EET-centric KPIs definition, with all evaluation metrics and formulas derived

D2.1: EET-centric KPIs definition, with all evaluation metrics and formulas derived
WP1, T2.1

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Technical references

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Disclaimer

Executive Summary

The present deliverable *D2.1 EET-centric KPIs definition, with all evaluation metrics and formulas derived* sets the stage for the monitoring and evaluation activities during POCITYF by defining the project's Key Performance Indicators (KPIs). The indicators will be used to evaluate the progress and performance of interventions in the Lighthouse (LH) cities, as well as the overall success of POCITYF as a Smart City Project. The present document describes the work performed in Task 2.1 of Work Package (WP) 2 (*T2.1 KPIs Definition per ETT*).

The KPIs included in this deliverable have been compiled through a methodological approach considering a variety of Smart Cities and Communities (SCC) frameworks and initiatives, transparent criteria for indicator evaluation and the expertise of POCITYF consortium partners. Such approach leads to a holistic performance framework grouped under eight KPI dimensions. The definition of POCITYF related KPI dimensions is of utmost importance for a holistic identification of appropriate indicators: the selected KPIs are not only linked to the four Energy Transition Tracks (ETTs), but also cover the main stakeholders' groups of POCITYF and reflect LH city needs. Eight (8) dimensions have been defined: a) Energy; b) Environmental; c) Economic; d) ICT; e) Mobility; f) Social g) Governance; h) Propagation. The initial assessment of existing KPIs frameworks led to the identification of a large group of indicators under each dimension – the initial KPI pool. This initial KPI pool has been reviewed and reduced based on transparent criteria: the indicators relevance to the project needs and objectives, availability of measuring data, measurability, reliability and familiarity by non-experts.

The reduced list has been further assessed through a series of meetings and iterations between partners (especially LH Site managers and ETT leaders). The process resulted to the finalized KPI list and associated KPI cards presented in this deliverable. The KPI cards, which integrate in a card format all the necessary information for the assessment of each indicator, include the description of each indicator along with all evaluation metrics and formulas, relevant aggregation/clustering levels (temporal, spatial, ETT-linked) and initial recommendations for data collection and measurement methodologies. Furthermore, a first assessment of the KPI ownership has been performed. The finalized list includes Core (extremely relevant to POCITYF that need to be monitored/evaluated) and Supporting (highly recommended but somehow risky in terms of the current capabilities of some cities to report them while they might be too specific for the scope of POCITYF) indicators as an added layer of flexibility for the successful monitoring process. The indicators have been further categorized into performance and progress evaluators (output-oriented) and project impact-oriented. The first are concrete indicators for monitoring the progress and effectiveness of implementations, while the latter assess the benefits of interventions as well as the higher-level goals to which POCITYF will contribute. The clustering of KPIs into various levels of granularity facilitates the monitoring and evaluation procedure. In terms of the spatial scale, the level of evaluation starts from the Building level to Building Blocks (Positive Energy Blocks - PEBs) to District Level (Positive Energy Districts - PEDs), ending up to the City level. In terms of the temporal scale, three levels have been defined: In-project, End of Project and Post-Project timeframes. Both scales assess scalability and replicability concerns linked to POCITYF objectives of wide and long-term impact.

Lastly, a series of Project Success Indicators (PSIs) have been identified (based on BEST tables and Grant Agreement Form - GAF) which provide a global view of the project success and its impact towards green, smart, resilient and autonomous cities. Their evaluation is required and thus their simplified cards are included in this deliverable. Moreover, the correspondence of these PSIs with already defined KPIs has been established along with guidelines for calculation using variables from specific KPIs.

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To conclude, D2.1 is the first step towards POCITYF's monitoring procedures. The KPI list will input D2.2 and D2.3, where ownership, data collection methods/sources as well as threshold criteria will be further detailed. Indicators and associated generated data defined herein, and monitoring procedures detailed later on, in D2.2 and D2.3, also complies with POCITYF Data Management Plan (D11.8). The partners involved in the associated tasks will have the flexibility to refine and further adjust, if necessary, these KPIs based on updated measurement capabilities and needs. The KPI definitions per ETT as presented in this deliverable will feed the evaluation plan, monitoring infrastructure and procedures and overall evaluation activities in WP2 and WP3, determinant to measure the work of WP6 and WP7.

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Abbreviations and acronyms

Abbreviation	Definition
ATES	Aquifer Thermal Energy Storage
BEMS/HEMS/CEMS	Building/Home/City Energy Management System
BMS	Building Management System
DHC	District Heating Cooling
DSM	Demand Side Management
DSO	Distribution System Operator
ESCO	Energy Service Company
ESU	Energy Supply Unit
ETT	Energy Transition Track
EV	Electric Vehicle
FC	Fellow City
GA	Grant Agreement
GDP	Gross Domestic Product
ICT	Information and Communications Technology
IE	Innovative Element
IPR	Intellectual Property Rights
IS	Integrated Solution
ISO	International Organization for Standardization
KPI	Key Performance Indicator
LH	LightHouse
LV/MV	Low Voltage/Medium Voltage
NGO	Non-Governmental Organization
NZEB	Near Zero Energy Building
P2P	Peer-to-Peer
PAYT	Pay-As-You-Throw
PCM	Phase Change Materials
PEB	Positive Energy Building
PED	Positive Energy District
PPP	Public Private Partnerships
PSI	Project Success Indicator
PV	PhotoVoltaic
RES	Renewable Energy Source
SCC	Smart Cities and Communities
SCIS	Smart Cities Information System
SDG	Sustainable Development Goals

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Abbreviation	Definition
SEAP	Sustainable Energy Action Plan
TIPPING	The Innovation Perspective for New Governance on Islands
TSP	Technology and Service Providers
V2G	Vehicle to Grid
VPP	Virtual Power Plant
WP	Work Package

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1 Introduction

1.1 Scope, objectives and expected impact

Key Performance Indicators (KPIs) can act as a universal instrument to evaluate the progress of smart city strategies, supporting the monitoring of relevant solutions and projects [1]. According to Oxford's dictionary, the definition of a KPI is "*a quantifiable measure used to evaluate the success of an organization, employee, etc. in meeting objectives for performance*". The key difference between KPIs and other indicators is that KPIs are always tied to a goal, a target or an objective[2]. The development of smart city projects (SCCs) generates considerable interest in establishing novel smart city assessment frameworks and schemes. Within such frameworks, efficient procedures for measuring, monitoring and evaluating SCCs performance and impacts need to be detailed. At the same time a successful framework should carefully address possible challenges in timeframes spanning from prior to beyond the project implementation life-cycle[3].

In this context, several initiatives propose different monitoring and assessment KPI frameworks for smart city solutions promoting the cooperation and exchanging of know-how among smart cities. The selection of the most appropriate KPIs for smart city projects remains difficult though, as it requires expert knowledge [4]. Hundreds of KPIs are available, and the choice of the most suitable ones for each case is a challenging task. Given the fact that the smart city concept entails numerous interrelated dimensions, the process of evaluation through KPIs is challenging, because, on the one hand, it should satisfy city needs while on the other hand should allow an effective comparison on a national or international level with other cities or smart city projects. In the end, every smart city project adopts its own KPI repository which makes the inter-comparison of the outcomes among different projects and solutions problematic, indicating the need for a uniform monitoring of the energy smartification and smart city solutions [5].

POCITYF, as a Smart City project, incorporates a multitude of solutions that will accelerate the energy transition of its Lighthouse (LH) cities and help towards replication activities in its Fellow Cities (FC). This variety of solutions circulates around the citizens needs which causally relate to city needs. Positive energy buildings and districts, grid flexibility, circular economy, e-mobility and citizen-driven innovation are all an integral part of POCITYF ecosystem. Therefore, the project success can only be evaluated through specific, tailored KPIs which need to be defined according to the scope of the specific lighthouse interventions and the stakeholders needs but also provide comparability through established evaluation frameworks and monitoring databases. This is the core objective of this deliverable: to provide a complete list of KPIs based on a methodological approach that will take into account the needs of the cities, the technologies to be implemented and the literature of widely used frameworks in order to promote comparability. Moreover, through this process, the KPIs need to be fully defined including formulas, recommendations for data sources and collection methods, requirements, and spatiotemporal levels of assessment. These KPIs need to be inclusive, specific, transparent to misinterpretations and assess all levels of interest for a smart city. Through this process, the KPI list will serve as a backbone for the monitoring and evaluation activities in POCITYF, not only in terms of technological performance but also at the level of social engagement, acceptance and diffusion towards scalable and replicable innovations.

1.2 Relation to other POCITYF activities

A strong link has been established with the activities in *WP1-POCITYF Smart City Framework Towards an Integrated Deployment* (supported by WP6-WP7 activities) - especially T1.3-T1.6 which focus on developing the master visions of the cities and identifying the specifications of technological solutions. The innovative solutions characterization has been an important step towards the definition and selection of proper KPIs that can relate to these specific interventions. Moreover, T1.1 provided the list of POCITYF stakeholders which is utilized in D2.1 towards an inclusive evaluation of the indicators in relation to relevant stakeholders. Under WP2, the KPI framework is a necessary step towards the definition of the project evaluation plan (*T2.2 Test and Evaluation Planning*), detailed definition of monitoring data and infrastructure (*T2.3 Monitoring Data & Infrastructure Definition*) and monitoring plans (*T2.5 Progress & Performance Monitoring, T2.6 Social Engagement Monitoring*). Furthermore, the output of D2.1 (along with rest of WP2 activities) will directly feed the evaluation activities in *WP3 - Evaluation Activities, Socio-economic Impact Assessment and Recommendations*. Future activities in WP6 and WP7 (demonstration activities in LHs) will also relate to this deliverable as the implementation of solutions in both LHs of Evora and Alkmaar will require the monitoring and evaluation of implementations based on the defined KPIs. As the KPIs defined here incorporate social, governance and economic dimensions a link with activities in *WP4-Citizens Engagement and Open Innovation Activities* and *WP5-Business Models across Circular & Sharing Economy Pathways* is implicitly made. The KPI definition and evaluation metrics also relates to POCITYF's data management (the plan for data exploitation, preserving and accessibility) which are to be detailed in T11.4 Data and Ethics Management and associated D11.8 – Data Management Plan. Lastly, WP8 - Replication Plans and 2050 Vision by Fellow Cities will leverage the outcomes of the LH monitoring and evaluation process (thus connecting to the outcomes of this deliverable) towards the execution of feasibility studies and Fellow City replications visions based on lessons learnt and diffusion/scalability perspectives. The latter will be monitored by specific KPIs defined under the Propagation dimension.

1.3 Structure of the deliverable

The structure of D2.1 is as follows:

- Section 2 – Methodology: The methodology followed towards the definition of the KPI list is presented
- Section 3 – KPI definition and selection process: The section contains: a) detailed information on the definition process including a brief review of the intervention activities in POCITYF (Sec. 3.1), b) the review of several existing KPI frameworks that have been used as the initial pool for the KPI selection (Sec. 3.2), c) the definition of relevant dimensions and their relation to stakeholders (Sec. 3.3), d) the evaluation of the initial KPI pool towards the finalized KPI list along with analytics (Sec. 3.4) and e) the clustering and aggregation in evaluation levels (Sec. 3.5)
- Section 4 – POCITYF KPI Cards: The complete finalized list of KPI cards. Sections 4.1-4.8 include the KPI cards per dimension. The Project Success Indicators (PSIs) are also defined here (Section 4.9)
- Section 5 – Conclusions: A conclusive summary is included in this section
- Annex A: includes the refined KPI pool
- Annex B: includes the distribution of the final KPIs per Energy Transition Track (ETT)
- References - List of references that used in the document

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2 Methodology

2.1 Methodological approach

The methodological framework applied to define POCITYF's KPIs and successfully developed in this deliverable, includes eight (8) steps and has been finalized in collaboration with key partners from the two Lighthouse Cities; thus, it reflects the actual experiences and needs of the cities' ecosystems. POCITYF approach differentiates from other similar frameworks due to four key reasons: (a) specific emphasis is given on satisfying relevant stakeholder points of view concerning the deployment of smart city solutions; (b) an extensive KPI pool has been developed after an extensive review of relevant KPI frameworks, whereas the final KPIs have been selected based on a clear evaluation procedure for increasing transparency of results; (c) an out-of-the box thinking is adopted through the inclusion of targeted technological, mobility, governance (incl. legal) and propagation KPI dimensions, in addition to the standard (economic, environmental, social, ICT) ones usually applied; and (d) various levels of granularity and KPIs grouping are defined. The 8 steps are further described below.

<u>Step 1</u>: Analysing solutions from Grant Agreement Form (GAF) and WP1 collected data

The KPI selection process is based on the solutions included in POCITYF to assure proper monitoring and impact linkage. Thus, before proceeding to the KPI selection and definition there is a need to understand and clarify all intervention actions to be conducted in LHs (also in connection with WP1). This facilitates the better interconnection of POCITYF solutions and selected KPIs (KPIs should serve first of all the needs of the project). The specific step is described in detail in Section 3.1.

