driven in e-car sharing systems	Km driven in e-car sharing system after implementation (km/year or month)	Data from car sharing provider(s)	0	

7.3.1.1 Data input for Measure 3.1

Table 49: Data input for Measure 3.1 EC2B for tenants in Brf Viva

Parameter(s)	2018	2019	2020
Km driven by tenants before implementing the measure (km/year)	1106370		
Km driven by tenants in conventional cars after implementation (km/year)		569430	
the CO2 coefficient for conventional vehical (t CO2/km)	0,0001205		
the CO2 coefficient for electrical vehical (t CO2/km)	0		
number of cars owned before moving to the demonstration area	68		
number of cars owned after moving to the demonstration area		32	32
Km driven by tenants after implementing the measure (km/year)		598500	
Km driven in e-car sharing system after implementation (km/year)		29070	
Very difficult (number of answers)	1		
Fairly difficult (number of answers)	0		
Slightly difficult (number of answers)	14		
Fairly easy (number of answers)	13		
Very easy (number of answers)	8		

7.3.1.2 Results from Measure 3.1

Table 50: KPIs results for Measure 3.1 EC2B for tenants in Brf Viva

KPI	2019	2020	2021	GA- Target
Carbon dioxide Emission Reduction (ton/year)	64,7			1040 tonnes reduction in 5 years
Reduction in car ownership among tenants	36	36		
Reduction in driven km by tenants (km)	507870			1360500 km/year car mile reduction among tenants and employees in the district for measure 3.1 and 3.2
Yearly km driven in e-car sharing systems	29070			

The carbon dioxide emission reduction is significantly lower than what could be expected per year to be in line with the target. Values have only been obtained for 2019. These values will be discussed with the project partner together with a general discussion on the expected impact of covid on the use of vehicles and the reduction in driven km by tenants for 2020 and 2021.

The results from KPIs based on surveys are given in the figure below.

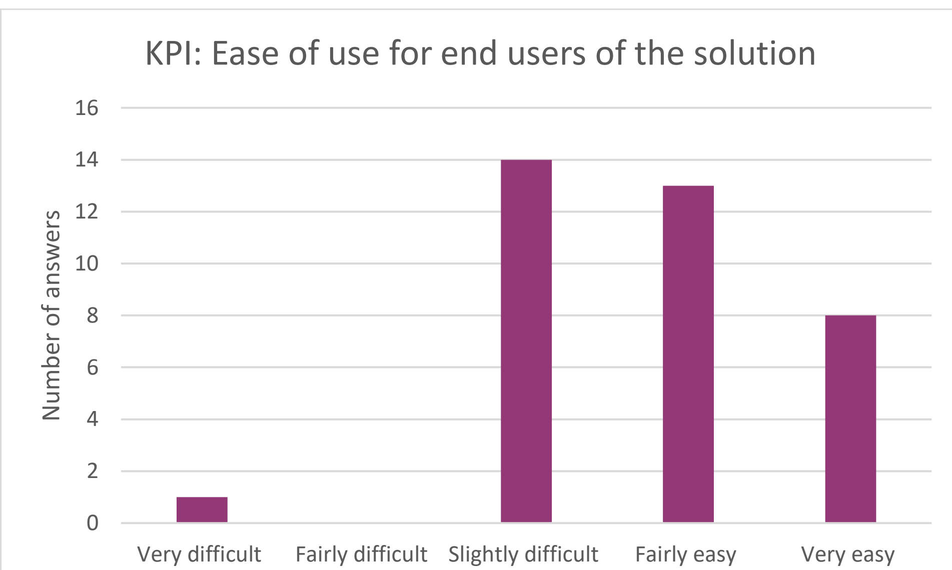


Figure 54: Results for KPI: Ease of use for end users of the solution, values for 2019

7.3.2 Measure 3.2: EC2B for employees on Campus Johanneberg

Four mobility hubs were created in the campus area, combining e-cars, e-bikes, and public transport, and the EC2B service, integrating these transport modes within one app, was launched in November 2020. Figure x below presents a map of the hubs. Due to the Covid-19 pandemic and restrictions and recommendations of working from home, avoiding physical meetings and avoiding the use of public transport, usage of the service has so far been very low.

Figure 55: To the left sign in the campus area explaining the mobility hub concept and where to find the mobility services included. To the right, shared e-bikes at one of the hubs.

Data for the measure will be provided by Trivector. The KPIs that have been selected to assess the success and suitability of this measure are summarized in the table below.

Table 51: Summary-list of KPIs and related parameters for Measure 3.2 EC2B for employees on Campus Johanneberg.

KPI	Parameter(s)	Data source	Baseline	Target
Carbon dioxide Emission Reduction	Km driven by employees before implementation (km/year or month)	Travel survey	Calculated based on travel survey data from equivalent area and register data on CO_2 -emissions from Swedish vehicles	1040 tonnes reduction in 5 years
	Km driven by employees after implementation (km/year or month)			
	Km driven in e-car sharing system by employees after implementation (km/year or month)	Data from car sharing provider(s)		
	the CO2 coefficient for conventional vehical (t CO2/km)	Data from car sharing provider		
	the CO2 coefficient for electric vehicle (t CO2/km)	Based on assumption by project partner		
Ease of use for end users of the solution	Very difficult (number of answers)	Questionnaire	No MaaS solution available to users	
	Fairly difficult (number of answers)			
	Slightly difficult (number of answers)			
	Fairly easy (number of answers)			
	Very easy (number of answers)			
Improved access to vehicle sharing solutions	Not at all number of answers	Questionnaire	Relating to previous availability of shared vehicles in the demonstration area	
	Poor number of answers			
	Somewhat number of answers			
	Good number of answers			
	“Excellent” number of answers			
Reduction in driven km by tenants and employees in the district	Km driven by employees before implementing the measure (km/year or km/month)	Travel survey	Calculated based on existing travel survey data from participating organisations	1360500 km/year care mile reduction among tenants and employees in the district for
	Km driven by employees after implementing the measure (km/year or km/month)			

				measure 3.1 and 3.2
Yearly km driven in e-car sharing systems	Yearly km driven in e-car sharing systems	Data from car sharing provider(s)	Relating to previous availability of shared vehicles in the demonstration area	

7.3.2.1 Data input for Measure 3.2

Table 52: Data input for Measure 3.2 EC2B for employees on Campus Johanneberg.

Parameter(s)	2019	2020	2021
Km driven in e-car sharing system (km/year or month)			11,5
the CO2 coefficient for conventional vehical (t CO2/km)			0,000121
the CO2 coefficient for electrical vehical (t CO2/km)			0
Very difficult (number of answers)	1		
Fairly difficult (number of answers)	1		
Slightly difficult (number of answers)	10		
Fairly easy (number of answers)	14		
Very easy (number of answers)	13		
Not at all (number of answers)	1		
Poor (number of answers)	1		
Somewhat (number of answers)	5		
Good (number of answers)	15		
"Excellent" (number of answers)	17		

7.3.2.2 Results from Measure 3.2

Table 53: KPIs results for Measure 3.2 EC2B for employees on Campus Johanneberg.

KPI	2019	2020	2021	GA- Target
Carbon dioxide Emission Reduction				
Reduction in driven km				
Yearly km driven in e-car sharing systems			11,5	

The KPIs for measure 3.2 have not been calculated as there were only two carpool travels done during the first six months of 2021. This low number is due to the situation with the Covid-19 pandemic which will affect the results for the implementation of this measure. Hopefully there will be more representative data in the nearby future. Dialog and discussion are ongoing with the responsible project partner. Discussions on the target for emission reduction will also be had since it set for measure 3.1 and 3.2 together.

The results from KPIs based on surveys are given in the figures below.

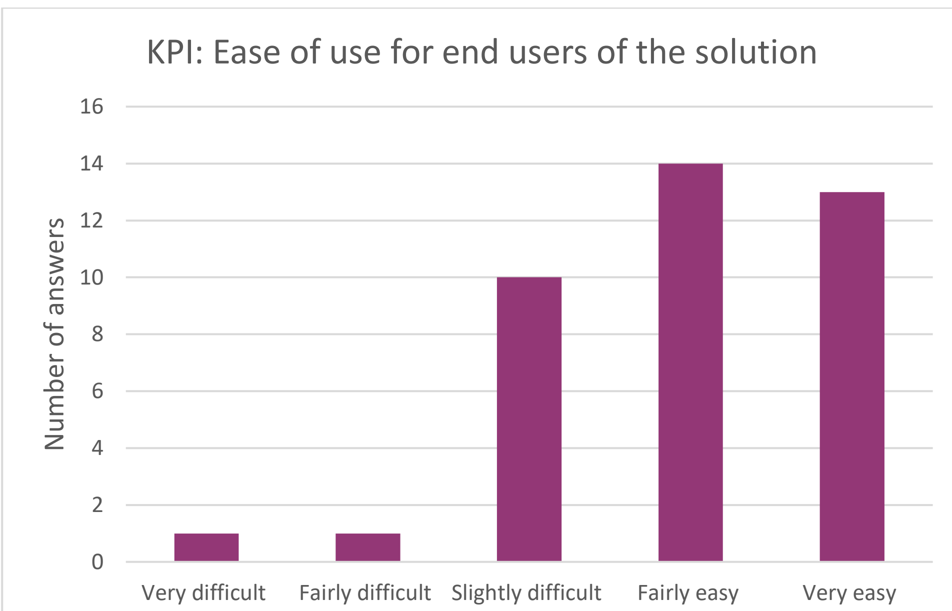


Figure 56: Results for KPI: Ease of use for end users of the solution, values for 2019