<u>Step 2</u>: Collecting background information on existing KPIs framework – Review and assess

The aim of step 2 is twofold: a) examine and assess existing KPI frameworks relevant to smart cities, valuable ideas, lessons learned and suggestions and extract what can be applied in POCITYF; b) develop an extensive pool of potential KPIs to be utilized in POCITYF building upon the recommendations of these frameworks. POCITYF extracted potential KPIs starting from Smart Cities Information System (SCIS) and CITYkeys to support uniformity among SCC projects. POCITYF also capitalizes on the outcomes and lessons learned from similar SCC Lighthouse projects, as well from International and European standards (e.g. ISO 37120:2018, ISO 37123:2019, ETSI) and strategic plans and initiatives (e.g. UN's Sustainable Development Goals, U4SSC). Finally, to ensure that more innovative KPIs are considered for inclusion in POCITYF's KPIs repository, a literature review of assessment frameworks in scientific journals that attempt to evaluate smart city performance on different levels was performed. The specific Step is described in detail in Section 3.2.

<u>Step 3</u>: Definition of KPIs dimensions in relation with stakeholders' perspectives

Step 3 aimed at defining the generic "dimensions" – parameters that were required to be considered for efficiently assessing and monitoring smart city solutions. This ensured that relevant KPIs were selected covering all aspects affecting the sustainability of smart city projects. Additionally, POCITYF ensures that all main groups of stakeholders are covered, so that most of them can be actively participating/represented in the evaluation of the solutions (from a first level) and of the city (to a final level). The specific Step is described in detail in Section 3.3

<u>Step 4</u>: Development of a KPI pool based on Steps 2 and 3

The combination of Steps 2 and 3 will lead to an extensive KPI pool (list) including various potential KPIs that can serve POCITYF's needs, separated per defined dimension. This can serve as an excellent basis to initiate discussions with POCITYF partners and LH managers for the selection of final KPIs. The KPI pool developed is presented in Annex A.

Step 5: Selection of KPIs based on pre-defined criteria

Step 4 lead to a vast amount of KPIs (in the order of hundreds) and as such there was a need to define a clear selection procedure to identify the most appropriate KPIs. To do so, POCITYF adopted the eight (8) selection criteria (relevance, availability, measurability, reliability, familiarity, completeness, non-redundancy, independence) proposed by the CIVITAS framework. Every indicator included in the pool was assessed using a Likert Scale (0-2 points) which allowed the development of a shortlist. The specific Step is described in detail in Section 3.4.

Step 6: Iterate with partners towards finalized KPI list.

KPIs to be included in the final repository should also reflect the opinion and needs of the POCITYF ecosystem, especially the LH cities. To ensure this, outcomes from Step 5 were shared with LH managers and key technology providers of POCITYF for their review. A continuous iteration process (through e-mail and teleconferences) was performed to develop the finalized KPI list. In this way, indicators that presented a particular interest for the LHs were integrated while others have been excluded due to monitoring associated risks (unavailability of data etc.). The specific Step is described in detail in Section 3.4.

Step 7: Group KPIs

Once the final repository of KPIs has been defined, the KPIs were grouped in several categories based on their key attributes and applicability (from Integrated Solution (IS) to ETT, from a building to the city level, from a present evaluation timeframe to a future/post-project one, from interventions effectiveness to project impact). This will facilitate the monitoring procedure and increase transparency of the assessment to be performed. In case it is observed that some levels of granularity are not adequately covered with the proposed KPIs, steps 4-6 will be re-examined and all necessary adaptations will be made to ensure that POCITYF's KPI framework is sufficiently addressing all issues. The specific Step is described in detail in Section 3.5.

Step 8: Finalize deliverable

The implementation of the above steps lead to a finalized list of POCITYF KPIs including all necessary information for their assessment (including evaluation metrics and guidelines, formulas, potential thresholds of performance, grouping in categories) in the form of KPI cards (available in Section 4). Metrics, data collection guidelines and thresholds/baselines will be further assessed in T2.2-T2.3 and respective deliverables. Furthermore, a set of indicators related to broad POCITYF impact are also proposed (Project Success Indicators – PSIs). These indicators are required to be assessed towards some specific Impact Objectives of POCITYF and SCC projects (as defined in the GAF). Although some of these PSIs can be directly linked to the defined KPIs, a large set need to be defined separately. In contrast to other impact related KPIs, this set of indicators (PSIs) do not fit into the chosen dimensions or/and are too simplified and case specific so that are excluded from the KPI selection methodology and process (see section 4.10 for more details). Despite their simplicity in terms of formulas and measurement, these indicators are bound to SCC impacts and objectives and thus required to be properly monitored and evaluated throughout the project.

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2.2 Methodology Implementation Plan

POCITYF adopts an iterative approach to implement the above-mentioned methodological framework characterized by a continuous interaction between the defined steps and among partners. Figure 1 summarizes the implementation plan of the methodology described in Section 2.1.

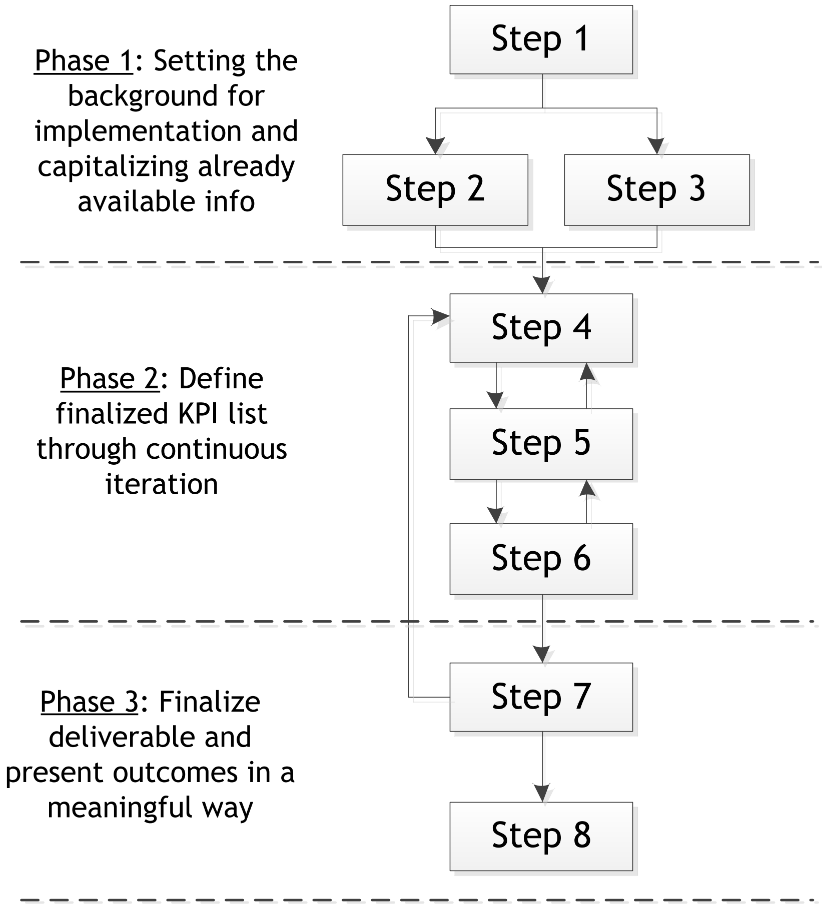

Figure 1. Methodology implementation plan

The implementation plan is divided into three (3) phases:

- Phase 1 includes Steps 1, 2 and 3. This phase sets a solid base for implementation by linking POCITYF's intervention actions in LHs with the objectives of this deliverable, as well as capitalizing already available information (proposed KPIs, dimensions, practical recommendations, etc.) from other relevant KPI frameworks. Through the careful definition of POCITYF dimensions it is ensured that KPIs for all important aspects of smart cities will be taken into account.
- Phase 2 includes Steps 4, 5 and 6. This phase includes all necessary evaluation procedures towards the definition of the final POCITYF KPIs repository. A key characteristic of this phase is that it requires the active involvement of key partners from POCITYF ecosystem and a continuous interaction to ensure that to be selected will address all LH and project needs.

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- Phase 3 includes Steps 7 and 8. This phase is fed by the outcomes of the previous Steps and phases with a view to present them in the most meaningful way, supporting the efficient monitoring and decision making.

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3 KPI definition and selection process

3.1 Brief overview of intervention activities in LHs

The success of POCITYF as a smart city project can be globally assessed by the extent to which it serves the cities and respective citizens needs and meets the project's objectives. Monitoring of this success can be performed in various hierarchical levels of evaluation, but the definition of proper metrics must always comply with the envisaged cities framework and intervention activities therein. These intervention actions, or innovative elements in POCITYF's case, form the innovative background on which cities will build, towards meeting their objectives and transitioning to a smarter future. It is thus important for any indicator defined to be able to monitor the progress and effectiveness of the implemented solutions in addition to monitoring and evaluating project's impact. As the individual innovation technologies should operate in a synergetic environment, the assessment process should be performed in a more holistic fashion.

Indeed, POCITYF energy transition strategy is built around four multidisciplinary and complementary Energy Transition Tracks (ETT), aiming to increase the integration of both commercialized and innovative energy systems, towards rendering current city blocks self-sustainable and more environmentally friendly for their citizens. Within these ETTs, POCITYF seeks to enable, demonstrate, replicate and accelerate the roll out of a set of 10 Integrated Solutions (IS) built on top of both mature and innovative technologies (innovative elements). The performance of these ISs should be monitored with tailored, when necessary, KPIs that can provide the required evaluation output data. Each of the Integrated Solutions target specific focus areas in order to address cities aimed transformation to safer, greener and more responsive ecosystems. IS 1.1 addresses Positive Energy (stand-alone) Buildings while IS 1.2 Positive Energy Districts Retrofitting. IS 1.3 is formed by solutions which aim to feed PEDs with waste streams promoting symbiosis and circular economy. The three ISs are grouped under *ETT #1: Innovative Solutions for Positive Energy (CH) Buildings and Districts*. Similarly, IS 2.1 deals with flexible and sustainable electricity grid networks with innovative storage solutions, while IS 2.2 with flexible and sustainable district heating/cooling with innovative heat storage solutions. Both IS are grouped under *ETT #2: P2P Energy Management and Storage Solutions for Grid Flexibility*. IS 3.1 refers to Smart V2G EVs charging and IS 3.2 to e-mobility services for citizens and auxiliary EV technologies, grouped under *ETT #3: e-Mobility Integration into Smart Grid and City Planning*. Lastly, IS 4.1 deals with Social Innovation Mechanisms towards Citizen Engagement, IS 4.2 with Open Innovation for Policy Makers and Managers and IS 4.3 with Interoperable, Modular and Interconnected City Ecosystems, all under the umbrella of *ETT #4: Citizen-Driven Innovation in Co-creating Smart City Solutions*. Finally, POCITYF aims to demonstrate the integration of the latest generation of ICT solutions within existing city platforms over open and standardized interfaces enabling data exchange/monitoring for the development of new innovative services ICT solutions (cross-ETT elements). Figure 2 summarizes all ISs and ETTs of POCITYF.

The innovative elements to be demonstrated in LHs under each IS (and ETT) are (mostly) mature technologies with a high innovative component, which will contribute towards POCITYF objectives and envisaged impact. By monitoring and evaluating their progress and performance, POCITYF impact can be also assessed via proper aggregation methods. As each technology is quite unique, very detailed indicators can be defined to assess every aspect of the technological performance (e.g. durability, integrability, operability, etc). This would lead to a very large number of indicators, rendering the monitoring process during POCITYF impossible. A robust and concise set of indicators should focus on the intervention activities focus areas, keeping in mind the project's objectives. By examining though each innovative element, its characteristics, technological

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aspects and envisaged implementation details, a first assessment of the evaluation focal points can be performed.

This first assessment is the base for choosing appropriate KPI frameworks in the following sub-section, defining the KPIs Dimensions relevant to POCITYF and smart cities projects and finally extracting relevant KPIs that are included in the initial and preliminary KPI pool. In collaboration with the LHs ecosystems, these preliminary and basic analysis is to be refined and detailed, building upon the stakeholders' perspective, cities and project needs as well as precise KPI selection criteria which are detailed in the following sub-sections.

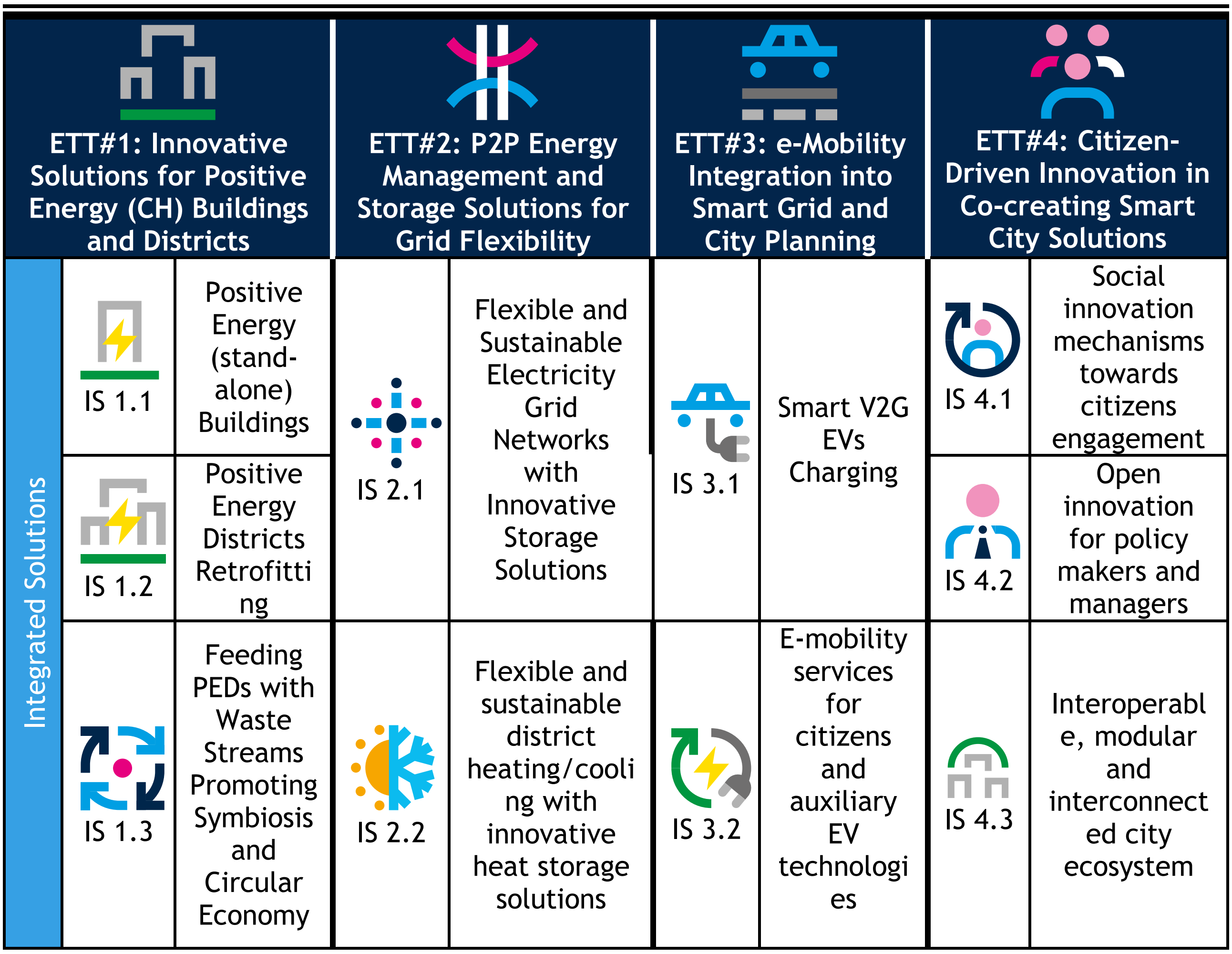

Figure 2. POCITYF's Energy Transition Tracks (ETTs) and Integrated Solutions (ISs)

To this respect, a deep review of the technologies to be implemented has been performed. This work serves as an interlinkage between the specific technologies, the integrated solutions focus areas and a preliminary assessment of the evaluation focal points. A thorough description of the innovative elements/technologies is outside the scope of this deliverable and the reader is referred to D11.7 for a detailed analysis of the IEs as well as future Deliverables under WP1, WP6 and WP7.

Table 1-4 describe the intervention activities focus areas, the related innovative technologies (elements) to be implemented during POCITYF as described in the GAF and the main evaluation focal points on which the solutions should be globally assessed and monitored. As mentioned,

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these evaluation focal points form the basis for the KPI framework review and KPI dimensions definition as detailed in the following subsections.

Table 1 ETT #1 – Evaluation focal points and related technologies

	Focus area	Related POCITYF technologies	Evaluation focal points
IS 1.1	Achieving significant energy savings while enabling a high share of locally produced/consumed renewable energy on building level.	PV glass // PV canopy // PV skylight // Tegosolar PV // Traditional PV shingle // directional smart inverters // Energy router // BMS // 2nd life residential batteries // HEMS/BEMS // Positive Computing Data Centre // Insulation with circular materials // Triple glazing // Solar roofs and facades // Thermo acoustic heat pumps // Hybrid wind/solar generation system (Powernest) // Li-ion batteries // Cascaded heat pumps // Composite façade panels // PCM in the floor	Energetic performance // energy costs reduction for users (building level) // RES production // CO_2 reduction
IS 1.2	Achieving significant energy savings while enabling a high share of locally produced/consumed renewable energy on district level.	Smart Lamp posts with EV charging and 5G functionalities // Energy router // Smart distribution management system // P2P energy trading platform // Community Solar Farm // DHC (biomass, waste, geothermal) // ATES (heat/cold storage) // Li-ion/Li-metal batteries // DC lighting with EV charging // Solar roads // V2G	Energetic performance // cost reduction for users (district level) // RES production // CO_2 reduction
IS 1.3	Symbiosis and Circular economy	2nd life residential batteries // Pay-As-You-Throw (PAYT) // Reverse collection of waste // Circular economy building practices // ATES (heat/cold storage) // PCM in the floor // Waste management tools	Waste management/reduction performance // circular economy attributes

Table 2 ETT #2 – Evaluation focal points and related technologies

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	Focus area	Related technologies	Evaluation focal points
IS 2.1 IS 2.2	Maximizing self-consumption (electricity and district heating/cooling)	2nd life residential batteries // Stationary batteries // LV and MV storage systems // Freezing storage in store // ATES // Low temperature waste heat // P2P energy trading platform // City Energy Management System	Energy savings // Increased energy storage capacity at district level
IS 2.1 IS 2.2	Reducing grid stress and avoid load and generation curtailment (electricity and district heating/cooling)	DC grid // VPP // Fuel cells (hydrogen) // V2G // Low temperature smart heat grid // Geothermal source // LV and MV storage systems // Stationary batteries // Low temperature waste heat // City Energy Management System // P2P energy trading platform	Reduced energy curtailment // Energetic efficiency
IS 2.1 IS 2.2	Increasing the financial value through flexibility services to the grid (electricity and district heating/cooling) and the market	Market-oriented building flexibility services // Thermal grid controllers // Micro-grid controller platform // City Energy Management System //PowerMatcher // P2P energy trading platform // City Energy Management System	Energy savings // energy management performance // increased grid flexibility // increased revenues via energy market participation

Table 3 ETT #3 – Evaluation focal points and related technologies

	Focus area	Related POCITYF technologies	Evaluation focal points
IS 3.1 IS 3.2	Reducing the impact of electro-mobility on the energy system	EV charging management platform // Virtual Power Plant (VPP) // EV sharing // Hydrogen powered HD vehicles // V2G	Electricity consumption reduction
IS 3.1 IS 3.2	Increasing the penetration of e-vehicles utilizing RES	V2G // EV charger prototype with PV integration // Bidirectional smart inverters // Smart Lamp posts with EV charging and 5G functionalities // Intelligent and optimal control algorithms // Smart solar charging // DC lighting with EV charging // Solar roads // Virtual Power Plant (VPP)	Increased EV penetration // Fast charging

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	Focus area	Related POCITYF technologies	Evaluation focal points
IS 3.1 IS 3.2	Supporting grid flexibility with e-mobility	V2G // Virtual Power Plant (VPP) // Intelligent and optimal control algorithms // Bidirectional smart inverters // Smart Lamp posts with EV charging and 5G functionalities // DC lighting with EV charging	Increased flexible distribution capacity
IS 3.1 IS 3.2	Promoting decarbonization of the mobility sector	EV sharing // Hydrogen powered HD vehicles // Solar roads // V2G // Smart solar charging // EV charger prototype with PV integration	Ecological/Carbon footprint reduction
IS 3.1 IS 3.2	Reducing citizen's mobility costs	EV sharing // V2G	Increased public transport and shared mobility services for citizens

Table 4 ETT #4 - Evaluation focal points and related technologies

	Focus area	Related POCITYF technologies	Evaluation focal points
IS 4.1 IS 4.2	Incentivize citizens for co-creating, co-delivering and co-capturing value by the smart city solutions	Digital transformation in Social Innovation // Gamification platform // Tourist apps // Cultural experiences market (mobile app) // Mobile apps on energy consumption // Value based design // InnoFest concept) // City Urban Platform // Wi-fi data acquisition systems // Data lake intelligence for positive communities // Smart-cloud for innovative Startups // Citizen Information Platform // Data acquisition systems // City Data Hub)	Increased citizen awareness and engagement
IS 4.2 IS 4.3	Create an open innovation ecosystem	TIPPING approach // Eco- Acupuncture // City Urban Platform // Data lake intelligence for positive communities	Increased number of novel products and services
IS 4.1 IS 4.2 (incl. ICT related solutions)	Empower consumers to become prosumers and energy donators	Connect with Energy (Digital transformation in Social Innovation) // GRIDS EnergyCity // PowerMatcher // Data lake intelligence for positive communities	Increased number of prosumers and energy donors

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3.2 Review of existing KPIs frameworks

The need for a uniform monitoring of the energy smartification throughout Europe has led to initiatives promoting the cooperation and exchanging of know-how among European cities. Initiatives such as the Smart Cities Information System (SCIS) and CITYkeys have created platforms of interaction along with a list of KPIs for the evaluation of systems and technologies demonstrated in smart city projects. In that respect and as mentioned in Section 2.1 (Step 2), POCITYF will extract potential KPIs starting from these two sources to ensure uniformity with European Strategy. POCITYF will also capitalize on the outcomes and lessons learned from similar SCC Lighthouse projects as well from International and European standards (e.g. ISO 37120:2018, ISO 37122:2019) and strategic plans and initiatives (e.g. UN's Sustainable Development Goals). Finally, to ensure that more innovative KPIs will be considered for inclusion in POCITYF's KPIs repository, a literature review of assessment frameworks available in scientific journals that attempt to evaluate smart city performance on different levels was performed. The detailed description of all relevant frameworks, as well their envisioned connection with POCITYF's KPI dimensions and ETTs is presented below.

3.2.1 Smart Cities Information System (SCIS)

In order to identify the POCITYF KPIs, the updated SCIS Monitoring KPI Guide (2018)[6] was extensively studied as it focuses on the development of indicators to measure technical and economic aspects of energy, mobility and ICT related measures applicable in projects such as Smart Cities and Communities (SCC), Energy Efficient buildings (EeB) and designated projects funded under the calls for Energy Efficiency (EE). The SCIS KPI guide: a) provides a description of key performance indicators and their application to the different objects of assessment, b) identifies the data requirements for their calculation and c) describes the methodology for the calculation of these indicators. Thus, SCIS provides an excellent framework for KPIs selection to be used in POCITYF's own framework/repository incorporating indicators relevant to POCITYF ETTs #1-3.

Assessment Framework: The framework structure designed for the evaluation of the performance of a city's energy transition is based in the definition of city indicators in two clusters. 1) Core KPIs: technical (3 KPIs), environmental (3 KPIs), economic (5 KPIs), ICT (7 KPIs), mobility (8 KPIs). Those KPIs identified as the most relevant for SCIS and which should be implemented by the projects in scope of SCIS. Some of these KPIs may not apply to all projects. 2) Supporting KPIs (10 KPIs): relevant for SCIS, their use is recommended. The framework consists of **36 indicators**.

3.2.2 CITYkeys

The CITYkeys evaluation framework[7] is primarily performance oriented and supports Smart Cities in strengthening their strategic planning, evaluating the success of smart city projects and the possibility to replicate the (successful) projects in other contexts. It focuses on the city as well as the project level while establishing a link between the two. Thus, the CITYkeys framework, although it supports the identification of indicators in various areas in smart cities i.e. health, education etc. it also provides an excellent framework for POCITYF KPIs selection, incorporating indicators relevant to POCITYF ETTs #1-4. The CITYkeys evaluation framework:

1. Evaluates the impact of a smart city project, comparing before and after situations or comparing expected impacts with a reference situation. As such they can also serve to benchmark projects against each other. It should be noted that a complete project assessment includes an extensive description of the context of the project, the activities and technologies in the project, financing and the business model, and the implementation process.

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2. Monitors the progress of the city as a whole towards smart city goals. The time component - “development over the years”- is an important feature. The city indicators may be used to show to what extent overall policy goals have been reached, or are within reach. In addition, city-level indicators may be used to compare cities with each other, although such a comparison should be done with care.