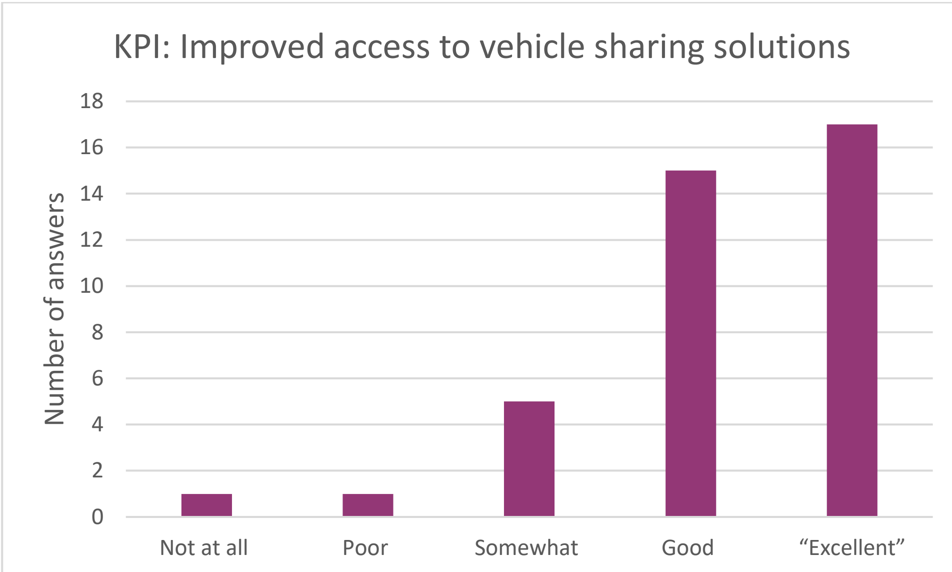


Figure 57: Results for KPI: Improved access to vehicle sharing solutions, values for 2019

7.3.3 Results of the KPIs for TT3

(Aggregation is not available yet in the KPI tool)

7.4 TT4 Digital transformation and services

7.4.1 Measure 4.1: CIM - City Information Model

Gothenburg wishes to establish a CIM (City Information Model) and use digitalization (and primarily geospatial data) as a driving force. BIM is the existing well-established approach that most construction companies use to model, build and visualize buildings, bridges and streets. CIM can be explained as an extension of BIM (Building Information Model) to encompass an entire city.

In IRIS a pilot of CIM will be demonstrated with the objective to take the first steps to build a CIM. The pilot is intended to take advantage of BIM and the BIM data already delivered to the city, and create a tool to collect, validate, and save the data.

The ambition is to demonstrate the City Information Model pilot for the areas around three reference projects, within infrastructure, that provide or will provide BIM data in the pilot. Johanneberg was the original area where the pilot was to be demonstrated, but there will not be any data from infrastructure BIM here, so the main focus is the areas around reference projects, see map in Figure 58Figure 58. It has proven to be harder than expected to get projects to share BIM data, which means that one of the reference projects might have to be replaced.

Figure 58: Map over areas for CIM pilot demonstration

The KPIs that have been selected to assess the success and suitability of this measure are summarized in the table below.

Table 54: Summary-list of KPIs and related parameters for Measure 4.1 CIM- City Information Model

KPI	Parameter(s)	Data source	Baseline	Target
Advantages for end-users	No advantage	Questionnaire		
	Little advantage			
	Some advantage			
	High advantage			
	Very high advantage			
Ease of use for end users of the solution	Very difficult (number of answers)	Questionnaire		
	Fairly difficult (number of answers)			
	Slightly difficult (number of answers)			
	Fairly easy (number of answers)			
	Very easy (number of answers)			
Quality of open Data	Number of datasets that are DCAT compliant in CIM pilot [integer]	Manual check by Gothenburg City	0. There is no CIM Pilot and there are no Datasets in the CIM pilot.	100% of DataSets in CIM pilot are DCAT compliant.
	Total number of datasets in CIM pilot [integer]	Manual check by Gothenburg City		
Open data-based solutions	Number of services based on open data [integer]	Manual check, how many applications exist after Innovation Challenge by Gothenburg City.	0. There is no CIM Pilot API and therefore there are no applications using it.	Number of applications using the API are more than 5.

Usage of open source software	Number of open-source software solutions used [integer]	Manual check by Gothenburg City and Tyréns	0. There is no CIM Pilot and therefor there are no solutions built with or without open source software.	No full purchased solution from one single company is used in the CIM pilot.

7.4.1.1 Data input for Measure 4.1

Table 55: Data input for Measure 4.1 CIM- City Information Model

Parameter(s)	2020	2021
No advantage (number of answers)	0	
Little advantage (number of answers)	0	
Some advantage (number of answers)	1	
High advantage (number of answers)	3	
Very high advantage (number of answers)	4	
Very difficult (number of answers)	0	
Fairly difficult (number of answers)	1	
Slightly difficult (number of answers)	0	
Fairly easy (number of answers)	3	
Very easy (number of answers)	5	
Number of datasets that are DCAT compliant in CIM pilot	0	0
Total number of datasets in CIM pilot	7	7
Number of services based on open data	7	7

7.4.1.2 Results from Measure 4.1

Table 56: KPIs results for Measure 4.1 CIM- City Information Model

KPI	2020	2021	Target
Open data-based solutions	0	0	Number of applications using the API are more than 5
Quality of open Data	100%	100%	100% of DataSets in CIM pilot are DCAT compliant.

The target has been reached for KPI Quality of open data but not for the KPI open data-based solutions. This will be discussed with the responsible project partner to get a status update on the expected outcome and reason for no applications using open data-based solution yet.

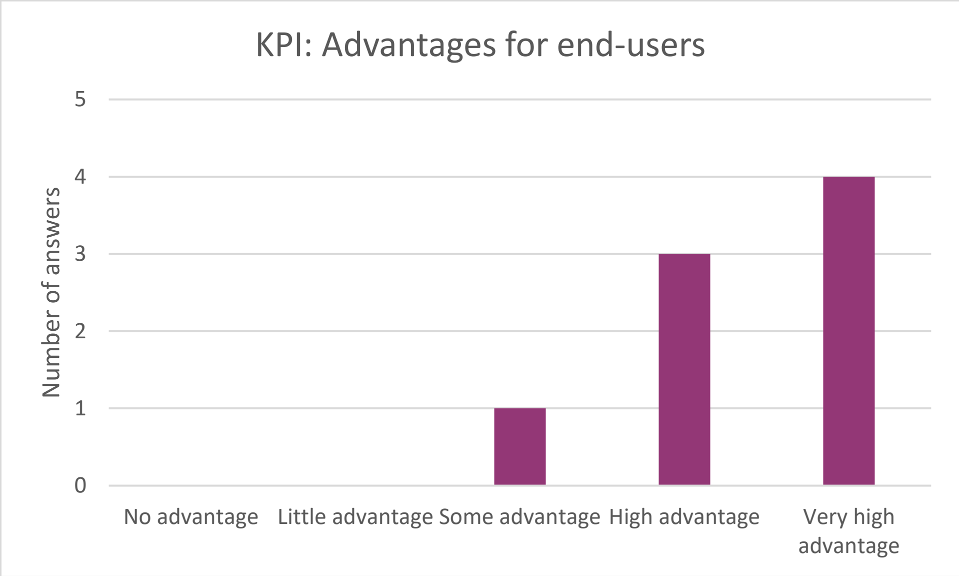


Figure 59: Results for KPI: Advantages for end-users in 2020

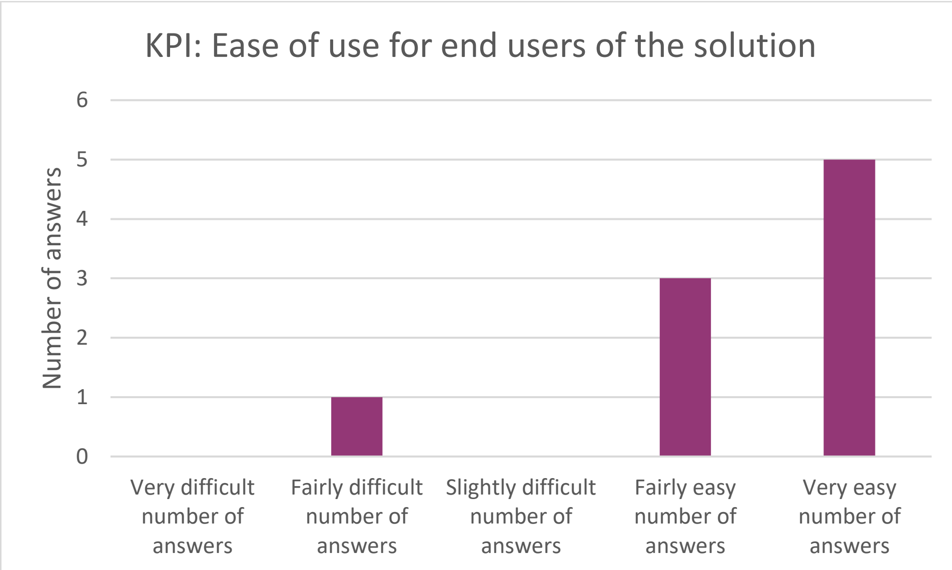


Figure 60: Results for KPI: Ease of use of end users of the solution, values for 2020

7.4.2 Measure 4.2: Energy Cloud

The purpose of the Energy Cloud demonstrator is to showcase the value of easy access to structured energy data to promote and support the reduction of energy consumption in buildings – initially at Chalmers Campus and in the Gothenburg City and eventually in Sweden, Europe and the rest of the world. The objective includes demonstrating how efficient building management, development and replication of innovative energy services can be accelerated by the application of standardized data semantics across the real estate industry. Energy Cloud will collect energy data from buildings in Gothenburg, including micro-production, EV-charging, building control systems, smart meters and tenants and the data will be categorized according to a unified semantic, RealEstateCore (see https://www.realestatecore.io and https://doc.realestatecore.io/3.1/full.html), that enables easy sharing of data between stakeholders in the building sector and the smart city as well as fast replication of data-driven energy efficiency services.