3. Assess how the project has contributed to the objectives at city level. This requires connecting outcomes of a project evaluation with corresponding indicators on the city level.

Assessment Framework: The CITYkeys assessment framework structure focuses on evaluating social sustainability (People) (27-22 KPIs), environmental sustainability (Planet) (25 KPIs), economic sustainability (Prosperity) (18 KPIs), governance (13 KPIs) by means of developing and implementing smart city projects and propagation (18 KPIs) by means of the potential of individual smart city projects to be replicated in other cities and contexts. The framework consists of **99 indicators**.

3.2.3 Other smart cities/LH projects

The smart city concept led to the need for knowledge exchange about monitoring and evaluation among smart cities and communities and relevant information is available in the SCIS platform. There are 17 SCC lighthouse (LH) projects with a total of 44 LH Cities and 70 Fellow Cities that showcase solutions in the three (3) main fields of secure, affordable and clean energy, smart e-mobility and smart ICT tools and services. Each of them adopts a specific assessment framework to evaluate its smart city performance and expected impacts, based also on data, experience and stories collected from other completed or ongoing SCC projects and wider methodological frameworks (i.e. ITU, ISO etc.). Table 5 presents a number of indicative SCC EC-funded projects including some key characteristics of the assessment framework, they developed to evaluate and monitor performance. It should be noted that only projects for which a detailed list of all KPIs was publicly available are included in the analysis (serving as potential sources for feeding POCITYF’s KPI pool).

Table 5. Indicative assessment frameworks by EC-funded LH projects.

Project Name	Description
IRIS-Integrated and Replicable Solutions for Co-Creation In Sustainable Cities	The IRIS project envisages the smartification of the energy grid with an increased RES penetration and novel energy storage solutions, along with an advanced electrified urban transport system serving both mobility needs and additional electricity grid flexibility requirements. IRIS orchestrates the demonstration of the specific technology solutions and social policies in demo city environment with and active participation of citizens. The flagship cities of Nice (FR), Goteborg (SE) and Utrecht (NL) serve as a testbed for innovative solutions focusing on smart energy transition and positive energy districts, smart sustainable mobility, ICT and digital city innovation, citizen engagement and co-creation actions.
Assessment Framework	
The assessment framework uses an agile approach for determining a pool of KPIs able to estimate the impact of both conventional and innovative solutions and also demonstration	

activities, categorized in six **(6) dimensions**: technical, environmental, economic, social, ICT and legal. The proposed framework supports also the clustering of solutions in five (5) Transition Tracks as follows: TT#1-Smart renewables and closed-loop energy positive districts, TT#2-Smart Energy Management and Storage for Grid Flexibility, TT#3-Smart e-Mobility Sector, TT#4-City Innovation Platforms (CIP) and TT#5-Citizen Engagement and Co-Creation. In this context, a holistic evaluation of the proposed solutions is achieved by defining also the levels of evaluation and integrating interests of the relevant stakeholders. The final set of KPIs consists of **75 indicators**, defined per domain, taking into account also indicative calculated thresholds for scalar quantification and monitoring performance of the solutions through the assessment criteria. The framework structure goes a step forward to the definition of KPIs for smart city solutions and aligns well with POCITYF activities and goals.	
Reference: D1.1-Report on the list of selected KPIs for each Transition Track, accessible: https://irissmartcities.eu/public-deliverables	

Project Name	Description
<u>REPLICATE</u> - Renaissance of Places with Innovative Citizenship and Technologies	REPLICATE is a European research and development project relevant with POCITYF, as it deals with the deployment of energy efficiency, mobility and ICT solutions in city districts. REPLICATE aims to significantly increase resource and energy efficiency, improve the sustainability of urban transport, drastically reduce greenhouse gas emissions and improve the quality of life for citizens across Europe, by generating smart city business models and tailor-made solutions in the demonstration areas. REPLICATE coordinates the deployment of relevant integrated solutions in three LH cities: San Sebastian (ES), Florence (IT) and Bristol (UK).
Assessment Framework	
The specific project has taken into consideration various KPI sources for the monitoring and the evaluation process of the city performance. After a thorough review process, several KPIs of other EU smart city projects, initiatives or worldwide associations were used and adopted. Because of their alignment with REPLICATE project, the International Standard **ISO 37120**, **STEEP** and **CITYkeys** among other projects have been studied deeply. STEEP indicators framework consists of 46 indicators and was used in REPLICATE as a base to define city level KPIs. Therefore, the definition of REPLICATE dimensions and categories was mainly based on STEEP and several of STEEP indicators were included in REPLICATE framework and completed with indicators from other sources. **CITYkeys** indicators, as mentioned above, are commonly used for the evaluation, success and replication of Smart City projects, capitalizing on existing smart city and sustainable city indicators systems. The International Standard **ISO 37120** established definitions and methodologies for a set of city indicators to steer and measure delivery of city services and quality of life, providing with a set of 100 standardized indicators. Other sources of information for the construction of REPLICATE city level KPI framework, with some relevance to POCITYF goals were also **PLEEC project, Eurostat, ESCI** and **ITU.** The PLEEC project uses an integrative approach to achieve the sustainable, energy-efficient, smart city, providing with a set of 60 indicators in order to describe energy efficient urban development in a quantitative way, based on the definition of key fields and respective domains for energy	

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efficient development. Eurostat, within the "Urban Audit", provides with city statistics, data collection, information and comparable measurements on the different aspects of the quality of urban life in European cities, with a total of 100 indicators. The Emerging and Sustainable Cities Initiative (ESCI) proposes a list of 23 indicators, while the ITU report 'Key performance indicators definitions for smart sustainable cities' of the ITU Focus Group on Smart Sustainable Cities (FG-SSC) covers specifically a set of 17 ICT-related KPIs for smart cities. The selection of the potential KPIs for REPLICATE has been made taking into account that the framework should fulfil the following objectives: Providing an overview of the city performance, monitoring of the performance, allowing understanding the motivations of changes in the city performance, making comparisons between cities (i.e. FCs position in comparison with LHs) and contributing to the development of future standards. Two (2) classifications were made in order to proceed in the selection and validation of indicators and define the evaluation of the KPI framework. Firstly, seven (**7) dimensions** have been defined in order to classify the indicators, covering as a whole city performance: City description (5 indicators), Energy and Environment (14 indicators), Mobility and Transport (14 indicators), Infrastructures for innovation (6 indicators), Governance (5 indicators) , Social (5 indicators) and, Economy-Finance (7 indicators). As a result of this process the city level KPIs framework for REPLICATE project contains a total of **56** KPIs. Regarding the evaluation level of analysis, indicators were also classified according to the applicability scale at three (3) levels: a) National / Regional, b) Local / City, c) District.
Reference: REPLICATE-D10.2: Report on indicators for monitoring at city level, accessible: https://replicate-project.eu/public-deliverables-download/

Project Name	Description
MATCHUP - Maximizing the Upscaling and replication potential of high level urban transformation strategies	MatchUp aims to create and adopt solutions in energy, mobility and ICT in order to improve the quality of life for citizens and boost the local economies. MatchUp provides with a consistent method to make an advanced city diagnosis and assess the progress of the cities on the road to sustainability and smartness. MatchUp's innovative solutions are demonstrated in three LH cities: Valencia (ES), Dresden (DE) and Antalya (TR).
Assessment Framework	

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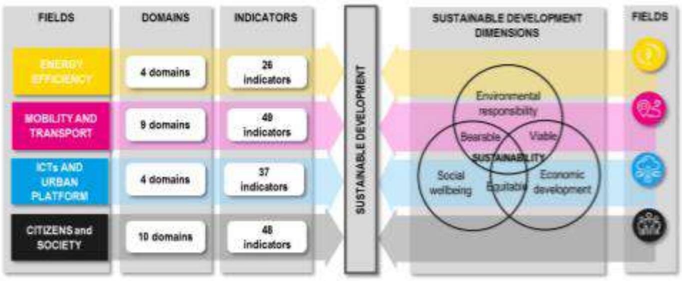
MAtchUP project structured its evaluation framework based on the concept of sustainable development, two **(2) evaluation levels** (city level and project level) and in the definition of **indicators** that evaluate the status before the project implementation and the improvements achieved during the transformation process. The levels of evaluation measure two axes of the project: urban planning based on efficient measures (under city level framework) and execution of efficient measures in the cities (project level framework). The indicators have been classified under three **(3) dimensions** that comprise the term sustainability: environment, economy and social, also grouped into four **(4) fields** of the implemented solutions: Energy in Sustainable buildings and districts, Mobility and Transport and City infrastructure, ICT and Urban Platforms and Non-Technical actions related to Citizens and Society resulting in a sum of 160 indicators. Within the MAtchUP evaluation framework, there is also a list of indicators related to Governance, classified into several domains like local government support, civic engagement and governance or governance collaboration. Consequently, a total of **188 indicators** along with a set of measurable objectives is determined and further divided in particular areas of study for the deployment and implementation of the project.



Reference: MatchUp-D1.1: Indicators tools and methods for advanced city modelling and diagnosis, accessible: https://www.matchup-project. eu/technical-insights/

Project Name	Description
<u>**SMARTEnCITY**</u> – Towards Smart Zero CO_2 Cities across Europe	SmartEnCity envisions to create Smart Zero CO_2 Cities across Europe through urban regeneration strategies, integrated urban plans and district integrated interventions. SmartEnCity's main objective is to develop highly adaptable and Europe-wide replicable strategies towards the transition into sustainable, smart and resource-efficient cities, by improving energy efficiency and maximising renewable energy supply. The project is mainly associated with the implementation of energy efficiency and RES measures in dwellings and vehicles. There are three LH Cities participating in SmartEnCity Project: Vitoria-Gasteiz (ES), Tartu (EE) and Sonderborg (DK).

Assessment Framework

The evaluation framework was developed taking into consideration **evaluation protocols** based on a set of KPIs for reporting the performance, estimating the impact and measuring the level of achievement. The specific project proposes a methodology with a holistic point of view for evaluating the performance of the interventions using **indicators** which have been selected from **SCIS** platform and **CITYkeys** project. The framework structure was built upon the performance of the **interventions** demonstrated in the project: district renovation, urban mobility and citizen engagement as well as the social acceptance and the environmental benefits. KPIs are grouped into four **(4) categories**: technical, environmental, social and economic. Such structure

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is aligned with the scheme proposed by SCIS. The protocols of evaluation are: Energy Assessment, ICT, LCA, Mobility and Cross-Cutting. Some KPIs are evaluated through sensors, requiring a monitoring for two years, while, other indicators (mainly related to social and economic issues) can be evaluated through surveys to be delivered at the beginning of the project and the end of the project implementation. A list of KPIs for each category (technical, environmental, social, and economic) and by type of intervention (district renovation, mobility and citizen engagement) is provided, with a total of **149 indicators**.	
Reference: SmartEnCity - D7.2: KPIs Definition available: https://smartencity.eu/media/smartencity_d7_2_kpis_definition_v1.0.pdf	
Project Name	**Description**
MYSMARTLIFE - Smart Transition of EU cities towards a new concept of Smart Life and Economy	MySMARTLife project aims at the development of an Urban Transformation Strategy to support cities in the definition of transition models, as a suitable path to reach high level of excellence in the development process, addressing the main city challenges and demonstrating Smart PEOPLE and Smart ECONOMY concepts for empowering also the implementation of such solutions in the cities. Its envisaged Advanced Urban Planning consists of an integrated approach for the planned solutions on the basis of a rigorous impact assessment, an active citizen engagement in the decision-making process and a structured business approach from the city business model perspective and the identification of the most promising replicable actions to be included in the future city plans. Three LH cities: Nantes (FR), Hamburg (DE) and Helsinki (FI) have as commitment the deployment of a big set of large-scale interventions, actions and data collection for the monitoring of the performance and evaluation of the impacts. To this end, around 150 actions are foreseen to be implemented in the three cities in technological and non-technological domains.
Assessment Framework	
The presented evaluation framework has been developed taking into consideration the specific requirements of MySMARTLIFE project concept and also aspects and activities to assess the performance from a holistic point of view. The project proposes the deployment of solutions and actions and their evaluation across **six (6) fields**: Energy & Environment, Mobility & Transport, Urban Infrastructure, Citizens, Economy, Governance. In that respect, this framework adopts a **twofold scope** in order to measure the project activities at Project level (i.e. demonstration areas) and Smart City level, and also considers the five **(5) major themes defined by CITYkeys** (People, Planet, Prosperity, Governance and Propagation) and **SCIS** indicators. In addition, in order to evaluate the proper impacts of the actions implemented, some of the impacts due to project actions were identified at the beginning of the project and grouped in the five **(5) specific categories** of energy, environmental, economic, social and policy impacts. Specific categories of indicators have been defined for the two level of evaluation, that are classified also according to different criteria such as the relevance of evaluation (core and complementary indicators) and the data collection methods (from	

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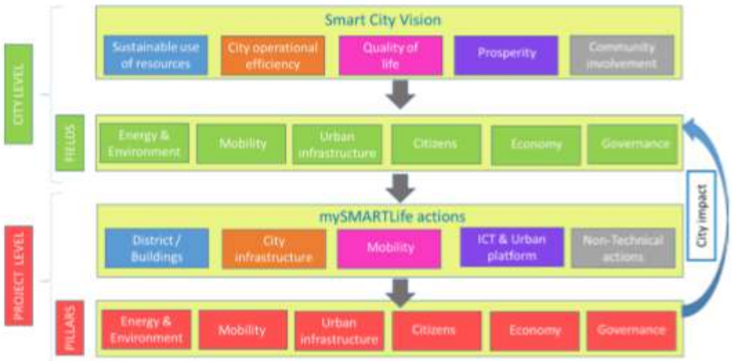
metering as primary, from formulas or interviews as secondary).The total number of KPIs used are **151 indicators**.