The primary demonstration area for the Energy Cloud demonstrator will be the Chalmers University Johanneberg campus, see figure belowFigure 61. This includes buildings such as HSB Living Lab, with advanced digitalization and comprehensive sensor and energy data acquisition systems. Furthermore, older office and student housing buildings on the Chalmers campus with more standard and generic low-end data acquisition solutions and some new and ongoing housing development projects in downtown Gothenburg representing the present standard set up for modern commercial building projects including on-site electricity micro-production, EV charging solutions etc.

Figure 61: A map depiction of the Chalmers Campus Johanneberg. The location of AWL, one of the buildings in the Energy Cloud demonstrator also part of the transition track #2 demonstrator is marked in red

The KPIs that have been selected to assess the success and suitability of this measure are summarized in the table below.

Table 57: Summary-list of KPIs and related parameters for Measure 4.2 Energy Cloud

KPI Selection	Parameter(s)	Data source	Baseline	Target
Open data-based solutions	Number of services based on open data in the Energy Cloud demonstrator [integer]		There is no Energy Cloud demonstrator and therefore there are no applications using it.	Number of applications using the REC compliant datasets in the Energy Cloud demonstrator are more than 3.
Quality of open Data	Number of datasets using DCAT standards in Energy Cloud demonstrator		There is no Energy Cloud demonstrator and there are no Datasets in the Energy Cloud pilot	100% of DataSets in Energy Cloud demonstrator are REC compliant.
	Total number of datasets in Energy Cloud			

7.4.2.1 Data input for Measure 4.2

Table 58: Data input for Measure 4.2 Energy Cloud

Parameter(s)	2020	2021
Number of services based on open data	1	1
Number of data sets using DCAT standards	0	0
Total number of data-sets	6	6

7.4.2.2 Results from Measure 4.2

Table 59: KPIs results for Measure 4.2 Energy Cloud

KPI	2020	2021	Target
Open data-based solutions	1	1	Number of applications using the REC compliant datasets in the Energy Cloud demonstrator are more than 3.
Quality of open Data	0%	0%	100% of DataSets in Energy Cloud demonstrator are REC compliant.

The KPI Quality of open data is not near the set target with no data sets using DCAT standards while the target for KPI Open data-based solutions is at least in part fulfilled. Discussions will be had with the responsible project partner.

7.4.3 Results of the KPIs for TT4

(Aggregation is not available yet in the KPI tool)

8 Output to other work packages

The output of WP9 is to assess to what extent the project has reached the goals and objectives defined in the project proposal. This work in WP9 is relevant to all work packages and partners. The monitoring and evaluation in task 9.5 will provide information concerning the performance of the different solutions demonstrated in the three LH cities in IRIS which is important for the replication of the solutions in the LH cities (WP5, WP6 and WP7) and in the follower cities (WP8).

The work in task 9.5 built on the work done in TT9.3 *Establishment of a unified framework for harmonized data gathering, analysis and reporting* and TT9.4 *the monitoring framework and established baseline.* The deliverable D9.7 *Report on evaluation and impact analysis for integrated solutions* will be based on D9.6.

D9.6 was supposed to be an intermediate report and a give first indication of how the different measures performed. However, as a large quantity of measures have not yet produced a sufficient amount of data, and therefore are excluded from this report, it is more of a status report on the process of collecting and transferring data. Nevertheless, this deliverable is strongly related to the deliverable D5.8 [3], D6.8 [4] and D7.8 [5] and provides an overview of the status of monitoring and evaluation in the IRIS project.

9 Conclusions

The scope of this deliverable was to provide intermediate results of the demonstration activities in the three LH cities and the impact of actions for the IRIS project. However, it is difficult to give an initial impression of the impact of the LH cities demonstration activities as only 30 percent of the measures have connection and transfer of data to the KPI tool and therefore are included. In Gothenburg 50 percent of the measures are included, for Nice it is 25 percent and Utrecht 16 percent. Furthermore, data has not been collected for a sufficient amount of time to draw conclusions on the impact of the different measures and to compare them to each other, at this stage. The reasons for the exclusion of so many measures vary but the Covid-19 pandemic has had a negative impact and led to delays in implementation. Furthermore, it will possibly have an impact on the data already collected for 2020 and 2021 since the use of energy and travel patterns have been affected when people have worked from home.

The conclusions will therefore focus on challenges in the process of gathering and transferring data into to KPI tool and outlining the steps to be taken to ensure that enough data is collected for all measures included in the IRIS project.

9.1 Challenges in collecting data and initial evaluation

Definitions of KPIs need to be clear enough to avoid misinterpretation and ensure that parameters are given in the correct unit while still leaving room for flexibility. This is to allow to update the KPI during the project to make them better suited for different types of measures. This has particularly been the case for the KPI Carbon dioxide emission reduction, which is used for different energy carriers/use cases. Furthermore, some KPIs need to be separated depending on energy carrier, e.g. thermal or electrical for KPI Peak Load reduction, to avoid comparing and adding values together that are not relevant to add or compare. The KPIs used in the IRIS project have continuously been adjusted and updated to better suit the requirements and serve their purpose. This in turn provides a challenge, as the parameters needed from partners measurements should be clearly defined at an early stage to ensure that data can be collected.

Complexity of APIs and the lack of standards have made data extraction and transfer into the KPI tool more difficult. Furthermore, not all measures in IRIS are connected to CIP which means that manual data collection was required and a systematic procedure for this collection needed to be developed and introduced to the partners.

Delay in implementation and/or start of monitoring of measures have led to data being collected for a short period than initially planned, which makes evaluation more difficult.

9.2 Next steps

A clear focus for the continued work of WP9 is needed to ensure that data from all measures is being transferred to the KPI tool, either manually or through CIP. For the measures that are excluded from this report discussion will continue with the responsible partners to ensure a smooth transfer of data as soon as possible. Challenges and issues will be identified and discussed to minimize risk of further delays.

For the measures that have already provided data and KPIs, the next steps will be discussions with responsible partners regarding results that are not in line with set targets or appear in-correct. The aim of these discussions will be to identify possible errors in data, assumptions or targets and find solutions to them.

As more data is being transferred to the KPI tool, the calculations made in the tool will continue to be validated through manual calculations.

Another important next step will be to identify and perform sensitivity analysis regarding key assumptions that have a large impact on the results. The CO_2 emission factors used have already been identified as a crucial factor to perform a sensitivity analysis on. This analysis will highlight how the assumed level of emissions influences the results in a specific location, but also aim at making it easier for follower cities and others, to evaluate the use of such a measure in other locations/under other circumstances.

9.3 Recommendations and lessons learned

Our experiences in updating the KPIs in the past period of the IRIS project confirm again the lessons learnt on the KPI revisions which are described in paragraph 3.4 of D9.5 [1].

It is important to repeat that, even though it seems that KPIs can be chosen and defined in an early stage of a project, there should always be the possibility to modify them during the project period. Progressive insight, changes in the demonstrators or the emergence of interesting new indicators will require flexibility in the methods of monitoring and evaluation. When doing so, a detailed record of the modifications should be kept, to make sure that any unforeseen side-effects can be dealt with.

Furthermore, the importance of formulating the KPIs in a clear and concise manner, to enable uniform interpretation of equations and identification of parameters needed, has been highlighted throughout the work of WP9. This is vital to enable comparison of the impact of different measures that are evaluated with the same KPI. It is important to keep in mind, when KPIs are modified and adjusted, that there is a trade-off between making a KPI general and thereby more useful for different measures and making a KPI very specific and thereby getting a higher level of detail but less possibilities for comparisons.

When planning a similar project, it is important to budget sufficient time to allow for continuous discussion with project partners on monitoring and evaluation throughout the project, as well as being aware of the challenges of choosing and formulating KPIs and that this process will continue over time. Furthermore, the KPIs process could benefit from working more Transition Track wise to allow for knowledge exchange between similar measures with regards to challenges and thereby creating synergies which cannot be found to the same extent when exchange primary occur on LH city level.

The continued work in WP9 will focus on gathering data for all measures in the project, validating the data and evaluating the measures with the help of the KPIs. To aid this process meetings are planned with LHC managers to identify and discuss remaining challenges and barriers for data collection and transfer to the KPI tool with special focus on the measures excluded from this report. Furthermore, discussion will be had with responsible partners regarding the initial results, presented in this report, that deviate from what could be expected. The influence of the Covid-19 pandemic on the set targets for different measures will also be discussed.

10 References

All public IRIS deliverables are accessible through: https://irissmartcities.eu/public-deliverables

[1] IRIS, “D9.5: Report on monitoring framework in LH cities and established baseline,” 2020.

[2] IRIS, “D9.4: Report on unified framework for harmonized data gathering, analysis and reporting,” 2019

[3] IRIS, “D5.8 Preliminary report on Utrecht lighthouse demonstration activities” 2021

[4] IRIS, "D6.8 Preliminary report on Nice lighthouse demonstration activities” 2021

[5] IRIS, "D6.8 Preliminary report on Gothenburg lighthouse demonstration activities” 2021

[6] IRIS, “D9.2: Report on monitoring and evaluation schemes for integrated solutions,” 2019.

Annex 1 List of modifications of KPI cards

Date	Name	Modifications
2021-05-04	E.P.Bontekoe	• CO2 emission reduction: o Focus on emission reduction o Added use cases and examples • CO emission reduction: o Homogenized with CO2 emission reduction o Changed KPI output to number (tonnes CO) instead of %, in order to make the KPI applicable as indicator for grant agreement goals o Added use case of sustainable transport o Small typographic modifications in title and description • NOx emission reduction: o Homogenized with CO2 emission reduction o Changed KPI output to number (Tonnes Nox) instead of %, in order to make the KPI applicable as indicator for grant agreement goals o Added use case of sustainable transport o Small typographic modifications in title and description • Fine particulate matter emission reduction: o Changed PM to FPM in KPI description o Homogenized with CO2 emission reduction o Changed KPI output to number (Tonnes FPM) instead of number per capita, in order to make the KPI applicable as indicator for grant agreement goals o Added use case of sustainable transport o Small typographic modifications in title and description
2021-05-05	L.Eriksson	• Reduction in driven km by tenants and employees in the district ○ Added formula for clarity • Reduction in car ownership among tenants ○ Added formula for clarity • Increased system flexibility for energy players/stakeholders ○ Added formula and made differentiation between thermal and electrical ○ Changed description to make it clearer • Storage capacity installed ○ Changed formula so it can be calculated when baseline is 0, in this case it is not percentage but absolute value • Reduced energy cost for costumers ○ Added explanation of parameters used to calculate KPI • User Engagement ○ Added description Number of participants/users of the platform • Quality of open data

		○ Added explanation: Number of Data sets using DCAT standards/Total number of data sets in open repositories
2021-05-20	E.B.	Changed emission factor for CO2 to Tonnes/kWh as inputs will also be in kWh
2021-07-07	E.B.	Changed all instances of the word 'Energetic' in 'Energy' in the context of 'Energy Self Supply' (KPI 10)
2021-08-23	L.E.	• Storage capacity installed ○ updated to have two separate formulas based on energy carrier, one for thermal storage and one for electrical storage. ○ The formula which calculates the KPI when the baseline is not zero is removed as with it it will not be possible to add the storage capacities of the same energy carrier together since it is not in kWh but rather in percentage. • Increase system flexibility ○ Removed the alternative formula SFAC, where cost was involved as this is not used and does not give the KPI in the same unit
2021-08-24	L.E.	• Storage Energy Losses ○ Added this KPI card as it was missing in this report. It was put last to not change numbers of previous KPIs and cause confusion.
2021-09-06	L.E.	• Updated the CO2 emission reduction card with numbers for the use cases I-IV.
2021-09-13	L.E	• Updated the KPI Increase in Local Renewable energy production so that it gives increase as a quantity of energy (separate KPI for electricity and thermal) not relative to the base case since the measures in IRIS have zero as base case and then the KPI formula as previously stated gives the same number/info as the KPI Degree of energy self-supply by RES.
2021-10-08	L.E	• Added subscripts and updated the formula for use case IV of KPI Carbon dioxide emission reduction to clarify kilometres and emissions factors to use.
2021-10-	L.E	• Removed % as the unit for KPI38 and KPI39
2021-11	E.B.	• Changed % into kWh as unit for KPI 42 (storage capacity installed)
2021-11	E.B.	• Added formula to KPI 7 CO2 reduction cost efficiency

Annex 2 Measure Numbering

The numbering of the measures is based on the IRIS measure tracker, which can be found online

Utrecht Demonstration measure tracker

Transition Track 1: Retrofit activities apartment buildings	
Measure 1	District wide PV
Measure 2	LT district heating
Measure 3	HEMS TOON
Measure 4	NZEB refurbishment
Measure 5	Smart (hybrid) e-heating systems
Measure 6	AC/DC home switchboxes
Measure 7	Smart DC Street Lighting
Transition Track 2: Placement Solar V2G charging points	
Measure 1	Solar V2G charging points for e-cars/e-vans (demand driven)
Measure 2	Solar V2G charging point for e-buses
Measure 3	Stationary storage in apartment buildings
Measure 4	EMSs- Smart Energy Management System
Transition Track 3	
Measure 1	V2G e-cars (demand driven)
Measure 2	V2G e-buses
Transition Track 4	
Measure 1	Monitoring E-Mobility with LoRa network
Measure 2	Smart Street Lighting with multi-sensoring
Measure 3	3D Utrecht City Innovation Model
Measure 4	Monitoring Grid Flexibility
Measure 5	Fighting Energy Poverty
Transition Track 5	
Measure 1	Community building by change agents
Measure 2	Campaign District School Involvement
Measure 3	Campaign Smart Street Lighting
Measure 4	Co-creation in Local Innovation Hub
Measure 5	VR New Home and District Experience

Gothenburg Demonstration measure tracker

Transition Track /	Measure title
Transition Track 1	
Demonstration 1	At least 200 kWh electricity storage in 2nd life batteries powered by 140 kW PV
Demonstration 2	Heating from geo energy with heat pumps (2-300 m deep boreholes)
Demonstration 3	Cooling from geo energy without chillers
Demonstration 4	Local energy storages consisting of water buffer tanks, structural storage and long-term storage in boreholes
Demonstration 5	Seasonal energy trading (cooling in summer season) with adjacent office block
Demonstration 6	Advanced Energy Management System to achieve peak shaving and minimal environmental impact
Demonstration 7	Building Integrated Photovoltaics (BIPV) in façade
Transition Track 2	
Demonstration 1	350 V DC building microgrid utilizing 140 kW rooftop PV installations and 200 kWh battery storage
Demonstration 2	PCM cooling storage
Demonstration 3	Low temperature DH 45/30 system for six buildings
Demonstration 4	Integration and evaluation of a 200kWh energy storage
Transition Track 3	
Demonstration 1	EC2B, version for accomodation (Riksbyggen's BRF Viva)
Demonstration 2	EC2B, version for workplaces (Johanneberg campus area)
Transition Track 4	
Demonstration 1	CIM- City Information Model
Demonstration 2	Energy Cloud
Transition Track 5	
Measure 1	ME model
Measure 2	SCH - smart city hub
Measure 3	CD - continuous dialogue
Measure 4	ILC - inclusive life challenge
Measure 5	Minecraft competition
Measure 6	VR/3DBIM - building information modeling
Measure 7	PET - Personal Energy Treshold?

Nice Demonstration measure tracker

Transition Track / Measure	Measure title
Measure 1: IS 1.1 (Positive Energy Building)	Collective self-consumption at building scale (Palazzo Meridia)
	Collective self-consumption at building scale (UNS-IMREDD)
Measure 2: IS 1.2 (Near zero energy retrofit)	Optimization of heating load curve
Measure 3: IS 1.2 (Near zero energy retrofit)	Commissioning process from the design of the operation
Measure 4: IS 1.3 (Symbiotic waste heat network)	Dashboard providing real-time energy balance
Transition Track 2	
Measure 1: IS 2.1 Flexible electricity grid networks	LEM - Local Energy Management system
Measure 2: IS 2.2 Smart district heating with innovative storage	DHC Smart District Heating and Cooling optimization algorithm
Measure 3: IS 2.3 Utilizing 2nd life batteries for large-scale storage	Stationary storage deployment in buildings and local electric flexibility management
Transition Track 3	
Measure 1: IS 3.1 Smart solar V2G EV charging	Dynamic energy management of an EV charging network
Measure 2: IS 3.2 Innovative mobility services for the citizen	Free floating EV car sharing system
Measure 3: IS 3.2 Innovative mobility services for the citizen	Impact of urban environmental monitoring on citizen mobility
Transition Track 4	
Measure 1: IS 4.1 Services for urban monitoring	Sensors data collection in mobility through 5G IOT network
Measure 2: IS 4.2 Services for city management and planning	BIM/CIM data display
Measure 3: IS 4.3 Services for mobility	Charging infrastructure data for optimal EV-based free-floating car sharing
Measure 4: IS 4.4 Services for grid flexibility	Data interoperability with energy cloud
Transition Track 5	
Measure 1: IS 5.1 Co-creating the energy transition)	Public awareness campaign

Measure 2: IS 5.2 Participatory city modelling	Participation of citizens to city life
Measure 3: IS 5.4 Apps and I/F for energy efficient behavior	Citizens collective engagement
Measure 4: IS 5.4 Apps and I/F for energy efficient behavior	Citizen individual engagement

Annex 3 – KPI cards

Annex 3 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.

Changelog

Date	Name	Modifications
2021-05-04	E.P.Bontekoe	• CO_2 emission reduction: o Focus on emission reduction o Added use cases and examples • CO emission reduction: o Homogenized with CO_2 emission reduction o Changed KPI output to number (tonnes CO) instead of %, in order to make the KPI applicable as indicator for grant agreement goals o Added use case of sustainable transport o Small typographic modifications in title and description • NOx emission reduction: o Homogenized with CO_2 emission reduction o Changed KPI output to number (Tonnes Nox) instead of %, in order to make the KPI applicable as indicator for grant agreement goals o Added use case of sustainable transport o Small typographic modifications in title and description • Fine particulate matter emission reduction: o Changed PM to FPM in KPI description o Homogenized with CO_2 emission reduction o Changed KPI output to number (Tonnes FPM) instead of number per capita, in order to make the KPI applicable as indicator for grant agreement goals o Added use case of sustainable transport o Small typographic modifications in title and description
2021-05-05	L.Eriksson	• Reduction in driven km by tenants and employees in the district ○ Added formula for clarity • Reduction in car ownership among tenants ○ Added formula for clarity • Increased system flexibility for energy players/stakeholders ○ Added formula and made differentiation between thermal and electrical ○ Changed description to make it clearer • Storage capacity installed ○ Changed formula so it can be calculated when baseline is 0, in this case it is not percentage but absolute value • Reduced energy cost for custumers ○ Added explanation of parameters used to calculate KPI

		• User Engagement
		  ○ Added description Number of participants/users of the platform
		• Quality of open data
		  ○ Added explanation: Number of Data sets using DCAT standards/Total number of data sets in open repositories

2021-05-20	E.B.	Changed emission factor for CO2 to Tonnes/kWh as inputs will also be in kWh
2021-07-07	E.B.	Changed all instances of the word 'Energetic' in 'Energy' in the context of 'Energy Self Supply' (KPI 10)

2021-08-23	L.E.	• Storage capacity installed
		  ○ updated to have two separate formulas based on energy carrier, one for thermal storage and one for electrical storage.
		  ○ The formula which calculates the KPI when the baseline is not zero is removed as with it it will not be possible to add the storage capacities of the same energy carrier together since it is not in kWh but rather in percentage.
		• Increase system flexibility
		  ○ Removed the alternative formula SFAC, where cost was involved as this is not used and does not give the KPI in the same unit