MySMARTLife two level-evaluation framework and its main features that correspond with the requirements is introduced as follows: Smart City Level or City evaluation framework is strongly related with the overall smart city concept vision, aiming to identify the main challenges of the cities through measuring the performance of city fields and application fields, with city level indicators and related audits. At project level, the target is to assess the effects of the project actions (MySMARTLIFE action) in the demosite, related with the project pillars that align with the type of impacts, using project level indicators. Apart from CITYkeys and SCIS, mySMARTLife evaluation framework has been also aligned with existing evaluation frameworks defined in other SCC projects, as **SmartEnCity**, **REMOURBAN**, **REPLICATE** and **CITyFiED**. Additionally, some indicators have been selected from Agenda for Sustainable development of the United Nations, United for Smart Sustainable Cities (**U4SSC**), Standard **ISO 37120**, **Eurostat** City Statistics, SEAP (Sustainable Energy Action Plan), **World Bank** and **OECD** (Organisation for Economic Co-operation and Development). Ref:[8] The figure depicts the approach of the Evaluation Framework.



Reference: D5.1-Integrated Evaluation Procedure, accessible: https://www.mysmartlife.eu/publications-media/public-deliverables/

Project Name	Description
SHARING CITIES - Building Smart Cities Together	The SHARING CITIES project focuses on increasing the speed and scale at smart solutions implemented across Europe and creating a collaborative smart city high market potential to develop affordable, integrated, commercial smart city solutions, by bringing together city authorities, businesses and research organisations and engaging citizens in new ways enabling transformation of their communities. Monitoring and evaluation forms a key element of SHARING CITIES, since it provides the means by which the work undertaken in the project becomes relevant to the wider policy and innovation community. The LH cities of the project are three: London (UK), Milan (IT) and Lisbon (PT).

Assessment Framework

The proposed Common Monitoring and Evaluation Framework (CMEF) of SHARING CITIES project attempts to deliver the effects of the People/Place/Platform (PPP) measures developed and deployed as part of the SHARING CITIES project and covers a wide range of relevant impacts. The framework includes the following key elements: measurable indicators, data standards and

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data collection methods defining also the specific evaluation targets to be addressed and the evaluation methods to be used including processes, data standards, data quality, data stewardship and key evaluation indicators. The evaluation targets that are briefly set, are categorized into six **(6) domains**: a) technical performance, b) impacts on attitudes and behaviours, c) wider systemic impacts including environmental impacts, d) security, safety and sustainability, e) institutional and business consequences, f) economic and social implications including those affected by efficiency, equity and social inclusion .The key evaluation and assessment targets concern the "Place" demonstrations from the PPP. Place itself comprises of four different repeatable measures: Building Retrofit & Local Renewable Energy Generation; Sustainable Energy Management Systems; Shared eMobility (which contains EV car sharing, eBike sharing, eLogistics, EV charging facilities and Smart Parking); and Smart Lamposts. The evaluation targets are associated with a set of **127 indicators**.	
Reference: D8.1: Common Monitoring and Evaluation Framework, accessible: http://www.sharingcities.eu/sharingcities/deliverables	
Project Name	**Description**
<u>**TRIANGULUM**</u> - The Three Point Project / Demonstrate. Disseminate. Replicate.	TRIANGULUM project is one of the European SCC Lighthouse Projects, set to demonstrate, disseminate and replicate solutions and frameworks for Europe's future smart cites. TRIANGULUM proposes a novel form of smart district development that integrates energy, ICT, sustainable transportation and business opportunities to improve the efficiency of commerce and governance as well as reduce greenhouse gas emissions. The integrated solutions are implemented in three cities of Eidhoven (NL), Manchester (UK) and Stavanger (NO).
Assessment Framework	
The mapping and evaluation framework of the project was based on a series of expected impacts across the LH cities, relevant to the five **(5) impact domains** of Energy, Transport, Citizen Engagement, Socio-economic/financial and ICT deployment. A seven-stage methodology for defining impact indicators is proposed. In this context, the framework includes a set of indicators and quantifiable units to measure or capture key parameters of demonstration activities. The indicators identified for assessing the impacts align with both the preferred metrics and the respective commitments of the cities. The definition process led to a total of **79 indicators**. Useful information to build upon and generate an assessment framework for the performance of the cities was taken from relevant literature of smart city project evaluation frameworks such as CITADEL, PEOPLE, CITYKeys, EPIC, REMOURBAN and metrics i.e. Fraunhofer Assessment Guidelines.	
Reference: TRIANGULUM-D2.1: Common Monitoring and Impact Assessment Framework, accessible: https://www.triangulum-project.eu/?page_id=119	

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Project Name	Description
GROWSMARTER – Transforming Cities for a Smart, Sustainable Europe	GrowSmarter project focuses on demonstrated solutions for higher RES pentration, advanced mobility system and decreasing CO_2 emissions in the urban environment, by implementing several measures related to Low Energy Districts, Integrated Infrastructure and Sustainable Urban Mobility. The deployment of smart city solutions is delivered in the three cities of Stockholm (SE), Cologne (DE) and Barcelona (ES).
Assessment Framework	
The framework structure designed for the evaluation of the performance of a city's energy transition within GROWSMARTER is based on the definition of **city indicators** in three **(3) main dimensions**: Better quality of life, Environmental, Economical, and various sub-domains, agreed upon relevant goals. The measures divided into the above 3 main categories of interventions, depend on the type of measure in the evaluation plan and each of the categories contain measures from different "Smart Solutions". The first category, Low Energy Districts, is divided into two sub-categories: Building Evaluation and Local Evaluation. For each measure, at least one KPI is defined resulting in a total of **104 indicators**.	
Reference: GROWSMARTER-D5.1: Evaluation Plan, accessible: https://grow-smarter.eu/inform/publications/	

Project Name	Description
+CityxChange – Positive City ExChange	+CityxChange brings the two aPSIring Lighthouse Cities Trondheim (NO) and Limerick (IE) together with their distinguished Follower Cities Alba Iulia (RO), Pisek (CZ), Võru (EST), Smolyan (BG) and Sestao (ES), to underline their ambition to achieve sustainable urban ecosystems that have zero emissions and establish a 100% renewable energy city-region by 2050.
Assessment Framework	
The KPI Framework developed for the +CityxChange Project includes KPIs defined by the SCIS, as well as KPIs that are specifically defined for this project. While the SCIS KPIs focus on the technical and economic aspects of energy related measures, the project defined KPIs focus on indicators specifically developed to measure unique interventions, as well as other social indicators to measure the impact of the project on citizens. The KPI Framework is divided into the three core themes; 1) Integrated Planning and Design (IPD), where KPIs focus on measuring the impact of sub-tasks associated to larger interventions that aim to set up tools and local regulations for short and long term planning purposes. The tasks measured address key aspects that would assist in getting the first project interventions rolled-out; 2) Common Energy Market (CEM), where focus is on measuring the aspects of certain interventions that have changed due	

to ongoing roll-out and evolution of the project. The KPIs would essentially measure aspects of a project that could not be determined by design data; 3) CommunityxChange (CxC), where focus is on measuring the effect that interventions have on the public uptake of, and participation in energy efficiency initiatives of the +CityxChange Project.

Reference: D7.1 is publically available, https://cityxchange.eu/knowledge-base/approach-and-methodology-for-monitoring-and-evaluation/

Project Name	Description
STARDUST - Enlighting European Cities	The STARDUST project tackles urban challenges by designing and implementing innovative smart solutions in three Lighthouse cities (Tampere, Trento, Pamplona) with a holistic approach. Moreover, four Follower cities (Cluja-Napoca, Derry, Kozani, Litomerize) provide an avenue to cultivate tailored replication strategies that resonate the project's actions across Europe. More specifically, the main objectives are: • Establishing a constellation of cities offering sustainable and energy efficient living conditions. • Creating a network of smart ecosystems rooted on pro-active engagement among citizens, policy makers, industry and research institutions. • Launching the Open City Information platform, an ICT toolkit that provides highly valuable sets of structured data and information to citizens, cities and innovation actors. • Demonstrating the feasibility of the implemented smart solutions and their scalability, cost-efficiency and bankability under the context of eco-innovation.

Assessment Framework

The framework structure and methodology is designed to monitor and assess the impacts of the project on different time scales: i) Immediate progress evaluated through concrete output indicators; ii) Achieved impacts assessed by impact indicators; iii) Long-term effects evaluated through scalability of the solutions implemented based on scenarios in the Lighthouse cities and follower cities and their replication potential in other cities in Europe. The 17 elected indicators to assess the performance of 5 different clusters (Building and Energy, e-Mobility, ICT, Common City Level, and Long-Term Effects) are defined. KPIs are very much aligned with SCIS and CityKeys monitoring approaches. Data capture is expected to include traditional methods and other ways like city sensors, smart meters, or along with data from other R&D projects.

It will be useful to assess the suitability of Common City Level and Long Term Effects indicators to POCITYF cases.

Reference: STARDUST WP6 deliverable, not yet available online.

Project Name	Description

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UNaLab - Performance and Impact Monitoring of Nature-Based Solutions	The UNaLab project is contributing to the development of smarter, more inclusive, more resilient and more sustainable urban communities through the implementation of nature-based solutions (NBS) co-created with and for local stakeholders and citizens. Each of the UNaLab project's three Front-Runner Cities – Eindhoven (NL), Genova (IT) and Tampere (FI) and seven Follower Cities – Stavanger, Prague, Castellón, Cannes, Başakşehir, Hong Kong and Buenos Aires – and the Observers, Guangzhou and the Brazilian Network of Smart Cities has a strong commitment to smart, citizen-driven solutions for sustainable urban development, demonstration, experimentation and evaluation of a range of different NBS targeting climate change mitigation and adaptation along with the sustainable management of water resources.
Assessment Framework	
The current list of indicators of NBS performance and impact for use by UNaLab partner cities is based on the Indicator Evaluation Framework (IEF) Taskforce (also known as Taskforce 2.0) and include KPIs in the followint clusters: climate adaptation and climate change mitigation (carbon emissions, temperature); water management (flood vulnerability, drought vulnerability, water quality); green space management and biodiversity; air quality; and, economic activity and green jobs. This metrics will be extended with categories which are not defined yet by Taskforce such as urban regeneration; participatory planning and governance; social justice and social cohesion; and, health and well-being, which are also relevant to POCITYF to follow up.	
Reference: UnaLab WP3 deliverable, https://unalab.eu/system/files/2020-02/d31-nbs-performance-and-impact-monitoring-report2020-02-17.pdf.	

3.2.4 Scientific publications

Apart from relevant projects, scientific studies are also available introducing various assessment frameworks that attempt to evaluate smart city performance on different levels. In Table 6 a list of relevant frameworks is presented as identified in the literature (scientific journals). In order to narrow down the vast number of potential frameworks that could be included in this Table, only holistic frameworks that can assess various aspects of smartness were included (e.g. papers only dealing with mobility, or ICT were excluded from the analysis) whereas specific KPIs should be clearly presented.

Table 6. Indicative KPI frameworks applicable to smart city projects/solutions from scientific sources.