2021-08-24	L.E.	• Storage Energy Losses ○ Added this KPI card as it was missing in this report. It was put last to not change numbers of previous KPIs and cause confusion.
2021-09-06	L.E.	• Updated the CO2 emission reduction card with numbers for the use cases I-IV.
2021-09-13	L.E	• Updated the KPI Increase in Local Renewable energy production so that it gives increase as a quantity of energy (separate KPI for electricity and thermal) not relative to the base case since the measures in IRIS have zero as base case and then the KPI formula as previously stated gives the same number/info as the KPI Degree of energy self-supply by RES.
2021-10-08	L.E	• Added subscripts and updated the formula for use case IV of KPI Carbon dioxide emission reduction to clarify kilometres and emissions factors to use.
2021-10-	L.E	• Removed % as the unit for KPI38 and KPI39
2021-11	E.B.	• Changed % into kWh as unit for KPI 42 (storage capacity installed)
2021-11	E.B.	• Added formula to KPI 7 CO2 reduction cost efficiency

1.1. Accessibility of open data

<table>
<tr><th colspan="6">Accessibility of open data</th></tr>
<tr><td>KPI Description</td><td colspan="5">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</td></tr>
<tr><td>KPI Formula</td><td colspan="5">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</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>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">GOT</td></tr>
</table>

1.2. Access to vehicle sharing solutions for city travel

<table>
<tr><th colspan="6">Access to vehicle sharing solutions for city travel</th></tr>
<tr><td>KPI Description</td><td colspan="5">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</td></tr>
<tr><td>KPI Formula</td><td colspan="5">Number of vehicles available for sharing per 100.000 inhabitants</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="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>X</td><td>TSP</td><td>X</td></tr>
<tr><td>Energy Supply Unit</td><td></td><td>End-Users</td><td>X</td></tr>
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<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">LOM, UTR; VULOG; IRIS;</td></tr>
</table>

1.3. 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="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>X</td></tr>
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<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,</td></tr>
</table>

1.4. 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>
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<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>

1.5. Carbon dioxide emission reduction

Carbon dioxide emission reduction	
KPI Description	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.
KPI Formula	The emitted mass of CO_2 is calculated from the delivered and exported resource for each carrier: $$m_{CO_2} = \sum(R_{del,i}K_{del,i}) - \sum(R_{exp,i}K_{exp,i})$$ $R_{del,i}$ = the delivered resource for carrier i $R_{exp,i}$ = the exported resource for carrier i $K_{del,i}$ = the CO_2 coefficient for delivered resource carrier i $K_{exp,i}$ = the CO_2 coefficient for exported resource 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. Table to use generalized formula for use cases as explained below

Use case	General variable	Case variable
I: Energy savings	$R_{del,i}$	$E_{baseline}$
	$K_{del,i}$	$K_{baseline}$
	$R_{exp,i}$	$E_{measure}$
	$K_{exp,i}$	$K_{measure}$
II: Renewable energy production, when new production is zero-emission and replaces conventional production	$R_{exp,i}$	$E_{production}$
	$K_{del,i}$	$K_{baseline}$
	$R_{exp,i}$	$E_{production}$
	$K_{exp,i}$	0
III: Renewable thermal production using heat pump to replace part or all heating demand	$R_{del,i}$	$E_{HP,electricity}$
	$K_{del,i}$	$K_{baseline,el}$
	$R_{exp,i}$	$E_{production}$
	$K_{exp,i}$	$K_{baseline,heat}$

IV: Sustainable transport, when same amount of kilometers is replaced with zero-emission	$R_{del,i}$	$D_{measure}$
	$K_{del,i}$	$EF_{baseline}$
	$R_{del,i}$	$D_{measure}$
	$K_{del,i}$	$EF_{measure}$

CO_2Reduction

When the emitted mass of CO_2 is defined, the reduction of Carbon dioxide emissions can be calculated by:

$$CO_2Reduction \ = m_{CO_2\ baseline} - m_{CO_2}$$

$$= Baseline(\sum(R_{del,i}K_{del,i}) - \sum(R_{exp,i}K_{exp,i})) -$$

$$measure\ (\sum(R_{del,i}K_{del,i}) - \sum(R_{exp,i}K_{exp,i}))$$

Use cases:

I: When CO_2 reduction is achieved by energy savings:

$$CO_2Reduction \ = E_{baseline}\,K_{baseline} \quad - E_{measure}\,K_{measure}$$

$E_{baseline}$ = the energy use prior to implementing the measure

$E_{measure}$ = the energy use after implementing the measure

$K_{baseline}$ = the CO_2 coefficient of energy used in base case

$K_{measure}$ = the CO_2 coefficient of energy used after implementing the measure

II: When CO_2 reduction is achieved by renewable electricity production. The renewable energy can either be used in the building, and thereby reduce the need to import energy, or it can be exported and thereby lower the need for energy production by alternative production technology. The system boundary is expanded to include both options. The reduction is given by:

$$CO_2Reduction \ = E_{production}\,(K_{baseline} - K_{measure}) = if\ \ K_{measure} = 0$$
$$= \ E_{production}\,K_{baseline}$$

$E_{production}$ = the energy produced by the measure [kWh/year]

$K_{baseline}$ = the CO_2 coefficient of the delivered energy in case it would have been produced without the measure (base line). [t CO2/kWh]

	$K_{measure}$ = the CO_2 coefficient of the produced energy by the measure, for renewables this set to zero [t CO2/kWh] **III:** When CO_2 reduction is achieved by renewable heat production using heat pump technology it is assumed that the emissions associated with it is simply those associated with the electricity needed to run it. However, the renewable heat produced will lead to a reduced use of the baseline heating technology, in this case district heating ($E_{production} = (E_{DH,baseline} - E_{DH,measure})$). The resulting reduction is obtained from the following: $CO_2Reduction = (E_{DH,baseline}K_{DH,baseline}) - (E_{DH,measure}\ K_{DH,baseline} + E_{HPel,measure}\ K_{el,measure}) = K_{DH,baseline}(E_{DH,baseline} - E_{DH,measure}) - E_{HP\ electricity}\ K_{baseline,el} = E_{production}K_{baseline,heat} - E_{HP\ electricity}\ K_{baseline,el}$ $E_{DH,measure}$ = the heat delivered from district heating after implementing the measure [MWh/year] $E_{DH,baseline}$ = the heat delivered from district heating for the baseline [kWh/year] $K_{baseline,heat}$ = the CO_2 coefficient of the baseline heat production technology, i.e. district heating [t CO2/kWh] $E_{HPelectricity}$ = the electricity consumption of the heat pump [kWh/year] $K_{baseline,el}$ = the CO_2 coefficient of electricity [t CO2/kWh] $E_{production}$ = the thermal energy produced by the heat pump [kWh/year] **IV:** When CO_2 reduction is achieved by more sustainable transport solutions (for example Electric Vehicles or Electric busses), the reduction is based on the emission factor per kilometre (EF) and the number of driven kilometres (*D*). $CO_2Reduction = D_{baseline}\ EF_{baseline} - (D_{measure,CC}\ EF_{baseline} + D_{measure,ECS}\ EF_{measure})$ $D_{baseline}$ = the number of driven kilometres before implementing the measure $D_{measure,CC}$ = the number of driven kilometres by tenants in conventional cars after implementing the measure $D_{measure,ECS}$ = the number of driven kilometres by tenants in in e-car sharing system after implementing the measure $EF_{baseline}$ = the emission factor per kilometre in the baseline (conventional cars) $EF_{measure}$ = the emission factor per kilometre for the measure (e-car sharing system) To clarify what energy carrier is involved in the measure these subscripts are used for the measures where it is relevant: $CO_2Reduction_{electricity}$ = CO_2 emission reduction for measures related to electricity use

$CO_2Reduction_{heating}$ = CO_2 emission reduction for measures related to heating
$CO_2Reduction_{transport}$ = CO_2 emission reduction for measures related to transport

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 carriers as described in below tables:

National and European emission factors for consumed electricity (Countries of IRIS LH and FCs) (source: Covenant of Mayors).

Country	Standard emission factor ($t\ CO_2/MWh_e$)
Spain	0.440
Finland	0.216
France	0.056
Greece	1.149
Netherlands	0.435
Sweden	0.023
Romania	0.701
EU-27	**0.460**

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

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

For measures related to district heating the specific emissions related to the grids of the Light House Cities are used. (source Gothenburg: https://www.goteborgenergi.se/DxF-64187640/Miljovarden-for-fjarrvarme-2019-Prel.pdf?TS=637160498181668095)

City	Emission factor DH ($t\ CO_2$ eqv. /MWh)
Gothenburg	0.074
Nice	
Utrecht	
EU average???	

	When Emission factors are based on driven kilometers, European emission factors can be obtained by the table below, or by making use of more local data, for example on country level. *Table 1 AverageCO2 emission per driven km from new passenger cars (https://www.eea.europa.eu/data-and-maps/indicators/average-co2-emissions-from-motor-vehicles/assessment-2)* **Year** — **CO_2 Emission(gCO_2/ km)** **2019** — **122,4** **2018** — **120.8** **2017** — **118.5** **2016** — **118.1**				
Measurement procedure	1. Data collection 2. KPI calculation 3. Comparison with national emissions factor				
Unit of Measurement	tonnes/(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		

1.6. Carbon monoxide emission reduction

Carbon monoxide emission reduction					
KPI Description	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. Carbon monoxide emission reduction can be calculated similarly as carbon dioxide emission reduction. The main difference in the calculation is the emission factor, which has to be obtained for carbon monoxide emissions. **Use case:** When CO reduction is achieved by more sustainable transport solutions (for example Electric Vehicles or Electric busses), the reduction is based on the emission factor per kilometre (EF) and the number of driven kilometres (*D*). $$COReduction = D_{baseline}\,EF_{baseline} - D_{measure}\,EF_{measure}$$ $D_{baseline}$ = the number of driven kilometres before implementing the measure $D_{measure}$ = the number of driven kilometres after implementing the measure $EF_{baseline}$ = the emission factor per kilometre in the baseline $EF_{measure}$ = the emission factor per kilometre for the measure				
Measurement procedure	1. Data collection 2. KPI calculation				
Unit of Measurement	Tonnes /(year)		**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,		

1.7. CO2 reduction cost efficiency

<table>
<tr><th colspan="6">CO2 reduction cost efficiency</th></tr>
<tr><td>KPI Description</td><td colspan="5">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.</td></tr>
<tr><td>KPI Formula</td><td colspan="5">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.
$$CO_2 Reduction\ Cost\ Efficiency\ = Cost_{CO_2\ reducing\ measures}\ / CO_2 Reduction$$</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">$€/((ton\ of\ CO2) \cdot y)$</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></td><td>End-Users</td><td></td></tr>
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<tr><td>City</td><td>X</td><td>Representative Citizen Groups</td><td></td></tr>
<tr><td></td><td></td><td>Citizen Ambassadors</td><td></td></tr>
<tr><td colspan="3">Responsible Partner for KPI Data Collection</td><td colspan="3">CSTB, EDF, VULOG, Rb, AH, METRY, IRIS</td></tr>
</table>

1.8. Data loss prevention

<table>
<tr><th colspan="6">Data loss prevention</th></tr>
<tr><td>KPI Description</td><td colspan="5">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.</td></tr>
<tr><td>KPI Formula</td><td colspan="5">Lost datapoints in a period.</td></tr>
<tr><td>Measurement procedure</td><td colspan="5">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.</td></tr>
<tr><td>Unit of Measurement</td><td colspan="2">Number of lost datapoints per timeframe.</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>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></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">CIVITY, NCA, GOT</td></tr>
</table>

1.9. Data safety

<table>
<tr><th colspan="6">Data safety</th></tr>
<tr><td>KPI Description</td><td colspan="5">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.</td></tr>
<tr><td>KPI Formula</td><td colspan="5">Number of blocked malicious hacking attempts</td></tr>
<tr><td>Measurement procedure</td><td colspan="5">The CIP will keep detailed usage statistics.</td></tr>
<tr><td>Unit of Measurement</td><td colspan="2"># per unit /months/ years</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></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">GOT, CIVITY, NCA</td></tr>
</table>

1.10. Degree of energy self-supply by RES

Degree of energy self-supply by RES				
KPI Description	The degree of energy self-supply by RES (DE) 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.			
KPI Formula	$$DE_T = \frac{LPE_T}{TE_C}$$ 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)] $$DE_E = \frac{LPE_E}{EE_C}$$ 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)]			
Measurement procedure	1. Collection of data 2. Calculation of KPI			
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	
	Neighbourhood	X		Citizens	
	City	X		Representative Citizen Groups	
				Citizen Ambassadors	
Responsible Partner for KPI Data Collection			IRIS, BOEX, STED, CSTB, EDF, NEXITY, UNS, Rb, HSB, AH		

1.11. Developer engagement

<table>
<tr><th colspan="6">Developer engagement</th></tr>
<tr><td>KPI Description</td><td colspan="5">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.</td></tr>
<tr><td>KPI Formula</td><td colspan="5">Number of API calls per month</td></tr>
<tr><td>Measurement procedure</td><td colspan="5">Monitoring of API- calls with software.
The CIP will keep detailed usage statistics.</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></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></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">CIVITY, NCA, GOT,</td></tr>
</table>

1.12. Ease of use for end users of the solution

<table>
<tr><th colspan="6">Ease of use for end users of the solution</th></tr>
<tr><td>KPI Description</td><td colspan="5">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.</td></tr>
<tr><td>KPI Formula</td><td colspan="5">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.</td></tr>
<tr><td>Measurement procedure</td><td colspan="5">1. Undertaking of the survey
2. 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="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, NCA</td></tr>
</table>

1.13. Energy savings

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

1.14. Expiration date of open data

<table>
<tr><th colspan="6">Expiration date of open data</th></tr>
<tr><td>KPI Description</td><td colspan="5">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.</td></tr>
<tr><td>KPI Formula</td><td colspan="5">Percentage of outdated datasets on a city platform per timeframe</td></tr>
<tr><td>Measurement procedure</td><td colspan="5">Statistics from CIP.</td></tr>
<tr><td>Unit of Measurement</td><td colspan="2">% of obsolete data on city data platform per timeframe</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></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">GOT, CIVITY, NCA</td></tr>
</table>

1.15. Fine particulate matter emission reduction

<table>
<tr><th colspan="5">Fine particulate matter emission reduction</th></tr>
<tr><td>KPI Description</td><td colspan="4">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 (FPM) can cause major health problems in cities. According to the WHO, any concentration of particulate matter is harmful to human health. FPM 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 FPM 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).</td></tr>
<tr><td>KPI Formula</td><td colspan="4">The indicator is calculated as the direct (operational) reduction of the FPM emissions over a period of time. The result may be expressed as a percentage when divided by the reference FPM emissions. To calculate the direct FPM emissions, the total energy reduced, can be translated to FPM emission figures.

Carbon monoxide emission reduction can be calculated similarly as carbon dioxide emission reduction. The main difference in the calculation is the emission factor, which has to be obtained for carbon monoxide emissions.

Use case:
When FPM reduction is achieved by more sustainable transport solutions (for example Electric Vehicles or Electric busses), the reduction is based on the emission factor per kilometre (EF) and the number of driven kilometres (D).

$$FPMReduction = D_{baseline}\,EF_{baseline} - D_{measure}\,EF_{measure}$$
$D_{baseline}$ = the number of driven kilometres before implementing the measure
$D_{measure}$ = the number of driven kilometres after implementing the measure
$EF_{baseline}$ = the emission factor per kilometre in the baseline
$EF_{measure}$ = the emission factor per kilometre for the measure</td></tr>
<tr><td>Measurement procedure</td><td colspan="4">1. Data collection
2. KPI calculation</td></tr>
<tr><td>Unit of Measurement</td><td colspan="2">Tonnes /(year)</td><td>Threshold/ Target</td><td></td></tr>
<tr><td rowspan="6">Object of assessment</td><td>Building</td><td></td><td rowspan="6">Stakeholders</td><td>DSO | </td></tr>
<tr><td>Set of Buildings</td><td></td><td>TSP | </td></tr>
<tr><td>Energy Supply Unit</td><td></td><td>End-Users | </td></tr>
<tr><td>Set of Energy Supply Units</td><td></td><td>Governance | X</td></tr>
<tr><td>Neighbourhood</td><td>X</td><td>Citizens | </td></tr>
<tr><td>City</td><td>X</td><td>Representative Citizen Groups | </td></tr>
</table>

				Citizen Ambassadors	
Responsible Partner for KPI Data Collection			LOM, UTR		

1.16. 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,		

1.17. 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>

1.18. Increased consciousness of citizenship

<table>
<tr><th colspan="6">Increased consciousness of citizenship</th></tr>
<tr><td>KPI Description</td><td colspan="5">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.</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 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.</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></td><td>TSP</td><td>x</td></tr>
<tr><td>Energy Supply Unit</td><td></td><td>End-Users</td><td>x</td></tr>
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<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</td></tr>
</table>

1.19. Increased environmental awareness

Increased environmental awareness					
KPI Description	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.				
KPI Formula	Likert scale: Not at all – 1 – 2 – 3 – 4 – 5 – very much 1. Not at all: opportunities to increase environmental awareness were not taken into account in the project communication. 2. Poor: opportunities to increase environmental awareness were slightly taken into account in the project communication. 3. Somewhat: opportunities to increase environmental awareness were somewhat taken into account in the project communication, at key moments in the project there was attention for this issue. 4. Good: opportunities to increase environmental awareness were sufficiently taken into account in the project communication, the project utilized many possibilities to address this issue in their communications. 5. Excellent: opportunities to increase environmental awareness were taken into account in the project communication, the project utilized every possibility to address this issue both in online and offline communications.				
Measurement procedure	5. Data collection 6. 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, VEOLIA		

1.20. Increase in Local Renewable Energy production

<table>
<tr><th colspan="6">Increase in Local Renewable Energy production</th></tr>
<tr><td>KPI Description</td><td colspan="5">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.</td></tr>
<tr><td>KPI Formula</td><td colspan="5">$$LREG = ERES_{R\&I}$$
LREG = Annual Local Renewable Electricity Generation [MWh]
ERES = Annual electricity generated by RES by the measure/intervention [MWh]

$$LREH = HRES_{R\&I}$$
LRTG = Annual Local Renewable Thermal Generation [MWh]
HRES = Annual heating/cooling generated by RES by the measure/intervention [MWh]</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">MWh</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></td></tr>
<tr><td>Energy Supply Unit</td><td>X</td><td>End-Users</td><td></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></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">HSB, Rb, AH, IRIS, CSTB,BOEX, STED,</td></tr>
</table>

1.21. 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 through installed storage and/or production capacity on the demand side.
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. The KPI is defined separately for electrical and thermal system flexibility and is calculated by dividing the increased flexibility capacity divided by the peak power.</td></tr>
<tr><td>KPI Formula</td><td colspan="5">$$\Delta SF_{electrical} = \frac{SF_{R\&I\,el} - SF_{BAU\,el}}{P_{peak\,el}}$$
$SF_{BAU,\,electrical}$ = Installed capacity contributing to electrical flexibility at baseline [kW]
$SF_{R\&I,\,electrical}$ = Installed capacity contributing to electrical flexibility after measure is implemented [kW]
$P_{peak,electrical}$ = Peak electrical power after measure is installed [kW]
$$\Delta SF_{thermal} = \frac{SF_{R\&I\,thermal} - SF_{BAU\,thermal}}{P_{peak\,thermal}}$$
$SF_{BAU,\,thermal}$ = Installed capacity contributing to thermal flexibility at baseline [kW]
$SF_{R\&I,\,thermal}$ = Installed capacity contributing to thermal flexibility after measure is implemented [kW]
$P_{peak,thermal}$ = Peak thermal power after measure is installed [kW]

SF is the amount of load capacity participating in demand side management [W].</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>

1.22. 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>

1.23. Local community involvement in the planning phase

<table>
<tr><th colspan="5">Local community involvement in the planning phase</th></tr>
<tr><td>KPI Description</td><td colspan="4">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="4">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 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.
3. 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.
4. 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.
5. 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="4">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></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>

1.24. Nitrogen oxide emission reduction

<table>
<tr><th colspan="6">Nitrogen oxide emission reduction</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.
Quantitative reduction in NOx emissions (NO and NO2) achieved by the project.</td></tr>
<tr><td>KPI Formula</td><td colspan="5">NOx emission reduction can be calculated similarly as carbon dioxide emission reduction. The main difference in the calculation is the emission factor, which has to be obtained for NOx emissions.