Source	Assessment Framework
Angelakoglou et al. (2019)[9]	The specific study introduces a framework including six (6) steps for determining a repository of KPIs that are able to evaluate both business-as-usual and novel technologies and services related to smart city

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Source	Assessment Framework
	solutions. The implementation of the proposed framework led to the development of a repository of **75 KPIs** categorized in **six (6) dimensions** (technical, environmental, economic, social, ICT and legal KPIs) with the corresponding levels of assessment and stakeholders' group of interest and indicative thresholds for monitoring performance. This framework was built upon the experiences gained during the IRIS SCC project and can serve as an excellent basis for identifying KPIs that support POCITYF's objectives (especially Obj. 1-5). This is further supported by the fact that this framework also supports the clustering of solutions in Transition Tracks (in this case five (5) TTs are proposed) whereas specific emphasis is given on integrating all relevant stakeholder points of view concerning the deployment of smart city solutions in accordance with POCITYF's approach. All four (4) POCITYF's ETTs can potentially be fed by KPIs included in this framework.
Akande et al. (2019)[10]	The specific study proposes a framework for assessing and ranking cities based on how smart and sustainable they are. Hierarchical clustering and principal component analysis (PCA) are applied to select and cluster **32 KPIs** into **three (3) thematic areas**: a) Economy (7 KPIs); b) Environment (12 KPIs) and c) Society and Culture (13 KPIs). KPIs included in this framework are mostly fitted to assess smartness aspects on a city level and can be used to assess ETT#1 and ETT#4.
Huovila et al. (2019)[11]	To help cities in their choice, this paper compares seven recently published indicator standards for Smart sustainable cities (ISO 37120:2018, ISO/DIS 37122:2018, ETSI TS 103463, ITU-T Y.4901, 4902, 4903, SDG 11+ monitoring framework). A taxonomy was developed to evaluate **413 indicators** against five conceptual urban focuses (types of urban sustainability and smartness), **ten sectoral application domains** (energy, transport, ICT, economy, etc.) and five indicator types (input, process, output, outcome, impact). The results clearly discriminate between indicator standards suited for evaluating the implementation of predominantly smart city approaches versus standards more focused on sustainability assessment. All four (4) POCITYF's ETTs can potentially be fed by KPIs included in this study – however since most of these KPIs have already/will be examined in section 1.1.5, emphasis was mostly paid in ITU-T KPIs and the taxonomy developed (serving as feedback for other POCITYF's steps).
Tan et al. (2017)[12]	The specific study proposes an indicator framework for the assessment of smart cities putting emphasis on low-carbon city aspects. A total of **20 KPIs** are separated into **seven (7) assessment categories**: a) Energy pattern; b) Water; c) Social and living; d) Carbon and environment; e) Solid waste; f) Urban mobility and g) Economic. Most of the KPIs included in this framework can be used to assess ETT#1. Benchmark values that allow inter comparisons among cities' performance were also identified and are

Source	Assessment Framework
	presented - the specific info could help propose threshold values to monitor performance and impact during POCITYF.
Girardi and Temporelli (2017)[13]	The specific study proposes a new methodological approach, called Smartainability, that can estimate through quantitative and qualitative KPIs to what extent smart cities are more sustainable (and smart) due to the deployment of innovative technologies. The assessment is performed prior to the application of the respective technologies, an attribute that could be useful for POCITYF to preliminary assess the impacts and benefits of its many innovative elements to be demonstrated. The methodology was built upon the Guidelines for conducting a cost-benefit analysis of Smart Grid projects, a study made by European Commission JRC, and Smart Cities - Ranking of European medium-sized cities, realized by Vienna University of Technology, University of Ljubljana and Delft University of Technology. **Four (4) dimensions** of analysis are applied: a) Environment; b) Economy; c) Energy and d) Living. The methodology has been tested only on a district level (Expo Milano 2015 site) so far. Further recommendations are available for the implementation on a city level, including a set of **28 KPIs** and a new dimension - People - which evaluates the community life improvement (thus potential KPIs for ETT#4 can be extracted).
Dall'O et al. (2017)[14]	The specific study provides a method for assessing the smartness of a city through a set of indicators focusing on small and medium-size cities and communities. The KPIs selected are consistent with the ISO 37120 standard and are inspired by the environmental indicators included in Sustainable Energy Action Plans under the Covenant of Mayors Initiative, making them highly relevant to POCITYF's objectives. A total of **70 KPIs** are structured around **seven (7) evaluation areas**: a) smart economy (7 KPIs); b) smart energy (12 KPIs); c) smart environment (6 KPIs); d) smart governance (12 KPIs); e) smart living (17 KPIs); f) smart people (8 KPIs) and g) smart mobility (8 KPIs). Especially the KPIs included in the smart energy area, are highly in accordance and could feed ETT#1 and ETT#2.
Li et al. (2017)[15]	The specific study proposes a systematic approach, utilizing a bi-index method, to identify stakeholders and KPIs for multi-level (from building to district) energy performance analysis. KPIs are analyzed into **three (3) levels - strategic, tactical and operational**. The strategic KPI is aggregated and designed for the district level. The tactical KPI can be associated with the building and system level. The operational KPIs represent the operational performance of basic energy units. Although this study does not focus directly on smart city projects, it offers **35 specific performance indicators** that can serve the goals of smart city solutions focusing on energy performance which is highly relevant to POCITYF's objectives (especially Obj. #1 and #2) and ETT#1 and ETT#2.

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Source	Assessment Framework
Hara et al. (2016)[16]	The specific study proposes a set of KPIs for smart cities based on the Gross Social Feel-Good Index. The KPIs are structured upon **four (4) layers**: a) 1st layer includes the triple bottom line (Environment, Economy, Society) and Satisfaction generic categories; b) in the 2nd layer the Society category is further split into safety, health and comfort; c) the 3rd layer includes a total of **16 KPIs** utilized to assess the 2nd layer (environment/natural resource, energy, cost performance, accident, natural disaster, crime, information security, health management, prevention of illness, medical treatment, stress, diverse opportunities, barrier free, simplicity, ubiquitous, citizen's degree of satisfaction); d) the 4th layer includes the data needed (52 sub-KPIs) to calculate the KPIs in the 3rd layer. ETT#1 and ETT#2 can potentially be fed by KPIs included in this framework whereas KPIs for ETT#4 can be extracted from Society and Satisfaction categories (e.g. information security, simplicity, willingness to pay).
Lombardi et al. (2012)[17]	The specific study introduces a framework for classifying smart city performance indicators building upon the triple helix model and utilizing Analytic Network Process. The triple helix model was modified adding another unifying factor to the analysis, namely civil society (along with University, Government and Industry). A total of **63 KPIs** are proposed, organized into **five (5) clusters**: a) smart governance (related to participation) - 7 KPIs; b) smart human capital (related to people) - 12 KPIs; c) smart environment (related to natural resources) - 19 KPIs; d) smart living (related to quality of life) - 13 KPIs and e) smart economy (related to competitiveness) - 12 KPIs. KPIs included in this framework (especially in smart environment cluster) are mostly fitted to assess smartness aspects on a city level and can be used to assess ETT#1.

KPIs included in the above-mentioned frameworks (375 KPIs in total) can further help the population of POCITYF's KPI pool. It should be noted that various definitions of the term "smart city" are available[18], that are moving beyond the inclusion of ICT aspects also referring to quality of life. This lack of uniformity of smart city definitions can lead to diverse results and poses challenges to the target setting of cities. Indeed, Ahvenniemi et al.[19] analyzed 16 sets of city assessment frameworks comprising 958 indicators indicating noticeable differences between smart cities and urban sustainability frameworks, especially regarding their tendency to highlight environmental, social and economic aspects. Another interesting conclusion presented in this study is that, although decreasing energy should be an important goal for smart cities, the use of energy related KPIs is limited in the smart city frameworks. POCITYF will address this issue by including all necessary energy related KPIs in the framework.

3.2.5 Other sources (ISOs, EU strategical plans etc)

Finally, a large variety of indicators can be extracted from databases formed by international strategical planning initiatives, agreements and reviews as well as international and European standards. We identify below the most relevant/recent frameworks that are of use during the POCITYF KPI framework formation.

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UN's Global indicator framework for the Sustainable Development Goals

UN's Global indicator framework for the Sustainable Development Goals[20] and targets of the 2030 Agenda for Sustainable Development was developed by the Inter-Agency and Expert Group on SDG Indicators (IAEG-SDGs) and agreed upon, including refinements on several indicators, at the 48th session of the United Nations Statistical Commission held in March 2017. Adopted by all United Nations Member States in 2015, the SDGs are a call for action by all countries - poor, rich and middle-income - to promote prosperity while protecting the environment. They recognize that ending poverty must go hand-in-hand with strategies that build economic growth and address a range of social needs including education, health, equality and job opportunities, while tackling climate change and working to preserve our ocean and forests (sustainabledevelopment.un.org).

The framework is updated and refined in an annual basis. The framework includes 232 indicators on which general agreement has been reached (note that the total number of indicators listed in the global indicator framework of SDG indicators is 244 due to duplications). The indicators are categorized in relation to the 17 Sustainable Development Goals (SDGs) - the world's best plan to build a better world for people and our planet by 2030. As all EU countries have adopted the SDGs, the framework provides several opportunities for KPI extraction relevant to POCITYF main objectives: Creating new possibilities **to make cities safer, greener and more responsive** to the needs of their citizens, businesses and other organizations while **bringing** new technologies and renewed infrastructure to reduce household bills, create jobs and boost growth, for achieving a sustainable, low carbon and environmentally friendly economy, putting Europe at the forefront of RE production and efforts against global warming.

To this respect, the SDGs linked to POCITYF ambition are summarized below:

- Goal 7. Ensure access to affordable, reliable, sustainable and modern **energy** for all: **6 KPIs**
- Goal 8. Promote sustained, inclusive and sustainable **economic growth**, full and productive **employment** and decent work for all: **17 KPIs**
- Goal 9. Build resilient **infrastructure**, promote inclusive and sustainable **industrialization** and foster innovation: **12 KPIs**
- Goal 11. Make **cities** and human **settlements** inclusive, safe, **resilient** and **sustainable**: **15 KPIs**
- Goal 12. Ensure **sustainable consumption and production patterns: 11 KPIs** (13 in total with 2 common as Goal 8)
- Goal 13. Take urgent action to **combat climate change** and its impact: 0 KPIs (the SDG and related KPIs refer to national level and thus are not appropriate for POCITYF which is a city project)

In total **61 KPIs** are proposed in the POCITYF related subgrouping of this framework.

United for Smart Sustainable Cities (U4SSC) initiative

The "United for Smart Sustainable Cities" (U4SSC) is a UN initiative coordinated by ITU, UNECE and UN-Habitat, and supported by CBD, ECLAC, FAO, ITU, UNDP, UNECA, UNECE, UNESCO, UN Environment, UNEP-FI, UNFCCC, UNIDO, UNU-EGOV, UN-Women and WMO to achieve Sustainable Development Goal 11: "Make cities and human settlements inclusive, safe, resilient and sustainable". The set of KPIs under U4SCC[21] have been developed to establish the criteria to evaluate **ICT**´s contributions in making cities smarter and more sustainable, and to provide cities with the means for self-assessments. Intelligent use of ICT (through innovative City Information Platforms, Energy/mobility management, DSM, smart monitoring, etc) is a core element of

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POCITYF objectives, spanning all ETTs and thus the framework has important value as a source of ICT-specific KPIs for POCITYF.

The indicators are categorized in 3 dimensions: **Economy**, **Environment** and **Society and Culture.** Within each dimension, sub-dimensions provide focus on more specific areas of performance and progress. The indicators are further subdivided into **core** and **advanced** indicators. Core indicators are those that should be able to be reported on by all cities, provide a basic outline of smartness and sustainability and higher levels of performance can generally be achievable. Advanced indicators provide a more in-depth view of a city and measure progress on more advanced initiatives; however, they may be beyond the current capabilities of some cities to report or implement. The framework contains in total **91 KPIs** divided in each dimension as follows:

- Economy: 45 KPIs
- Environment: 17 KPIs
- Society and Culture: 29 KPIs

We note here that not all of the categories included under each dimension/subdimension are relevant to POCITYF goals and character (e.g. under Dimension Economy, Sub-dimension ICT, the Water and Sanitation Category and related KPIs are not relevant to POCITYF). Thus, the total number of KPIs that will be included in the initial KPI pool for POCITYF will be less than 91.

ISO/FDIS 37122 – Indicators for Smart Cities[22]

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The indicators detailed in ISO 37120 have quickly become the international reference point for sustainable cities. ISO/TC 268/WG2 experts have identified the need for additional indicators for smart cities. ISO 37122 complements ISO 37120 (see below) and establishes indicators with definitions and methodologies to measure and consider aspects and practices that dramatically increase the pace at which cities improve their social, economic and environmental sustainability outcomes. It is thus an excellent framework from which KPIs can be chosen towards the POCITYF KPI repository as it links with all POCITYF ETTs needs and objectives.

The indicators inside this framework are clustered under **23 categories**: Economy, Education, Energy, Environmental and Climate Change, Finance, Governance, Health, Housing, Population and Social Conditions, Recreation, Safety, Solid Waste, Sport and Culture, Telecommunications, Transportation, Urban/local Agriculture and Food Security, Urban Planning, Wastewater and Water. A total of 80 KPIs are identified.

Concerning POCITYF, the relevant categories are Economy (4 KPIs), Energy (10 KPIs), Environment and Climate Change (3 KPIs), Finance (2 KPIs), Governance (4 KPIs), Housing (2 KPIs), Solid Waste (6 KPIs), Telecommunication (3 KPIs), Transportation (14 KPIs) and Urban planning (4 KPIs). Thus, a total number of **52 KPIs** are used in the initial pool for POCITYF.