Use case:
When NOx reduction is achieved by more sustainable transport solutions (for example Electric Vehicles or Electric busses), the reduction is based on the emission factor per kilometre (EF) and the number of driven kilometres (D).

$$NO_x Reduction = D_{baseline}\, EF_{baseline} - D_{measure}\, EF_{measure}$$

$D_{baseline}$ = the number of driven kilometres before implementing the measure
$D_{measure}$ = the number of driven kilometres after implementing the measure
$EF_{baseline}$ = the emission factor per kilometre in the baseline
$EF_{measure}$ = the emission factor per kilometre for the measure</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">Tonnes/ (year)</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>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>

1.25. 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		

1.26. 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		

1.27. 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,		

1.28. Number of Free Floating subscribers

<table>
<tr><th colspan="6">Number of Free Floating subscribers</th></tr>
<tr><td>KPI Description</td><td colspan="5">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.</td></tr>
<tr><td>KPI Formula</td><td colspan="5">Number of final users involved</td></tr>
<tr><td>Measurement procedure</td><td colspan="5">1. Data collection</td></tr>
<tr><td>Unit of Measurement</td><td colspan="2">#</td><td>Threshold/ Target</td><td colspan="2"></td></tr>
<tr><td rowspan="7">Object of assessment</td><td>Building</td><td>X</td><td rowspan="7">Stakeholders</td><td>DSO</td><td></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></td><td>End-Users</td><td></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">VULOG</td></tr>
</table>

1.29. 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		

1.30. 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="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">GOT</td></tr>
</table>

1.31. 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		

1.32. People reached

<table>
<tr><th colspan="6">People reached</th></tr>
<tr><td>KPI Description</td><td colspan="5">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</td></tr>
<tr><td>KPI Formula</td><td colspan="5">(number of citizens reached/total number of citizens considered as the total target group of the project) * 100%</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="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, NCA, VEOLIA</td></tr>
</table>

1.33. Platform downtime

<table>
<tr><th colspan="6">Platform downtime</th></tr>
<tr><td>KPI Description</td><td colspan="5">To run a stable platform, monitoring is required to fix bugs and quickly improve the software environments.</td></tr>
<tr><td>KPI Formula</td><td colspan="5">Downtime per timeframe.</td></tr>
<tr><td>Measurement procedure</td><td colspan="5">The CIP will keep detailed usage statistics.</td></tr>
<tr><td>Unit of Measurement</td><td colspan="2">Minutes / (selected timeframe)</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>X</td></tr>
<tr><td>Neighbourhood</td><td></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">CIVITY, NCA, GOT,</td></tr>
</table>

1.34. Reduced energy cost for customers

<table>
<tr><th colspan="6">Reduced energy cost for costumers</th></tr>
<tr><td>KPI Description</td><td colspan="5">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.</td></tr>
<tr><td>KPI Formula</td><td colspan="5">$$COST_{REDUCTION} = \frac{COST_{R\&I} - COST_{BaU}}{COST_{BaU}}$$
$COST_{R\&I}$ = the energy cost for customers after implementing the measure [€]
$COST_{BaU}$ = the energy cost for customers for baseline [€]</td></tr>
<tr><td>Measurement procedure</td><td colspan="5">1. Data collection
2. KPI calculation</td></tr>
<tr><td>Unit of Measurement</td><td colspan="2">%</td><td>Threshold/ Target</td><td colspan="2"></td></tr>
<tr><td rowspan="7">Object of assessment</td><td>Building</td><td>X</td><td rowspan="7">Stakeholders</td><td>DSO</td><td>X</td></tr>
<tr><td>Set of Buildings</td><td>X</td><td>TSP</td><td>X</td></tr>
<tr><td>Energy Supply Unit</td><td>X</td><td>End-Users</td><td>X</td></tr>
<tr><td>Set of Energy Supply Units</td><td>X</td><td>Governance</td><td></td></tr>
<tr><td>Neighbourhood</td><td>X</td><td>Citizens</td><td></td></tr>
<tr><td>City</td><td>X</td><td>Representative Citizen Groups</td><td></td></tr>
<tr><td></td><td></td><td>Citizen Ambassadors</td><td></td></tr>
<tr><td colspan="3">Responsible Partner for KPI Data Collection</td><td colspan="3">Rb,EDF,</td></tr>
</table>

1.35. Reduced energy curtailment of RES and DER

<table>
<tr><th colspan="6">Reduced energy curtailment of RES and DER</th></tr>
<tr><td>KPI Description</td><td colspan="5">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.</td></tr>
<tr><td>KPI Formula</td><td colspan="5">$$Reduction\ of\ EnI = \frac{EnI_{baseline} - EnI_{R\&I}}{EnI_{baseline}} \cdot 100$$
EnI = Energy not Injected</td></tr>
<tr><td>Measurement procedure</td><td colspan="5">1. Calculation/determination of baseline
2. Data collection
3. 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></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">LOM, EDF,</td></tr>
</table>

1.37. Reduction in annual final energy consumption by street lighting

<table>
<tr><th colspan="7">Reduction in annual final energy consumption by street lighting</th></tr>
<tr><td>KPI Description</td><td colspan="6">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</td></tr>
<tr><td>KPI Formula</td><td colspan="6">$$ES_E = 1 - \frac{TE_C}{ER_E}$$
ES_T = Electric energy savings
TE_C = Electric energy consumption of the demonstration-site [kWh/(m^2 year)]
ER_T = Electric energy reference demand or consumption (simulated or monitored) of demonstration-site [kWh/(m^2 year)].</td></tr>
<tr><td>Measurement procedure</td><td colspan="6">1. Data collection
2. KPI calculation</td></tr>
<tr><td>Unit of Measurement</td><td colspan="2">%</td><td>Threshold/ Target</td><td colspan="3"></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></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">STED</td></tr>
</table>

1.38. Reduction in car ownership among tenants

<table>
<tr><th colspan="6">Reduction in car ownership among tenants</th></tr>
<tr><td>KPI Description</td><td colspan="5">Number of care ownership among tenants before and after moving in to the demonstration area</td></tr>
<tr><td>KPI Formula</td><td colspan="5">Survey among tenants

$C_{red} = C_{BaU} - C_{R\&I}$

C_{red} = Reduction in car ownership
C_{BaU} = number of cars owned before moving to the demonstration area
$C_{R\&I}$ = number of cars owned after moving to the demonstration area</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></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>X</td></tr>
<tr><td>Neighbourhood</td><td>X</td><td>Citizens</td><td>X</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">TRIV</td></tr>
</table>

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

<table>
<tr><th colspan="6">Reduction in driven km by tenants and employees in the district</th></tr>
<tr><td>KPI Description</td><td colspan="5">Kilometers driven by the tenants and employees in the district before and after moving in to the demonstration area.</td></tr>
<tr><td>KPI Formula</td><td colspan="5">$D_{red} = D_{BaU} - D_{R\&I}$

D_{red} = Reduction in km driven [km/year]
D_{BaU} = Driven km before moving to the demonstration area [km/year]
$D_{R\&I}$ = Driven km after moving to the demonstration area [km/year]</td></tr>
<tr><td>Measurement procedure</td><td colspan="5">1. Data collection
2. KPI calculation</td></tr>
<tr><td>Unit of Measurement</td><td colspan="2"></td><td>Threshold/ Target</td><td colspan="2"></td></tr>
<tr><td rowspan="7">Object of assessment</td><td>Building</td><td>X</td><td rowspan="7">Stakeholders</td><td>DSO</td><td>X</td></tr>
<tr><td>Set of Buildings</td><td>X</td><td>TSP</td><td>X</td></tr>
<tr><td>Energy Supply Unit</td><td></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>X</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">TRIV</td></tr>
</table>

1.41. 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= 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			

1.42. Storage capacity installed

<table>
<tr><th colspan="6">Storage Capacity installed</th></tr>
<tr><td>KPI Description</td><td colspan="5">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. To differentiate between energy carriers the KPI has a subscript, electrical or thermal.</td></tr>
<tr><td>KPI Formula</td><td colspan="5">If $SCI_{baseline}$ is zero:
$$Storage\ capacity\ installed_{electrical} = SCI_{R\&I,electrical}$$
$$Storage\ capacity\ installed_{thermal} = SCI_{R\&I,thermal}$$
$SCI_{R\&I,electrical}$ = electrical storage capacity installed after measure is implemented [kWh]
$SCI_{R\&I,thermal}$ = thermal storage capacity installed after measure is implemented [kWh]
$SCI_{baseline,electrical}$ = electrical storage capacity installed at baseline [kWh]
$SCI_{baseline,electrical}$ = thermal storage capacity installed at baseline [kWh]</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">kWh</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>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">UTR, NCA, GOT</td></tr>
</table>

1.43. 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		

1.44. Usage of open source software

<table>
<tr><th colspan="6">Usage of open source software</th></tr>
<tr><td>KPI Description</td><td colspan="5">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.</td></tr>
<tr><td>KPI Formula</td><td colspan="5">How easy is it to connect systems</td></tr>
<tr><td>Measurement procedure</td><td colspan="5">Survey</td></tr>
<tr><td>Unit of Measurement</td><td colspan="2">Likert scale (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></td></tr>
<tr><td>Set of Energy Supply Units</td><td></td><td>Governance</td><td>X</td></tr>
<tr><td>Neighbourhood</td><td></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">UTR, NCA, GOT</td></tr>
</table>

1.45. User engagement

<table>
<tr><th colspan="6">User engagement</th></tr>
<tr><td>KPI Description</td><td colspan="5">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.</td></tr>
<tr><td>KPI Formula</td><td colspan="5">• Number of final users involved
• Number of people with increased capacity
• Number of participants/users of the platform</td></tr>
<tr><td>Measurement procedure</td><td colspan="5">1. Data collection</td></tr>
<tr><td>Unit of Measurement</td><td colspan="2">#</td><td>Threshold/ Target</td><td colspan="2"></td></tr>
<tr><td rowspan="7">Object of assessment</td><td>Building</td><td>X</td><td rowspan="7">Stakeholders</td><td>DSO</td><td></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></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">UTR, NCA, GOT</td></tr>
</table>

1.46. Yearly km driven in e-car sharing systems

<table>
<tr><th colspan="6">Yearly km made through the e-car sharing system</th></tr>
<tr><td>KPI Description</td><td colspan="5">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</td></tr>
<tr><td>KPI Formula</td><td colspan="5">Number of kilometres done by the car-sharing fleet</td></tr>
<tr><td>Measurement procedure</td><td colspan="5">1. Data collection</td></tr>
<tr><td>Unit of Measurement</td><td colspan="2">km</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></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></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">UTR, NCA, GOT</td></tr>
</table>

1.47. Quality of open data

<table>
<tr><th colspan="6">Quality of open data</th></tr>
<tr><td>KPI Description</td><td colspan="5">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.</td></tr>
<tr><td>KPI Formula</td><td colspan="5">Percentage of data that uses DCAT standards
= Number of Data sets using DCAT standards/Total number of data sets in open repositories</td></tr>
<tr><td>Measurement procedure</td><td colspan="5">Manual monitoring/ research to calculate the number of standardized datasets.</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></td></tr>
<tr><td>Set of Buildings</td><td></td><td>TSP</td><td></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>X</td></tr>
<tr><td>Neighbourhood</td><td></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">UTR, NCA, GOT</td></tr>
</table>

1.48. Total Investments

48. Total Investments (€/m²)			
KPI Description	An investment is defined as an asset or item that is purchased or implement with the aim to generate payments or savings over time. The investment in a newly constructed system is defined as cumulated payments until the initial operation of the system. The investment in the refurbishment of an existing system is defined as cumulated payments until the initial operation of the system after the refurbishment. Within SCIS, total investments apply to the energy aspects of the system (e.g. high efficient envelope in a building) and exclude investments non-energy related (e.g. refurbishment of bathrooms).		
KPI Formula	$EPI_{BR} = \frac{I_{BR}}{A_d}$	$EPI_{ER} = \frac{I_{ER}}{A_d}$	$EPI = EPI_{BR} + EPI_{ER}$

1.49. Grants

49. Grants (%)			
KPI Description	Grants are non-repayable funds that a grant maker, such as the government, provides to a recipient, e.g. a business, for ideas and projects to provide public services and stimulate the economy. In order to receive a grant, an applicant must submit a proposal or an application to the potential funder. This could be either on the applicant's own initiative or in response to a request for proposal from the funder.		
KPI Formula	$G_{rBR} = \frac{G_{BR} * 100}{I_{BR}}$	$G_{rER} = \frac{G_{ER} * 100}{I_{ER}}$	$G_r = \frac{(G_{BR} + G_{ER}) * 100}{I_{BR} + I_{ER}}$

1.50. Total annual costs

<table>
<tr><th colspan="3">50. Total annual costs (€/year)</th></tr>
<tr><td>KPI Description</td><td colspan="2">The total annual costs are defined as the sum of capital-related annual costs (e.g. interests and repairs caused by the investment), requirement-related costs (e.g. power costs), operation related costs (e.g. costs of using the installation) and other costs (e.g. insurance). These costs (can) vary for each year.
• Capital related costs encompass depreciation, interests and repairs caused by the investment.
• Requirement-related costs include power costs, auxiliary power costs, fuel costs, and costs for operating resources and in some cases external costs.
• Operation-related costs include among other things the costs of using the installation and costs of servicing and inspection.
• Other costs include costs of insurance, general output, uncollected taxes etc.
The total annual costs are related to the considered interval of time (year). To make different objects comparable the same types of costs have to be included in the calculation.</td></tr>
<tr><td>KPI Formula</td><td>$TAC_{before} = C_E + C_{O\&M}$</td><td>$TAC_{after_i} = C_E + C_{O\&M} + C_F$</td></tr>
</table>

1.51. Payback

51. Payback (Years)	
KPI Description	The payback period is the time it takes to cover investment costs. It can be calculated from the number of years elapsed between the initial investment and the time at which cumulative savings offset the investment. Simple payback takes real (non-discounted) values for future monies. Discounted payback uses present values. Payback in general ignores all costs and savings that occur after payback has been reached. Payback period is usually considered as an additional criterion to assess the investment, especially to assess the risks. Investments with a short payback period are considered safer than those with a longer payback period. As the invested capital flows back slower, the risk that the market changes and the invested capital can only be recovered later or not at all increases. On the other hand, costs and savings that occur after the investment has paid back are not considered. This is why sometimes decisions that are based on payback periods are not optimal and it is recommended to also consult other indicators.
KPI Formula	Type A static: $EPP = \frac{EPI}{m}$ Type B dynamic: $$EPP = \frac{ln\big(m \cdot (1+d)\big) - ln(EPI - EPI \cdot (1+d) + m)}{ln(1+d)} - 1$$ Type C dynamic with energy price increase rate: $$EPP = \frac{ln\big(m \cdot (1+d)\big) - ln(EPI(1+p) - EPI \cdot (1+d) + (1+p)m)}{ln(1+d) - ln(1+p)} - 1$$

1.52. Return on Investment

52. Return on Investment (%)	
KPI Description	The return on investment (ROI) is an economic variable that enables the evaluation of the feasibility of an investment or the comparison between different possible investments. This parameter is defined as the ratio between the total incomes/net profit and the total investment of the project, usually expressed in %.
KPI Formula	$$ROI_T = \frac{\sum_{t=1}^{T}\left(IN_t - TAC_{after_t}\right) - (I_{BR} + I_{ER})}{I_{BR} + I_{ER}} * 100$$
Applicable to all economic indicators	
Input Parameters	EPI_{BR} = Total investment for all the interventions related to building *(envelope)* retrofitting in the district per conditioned area [€/m^2] EPI_{ER} = Total investment for all the interventions related to energy *(system)* retrofitting in the district per conditioned area [€/m^2] *EPI = Total investment for all the interventions relating to building envelope and energy system retrofitting [€/m^2]* I_{BR} = Total investment for all the interventions related to building *(envelope)* retrofitting [€] I_{ER} = Total investment for all the interventions related to energy *(system)* retrofitting [€] G_{rBR} = Share of the investment in building envelope retrofitting that is covered by grants [%] G_{BR} = Total grants received for the building *(envelope)* retrofitting of the district [€] G_{rER} = Share of the investment in energy *(system)* retrofitting that is covered by grants [%] G_{ER} = Total grants received for the energy *(system)* retrofitting of the district [€] G_r *= Share of the investment in building (envelope) and energy system retrofitting that is covered by grants [%]* A_d = Total floor area of the system renovated [m^2] TAC_{before} = Total annual energy cost of the reference system (i.e. energy, operation & maintenance) [€/year] TAC_{after_i} = Total annual energy cost of the system after the intervention (i.e. energy, operation & maintenance, financial) for year *i* [€/year] C_E = Total annual cost of the system supply [€/year] $C_{O\&M}$ = Total annual cost of the operation and maintenance of the facility [€/year] C_F = Total annual financing cost, if applicable [€/year] EPP = Economic payback [years] m = Average annual costs in use savings (€/year) = $TAC_{before} - TAC_{after}$ d (%) = Discount rate (d should be unequal to p) p (%) = Energy price increase rate (p should be unequal to d) ROI_T = Return on Investment [%] IN_t = Income in year t T = Duration of the economic analysis period: e.g. T=10, 15 and 20 [years]
Measurement procedure	1. Data collection 2. Simulation (for some input parameters)

<table>
<tr><td></td><td colspan="5">3. 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>X</td><td rowspan="8">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>Decision-making Bodies</td><td></td></tr>
<tr><td>Neighbourhood</td><td>X</td><td>Executive & Legislative Bodies</td><td></td></tr>
<tr><td>City</td><td>X</td><td>Citizens</td><td></td></tr>
<tr><td></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">UTR, NCA, GOT</td></tr>
</table>

1.53. Storage Energy Losses

<table>
<tr><th colspan="6">Storage Energy Losses</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. This KPI illustrates the energy losses because of battery storage, including the added voltage transformations. The conclusions of this KPI concern the effectiveness of this technology and thus, gives useful data concerning the financial feasibility of its integration.</td></tr>
<tr><td>KPI Formula</td><td colspan="5">$$SEL = \frac{E_{input} - E_{output}}{E_{input}} \cdot 100$$
E_{input} = the energy input in a piece of energy storage equipment
E_{output}= the energy output of a piece of energy storage equipment</td></tr>
<tr><td>Measurement procedure</td><td colspan="5">1. Data collection
2. KPI calculation</td></tr>
<tr><td>Unit of Measurement</td><td colspan="2">%</td><td>Threshold/ Target</td><td colspan="2"></td></tr>
<tr><td rowspan="7">Object of assessment</td><td>Building</td><td>X</td><td rowspan="7">Stakeholders</td><td>DSO</td><td>X</td></tr>
<tr><td>Set of Buildings</td><td>X</td><td>TSP</td><td>X</td></tr>
<tr><td>Energy Supply Unit</td><td>X</td><td>End-Users</td><td>X</td></tr>
<tr><td>Set of Energy Supply Units</td><td></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">UTR, NCA, GOT</td></tr>
</table>