ISO/FDIS 37120 – Indicators for City Services and Quality of Life[23]

The indicator framework of ISO 37120 focuses on city services and quality of life as a contribution to the sustainability of the city. In more detail, the indicators included in ISO 37120 have been developed to help cities: measure performance management of city services and quality of life over time; learn from one another by allowing comparison across a wide range of performance measures; and support policy development and priority setting. ISO 37120 as a KPIs framework is thus highly relevant to POCITYF objective of forming an open collaborative ecosystem towards

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improving citizens' quality of life, innovation and sustainability at district and city level and directly linked to ETT#4.

Indicators are categorized firstly into Core, Supporting and Profile indicators. Core indicators are required to demonstrate performance in the delivery of city services and quality of life. Supporting indicators are those recommended to demonstrate performance in the delivery of city services and quality of life and can be selected according to city objectives. Profile indicators are those recommended to provide basic statistics and background information to help cities determine which cities are of interest for peer comparison and are used as an informative reference.

All indicators are classified into themes according to the different sectors and services provided by a city. Indicators under each theme, where possible, are selected and paired on the basis of input and outcome indicators for further contextual analysis. The indicators inside this framework are clustered under the same 23 themes as in ISO 37122: Economy, Education, Energy, Environmental and Climate Change, Finance, Governance, Health, Housing, Population and Social Conditions, Recreation, Safety, Solid Waste, Sport and Culture, Telecommunications, Transportation, Urban/local Agriculture and Food Security, Urban Planning, Wastewater and Water. A total of 111 KPIs are identified.

Similarly to ISO 37122, concerning POCITYF, the relevant categories are Economy (9 KPIs), Energy (8 KPIs), Environment and Climate Change (9 KPIs), Finance (5 KPIs), Governance (4 KPIs), Housing (5 KPIs), Solid Waste (10 KPIs), Telecommunication (2 KPIs), Transportation (8 KPIs) and Urban planning (5 KPIs). Thus, a total number of **65 KPIs** are used in the initial pool for POCITYF.

ETSI technical specification on KPIs for "Sustainable Digital Multiservice Cities"

In Europe, the standardization activities on Smart sustainable cities are coordinated by a joint effort between CEN, CENELEC and ETSI on the Sector Forum on Smart and Sustainable Cities and Communities (SF-SSCC), created in January 2017, and following the work of a similar coordination group[24][25]. Until now, one set of Smart sustainable city indicators has been published by ETSI in the form of a technical specification on Key Performance Indicators for "Sustainable Digital Multiservice Cities"[26], supported by related group specification[27]. These indicators were originally defined by the European CITYkeys initiative, together with European cities, based on analysis of 20 cities' needs, 43 existing indicator frameworks and feasibility testing by around 50 cities and other stakeholders. The indicators are arranged in an extended triple bottom line sustainability framework, including the themes people, planet, prosperity, governance and propagation, and completed with specific smart city indicators. Under the main themes, subthemes conforming to major policy ambitions have been identified. Under these subthemes in total 73 city indicators in different categories have been selected. The selection has been based on an inventory of 43 existing indicator frameworks for cities indicators. The majority of the indicators in the ICT users' selection have been derived from existing indicator frameworks. New indicators have been suggested to fill gaps in existing frameworks.

The relevant categories for POCITYF are related to Planet (energy and mitigation, climate resilience, pollution and waste), Prosperity (jobs creation, green economy, innovation) and Governance (organization and community involvement).

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3.3 KPIs dimensions and stakeholders' perspectives

3.3.1 KPI dimensions relevant to POCITYF

Before proceeding with the identification of potential indicators that can serve the needs of POCITYF, there is a need to define which are the "dimensions" – parameters that need to be considered for efficiently assessing and monitoring smart city solutions. This can help us ensure that relevant KPIs will be selected covering all aspects affecting the sustainable energy transition of smart cities. Based on the analysis conducted in Section 3.2, eight (8) dimensions are most frequently presented in the inventory of the KPI relevant framework sources identified. Those are: energy, environmental, economic, ICT, mobility, social, governance, and propagation.

The dimensions of 'governance' and 'propagation' are the least common when compared to other dimensions in relevant frameworks but are of equal importance in the author's opinion since they seem to be catalysing the energy transition process. Governance is connected to the current EU legislative framework that is not uniform but fragmented across the various EU countries reflecting the capacity of the local governments to manage and valorise energy transition opportunities. The dimension of 'propagation' seems to be also of significant importance in smart city projects for evaluating the potential of scaling-up, dissemination and replication to other locations, other contexts and other cities while depending on the inherent characteristics of the project but also on external factors such as market conditions. ICT is also not so frequently presented but this is mostly due to the fact that ICT KPIs are embedded within other dimensions.

POCITYF will adopt all 8 dimensions towards setting a holistic performance framework, corresponding not only with the type of solutions and actions to be implemented, but also with the key objectives that are set by POCITYF. To avoid overlaps among different categories and increase transparency the technical dimension was re-named to "Energy" since it was observed that it mostly included energy-related aspects and KPIs. POCITYF proposes the eight dimensions presented in Table 7 as a more holistic option in studies for systems operation characterized by a medium to high TRL.

Table 7. KPI dimensions adopted by POCITYF

KPI dimension	Brief Description	KPI Examples
Energy	Energy performance is focusing mainly in the interventions facilitating energy transition.	Energy demand and consumption; RES generation ratio; Peak load reduction
Environmental	Environmental performance is increasingly important for smart cities striving to identify environmental risks and factors that impact life quality and natural resources and are of utmost importance for smart city planning and operation	CO_2 emissions reduction; Air quality, Noise pollution
Economic	Economic performance refers to the business efficiency and cost of each application and usage scenario from a market perspective.	Average cost of energy consumption; Cost savings; Return on investment
ICT	ICT performance is regarded as a key pillar for technology advancements in the smart city concept, enabling data management, privacy and security and data monitoring for the development of new innovative services.	Cybersecurity; Data privacy; Improved interoperability

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KPI dimension	Brief Description	KPI Examples
Mobility	Mobility performance is appropriate for smart city projects concerning the convergence of energy and transport sectors, the global EV market uptake and the increasing citizens' needs for sustainable mobility and e-mobility services.	EVs charging points; Clean mobility utilization; E-vehicle sharing solutions
Social	Social performance is crucial to estimate the extent to which the project and its designed collaborative action model facilitates the involvement of citizens and social actors in the planning, decision-making and implementation activities through social citizen-driven innovation mechanisms.	Citizen participation in co-creation processes and online decision making; Degree of users' satisfaction
Governance	Governance performance refers to the city governance from the side of the municipality administration, planning and evaluation mainly, but also include aspects of legal domain regarding the regulatory framework and its compatibility with the proposed solutions and implemented policies at project or at city level.	Involvement of the city administration; Legal framework compatibility; New rules / regulations due to the project
Propagation	Propagation performance assesses the potential for wider scalability and replicability of the solutions and actions demonstrated.	Social compatibility of solutions; Market demand; Diffusion potential

A more detailed description per dimension is presented below:

3.3.1.1 Energy

This dimension includes KPIs measuring energy performance and focusing mainly in the field of energy and the interventions towards energy transition. KPIs in Energy Dimension of POCITYF monitor the performance and assess the efficiency and effectiveness of the integrated solutions in the energy sector and systems of the city, such as the Electricity grid, DHC network, RES penetration, DERs mechanisms and their relation with active/passive users, at building and district level. Consideration was given in presenting a dimension of KPIs to evaluate in an overall and effective manner the energy technologies and results for Positive Energy Buildings (PEBs) and Positive Energy Districts (PEDs), and formulate long-term monitoring procedures for Energy Management and Storage Solutions related with buildings and grid sustainability, since they constitute two (2) of POCITYF Energy Transition Tracks; ETT#1 and ETT#2. The selected KPIs should quantify the benefits from the increase of energy self-consumption, higher share of locally produced RES (Obj.1), and preservation of cultural heritage (Obj.9), but also should evaluate P2P energy management based on specific energy targets focusing in grid flexibility, P2P trading, peak shaving and curtailment reduction (Obj.2). Calculations will be for example the energy demand and consumption of all systems (buildings, transport, industry, public services, ICT etc.), the energy efficiency of buildings and the capabilities of the energy storage solutions. Energy KPIs will be measured capitalizing on the energy or electrical metrics of the network (e.g. voltage/ frequency/peak load etc.), on data collection at building level, among feeders, customers and producers based on consumption profiles (e.g. active/reactive power exchanged with the network, usage of solar energy, energy for cooling, heating, symbiotic use, waste, hot water and lighting), from ICT management while also on model-based evaluations with reliable energy models and software that use numerical simulation to obtain data for electricity and thermal energy loads, energy flow paths and energy storage levels (e.g. building materials, batteries etc.). This dimension of KPIs is strongly affected by the global energy market and the diverse expectations

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of all stakeholder parties engaging in the energy network supply and operations, e.g. Distribution System Operators (DSOs), and also the potential of end-users as prosumers/consumers.

3.3.1.2 Environmental

Environmental performance is increasingly important for smart cities striving to identify environmental risks and factors that impact life quality and natural resources and are of utmost importance for smart city planning and operation. The dimension of Environmental KPIs in POCITYF project will play a pivotal role in the assessment of the environmental impact on different areas of application such as energy, storage and mobility. The associated indicators will be used to evaluate environmental preservation and sustainability in terms of climate change, air quality, people's health and safety, and waste management and treatment. In this respect, Environmental KPIs should estimate the total amount of greenhouse gases emissions, air and noise pollution levels (coming from buildings, energy distribution, industry and transport) in the pilot districts while also recycling parameters representing the effectiveness of waste management solutions. Environmental dimension in POCITYF is considered in ETT#1, 2 and #3 in order to monitor, measure and evaluate the demonstration results from an environmental impact perspective.

3.3.1.3 Economic

A list of indicators measuring and analysing economic and financial performance of the project is proposed, based on the investment concepts of business stakeholders, along with the selection of business models and associated scenarios to be examined at the demonstration sites of the project during whole life-cycle (Obj6). The economic analysis and evaluation with KPIs refer to the business efficiency and cost of each application and usage scenario from a market perspective. POCITYF aims to provide market-viable solutions by defining business-oriented KPIs to evaluate the day-to-day performance of solutions, actions, tools and applications. In a world-wide market where the exploitation of innovations is one of the most serious sources of profit, the local communities try to promote and support energy efficient measures and solutions targeting to economic and business development by reducing the electricity bills and engaging consumers to an energy sensitive attitude. Economic growth in smart city concept is measured not only on Gross Domestic Product (GDP) but also with inclusion of more holistic, internationally comparable indicators that reflect the progress towards a green economy. The green and low-carbon economy approach defines KPIs that measure economic investments to support growth through smart city policy responses, e.g. expenditures by the municipality for the transition towards a smart city, while taking also into account social implications and related environmental issues, as for example local job creation, incentives for final users in favour of low carbon measures etc. Therefore, economic dimension is horizontal and affects all the Energy Transition Tracks (ETTs) of the project. Public-private partnerships (PPP) for a new technology or initiative can give a serious handicap for the economic viability of smart cities and cost-effectiveness of innovative solutions.

3.3.1.4 ICT

Information and Communication Technology (ICT) dimension is regarded as a key pillar for technology advancements in the smart city concept, and in POCITYF project particularly, whereas the demonstration and integration of the latest generation of ICT solutions will enable data management, privacy and security and data monitoring for the development of new innovative services (Obj.1) while also resilience of whole energy management systems (Obj.2). ICT performance evaluation will help the project and related energy systems in the direction of measuring the level of success to anticipate risks and develop the capacity of the whole ecosystem to absorb, recover promptly and adapt to new or changing conditions, bringing into full play the efficiency and reliability for ETT#1 and ETT#2 of POCITYF. ICT is considered a distinct KPI dimension in POCITYF, because it determines specific evaluation targets related with a set of

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integrated solutions towards an Interoperable, Modular and Interconnected City Ecosystem (ETT#4, IS4.3). The KPIs included in this dimension deal with the monitoring and sensible control of the proposed technology solutions while also with the achievements of the central Energy Management Platform/City Information Platform and the interaction with citizens. Significant ICT topics such as Open Data and standardized interfaces, Smart Grid interconnection and increased hosting capacity for new loads are also taken into account and evaluated.

3.3.1.5 Mobility

This dimension is appropriate for smart city projects concerning the convergence of energy and transport sectors, the global EV market uptake and the increasing citizens' needs for sustainable mobility and e-mobility services. Mobility is considered as one of the eight KPI dimensions in POCITYF, since it comprises an energy transition track of the project (ETT#3) due to the roll-out and implementation of new components such as EV smart charging stations and V2G technologies in the existing electricity grid of the LHs. Mobility is also highly relevant to ETT#4 supporting citizen-driven innovation in co-creating smart city solutions. KPIs on Mobility Performance will be used to evaluate the targeted e-mobility integration into the smart grid and city planning as an enabler to grid flexibility (Obj.3), and also to record the sustainability levels of urban mobility in the pilots, with auxiliary EV technologies or mobility schemes like car sharing. This dimension contains KPIs taking into account and measuring the performance of new e-mobility technologies, a growing trend in smart cities due to the added value for both parties, energy and transport. Cities willing to reduce congestion and pollution as well as parking places, while the consumers are willing to increase the usage of the vehicles (the system operator) and the availability of EVs and shared vehicles (the citizens).

3.3.1.6 Social

This dimension is crucial to estimate the extent to which the project and its designed collaborative action model facilitates the involvement of citizens and social actors in the planning, decision-making and implementation activities through social citizen-driven innovation mechanisms (ETT#4). KPIs measuring social performance will try to assess the extent to which POCITYF favours collaboration of governments with citizens and provides an open innovation ecosystem for citizens to engage in smart city co-creation (Obj.5). Social dimension is an integral part for smart city success, setting specific KPIs for a program of policy formation and supportive structures to build an energy economy designed specifically around city's specific strategy and citizens' needs. In this context, the social performance domain indicates the degree of local community involvement in the project and the impact of a technology, scheme or policy to social factors. Because many times it is not easy for some parameters to be quantified, expressing social KPIs in a percentage scale or a Likert scale is a common method for evaluating impacts and interpreting outcomes. KPIs will evaluate the extent up to which end-users and citizens are willing to participate and are affected by the demonstration of solutions and smart city activities.

3.3.1.7 Governance

This KPI dimension consists of a set of indicators which correspond to many aspects that can be considered on the effective Governance of Smart Cities. The KPIs listed in the Governance dimension refer to the **City Governance** from the side of the municipality administration, planning and evaluation mainly, but also include aspects of **Legal** domain regarding the regulatory framework and its compatibility with the proposed solutions and implemented policies at project or at city level. Governance and legislation are often not flexible enough to follow the progress of technologies, especially when these are related to strongly regulated markets (energy and mobility). In this regard, the KPIs definition in this dimension is of utmost importance in monitoring the government policies and the legislative foundation on which technological solutions are likely

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to thrive or not. Governance will be assessed in terms of enabling data exchange/monitoring and development of new innovative services – e.g. city public services accessible online; in terms of existence of local sustainability plans and roadmaps- e.g. Bold City Visions; and in the spectrum of legislative flexibility concerning the policy improvement in new rules and regulations to allow the implementation of project and the legislative background for innovative solutions (ETT#4). Quantified measurements cannot easily be gathered, hence, governance KPIs monitoring and evaluation will be conducted using a percentage or 5-point Likert scale with the perspectives of the various stakeholders. Consequently, this is a very critical domain that reflects the involvement of the city authorities in the project for identifying regulatory barriers or legal flexibilities and propose practical recommendations or new regulations on how to overcome them (Obj.10).

3.3.1.8 Propagation

This dimension is adopted by POCITYF project in an attempt to assess the potential for wider scalability and replicability of the solutions and actions demonstrated. The aim of using a dimension related with the propagation level of smart city projects is to have a set of KPIs evaluating the suitability of the project to scale-up and exported to other communities or regions in the same country or abroad (Obj.7), the ability of citizens or users to access and use systems/solutions and the effectiveness of means and ways that allow technologies to scale-up. This is an effervescent issue in smart city projects, especially in EU, since most of the already mature technologies should be actually implemented in other pilot projects, in order to go on to long-term success. Scalability and replicability can be measured over multiple domains such as systems functionality, ICT modularity, technical/social compatibility, etc., by using indicators to describe the extent to which the project offers solutions of scaling-up in size or in density and capable of being replicated elsewhere. Propagation dimension is relevant to all ETTs of POCITYF from the point of view that all of them help POCITYF to reach out further cities in Europe and foster the replication of the solutions.

Figure 3. KPI Dimensions in POCITYF

3.3.2 Stakeholders perspective s

POCITYF values the inclusion of relevant stakeholders during and after its implementation phase as an essential element in co-creating sustainable districts and cities. Various stakeholders can be affected by the project and also affect the project implementation while they often possess and/or control information, resources and expertise needed for the implementation of the project. Additionally, the active participation of stakeholders is deemed necessary for the successful implementation of the solutions and the propagation of results. As such potential stakeholder's groups related to POCITYF are identified through: a) examination of other Smart City projects to extract relevant information and identify successful examples of stakeholders involvement; b) analysis of LH cities special needs and respective integrated solutions in order to identify stakeholders that can actively participate/be represented in the implementation/evaluation of solutions; c) internal communication of POCITYF experts. This set of stakeholders is in accordance with the work realized under *T1.1 - Elicitation of citizens and stakeholder requirements, risk perception and user acceptance determinants*. The main stakeholder groups identified are:

(**a**) Energy Utilities;

(b) Consumers (end-users);

(c) Technology and services providers;

(d) Policy-making bodies and Governance;

(e) Representative Citizen Groups

The five (5) groups identified as relevant to the POCITYF project represent all relevant stakeholder's whose perceptions, knowledge and experience are deemed important in the successful deployment of smart city solutions. All stakeholders' groups identified are being affected or affecting the deployment and roll out of solutions in energy, environmental, economic, social, ICT, governance, mobility, and propagation related aspects (dimension of the KPI framework). Each stakeholders group is analysed below along with its potential relation to the energy transition tracks which cluster the POCITYF solutions. Each stakeholder role can potentially be cross-cutting affecting or being affected by several KPI dimensions. In Section 4, relevant stakeholders are identified in each KPI card.

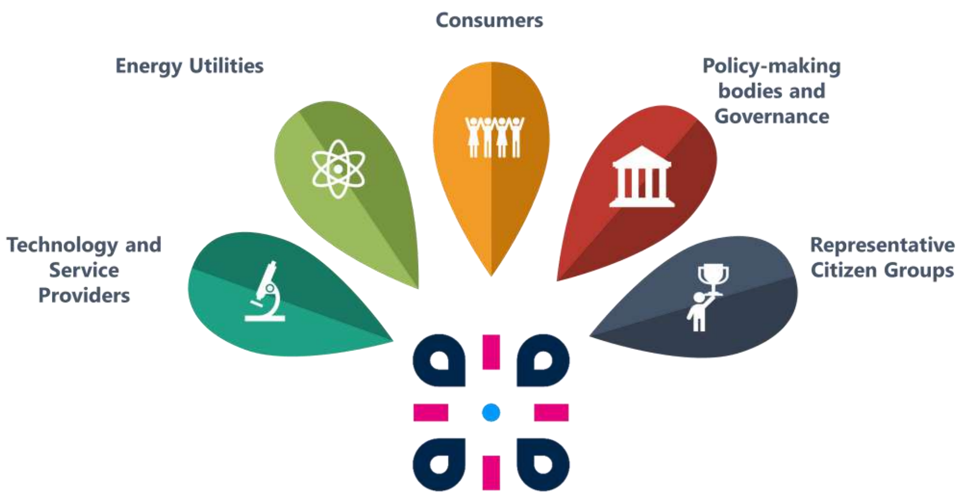

Figure 4 POCITYF Stakeholders

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3.3.2.1 Energy Utilities

Energy Utilities as defined in POCITYF incorporate Distribution System Operators (DSO), energy suppliers (providers) and producers. DSOs' role is to operate, maintain and develop the distribution network to ensure that electricity is delivered to end-users in a secure, reliable and efficient manner. Nowadays, the role of the DSO is broader and varies among countries due to their heterogeneity and differences in national regulation. Most often the distribution of electricity is controlled centrally by the regulating authorities. DSOs are nowadays asked to cope up with the big technological and socio-economic changes that are emerging in the electricity sector (e.g. the increasing production from intermittent renewable energy sources, the effective integration of electric vehicles and of demand side flexibility, the changing role of future consumers and the need to provide affordable energy to all). It is thence, of high interest for smart city projects to include the DSO's perspective related to the integrated solutions to be implemented. Similar to the DSOs, are the distributors of heating/cooling or other types of energy vectors (e.g., natural gas). As such with the term Energy Utilities, POCITYF refers to either the electricity or the heating/cooling distributors which includes both energy suppliers and producers. Energy producers might be centralized (power plants, wind farms etc) or local (local wind/solar energy generation), public (public utilities) or private (independent power producer – IPP) and their perspective is also crucial for Smart City projects as they produce the energy that meets the market demand. Energy suppliers (providers) act as middleman between the energy producers and the consumers, setting rates, buying energy and thus creating a competitive electric market. Their role enables customers to pursue energy savings plans and thus are directly linked to the energy market and needs of a smart city. Energy Utilities are considered as utilizers of POCITYF solutions valued for improving products and processes, profitability and skills in the field while acting as catalysts for their delivery. It is therefore clear that Energy Utilities play an important role to POCITYF ETT#1 and ETT#2 solutions, while their cross-cutting nature can affect also ETT#3 and ETT#4.

3.3.2.2 Consumers

Consumers (End-Users) are taking the centre stage in future energy systems. They are considered as the end-users who can provide feedback and improvement loops and can act as data providers/testers. In smart city projects consumers' participation is increasingly valued as they can: a) contribute to the city energy transition as data providers, motivated to contribute to services they can use themselves, b) participate in the smart city planning and provide input supporting decision making, and c) participate in the development and co-creation of smart city services that enable the smart cities while in parallel facilitate the end-user adoption. Regarding POCITYF ETT#1 and ETT#2 which focus on energy efficiency in buildings and districts, and storage as well as smart grid solutions respectively, consumers can be classified as residential and non-residential.

Residential consumers are mainly interested in reducing the energy consumption, as well as energy bills. Affordability and complexity are seen as the main barriers to adopting new technologies and cleaner energy sources. Millennials, however, seem to be more willing to try innovative solutions and are willing to pay more for cleaner energy sources.

Non-residential consumers are mainly driven to manage resources for economic reasons. They are increasingly motivated by climate change and sustainability while they're paying attention to environmental issues. More and more businesses have formal resource management plans in place and they're increasingly linking them to employee compensation. Non-residential consumers include factories, facilities, offices and generally non-residential buildings, municipal or private, with high energy demands.

Mobility related consumers can be grouped in those who use electro-mobility and car-sharing solutions, those who use e-mobility i.e. individual drivers or in the form of public transportation services (e.g., electric buses) enjoying less travel time and reduced pollution, and finally public transport operators, whose interest is mainly on upgrading their fleet of vehicles to electric ones in order to reduce operational costs and reduce CO2 emissions.

Other consumers include educational, health, social, and commercial organization and companies and are considered within POCITYF ETT#4, since they can potentially be end-users of the services provided and for co-creating solutions.

3.3.2.3 Technology and Service Providers (TSPs)

Technology and Service Providers (TSPs) are private or public sector industries, technological companies, research labs, universities (knowledge institutes), research institutes and service providers, including SMES and startups offering leading solutions for setting up intelligent and sustainable cities. ESCOs, aggregators and utilities are interested in connecting basic energy infrastructure with novel technologies in order to synergistically improve operational excellence, revenue potential and foster sustainable lifestyles. Towards this direction, it is essential for smart city projects to evaluate the impact of the different solutions (demand response, storage and EV management) to the different providers.

Furthermore, due to the fact that today transmission and distribution constitute a serious cost factor in the formula for the provision of electricity and fossil fuels are a scarce resource, the traditional model of centralised electricity is gradually transitioning to distributed energy generation that comes in several forms: city-scale CHP plants or micro, and off-grid generators for individual households, which produce electricity where it is consumed. While large grids produce failures and inefficiencies, decentralised energy and smaller grids appear to be a more reliable and cheaper alternative. The growth of small and medium-sized agents using solar photovoltaic panels, smart meters, vehicle-to-grid electric vehicles and EV chargers, home batteries and other ‘smart’ devices, induces an increase in flexibility of the electricity networks. These agents complemented with investors, AEC consultants and designers or housing associations can provide useful insights, beginning from the ones that own the largest share in the electricity mixture in each city, to small prosumers.

In POCITYF ETT#1, the TSPs are responsible for developing, executing and supervising the implementation of the solutions. In some cases, their role is also to promote citizen engagement (ETT#4) in order to reach the envisioned adoption rates for the new technologies. At the district level there are various types of market operators, such as housing corporations, who have experience in testing combined energy efficient solutions in buildings and companies manufacturing and supplying smart energy management systems for automating and controlling devices. For ETT#2, the traditional utility operators and their expected new business roles should be considered. ESCOs and aggregators are agents managing flexibility and DR schemes and negotiate on behalf of their customers with the operator for the provided services. For ETT#3, the role of the TSPs is to implement, maintain and operate the solutions. They are responsible for both the development and the commercial exploitation of the solutions in the market. They range from traffic management providers and vehicle manufacturers (usually large companies) dealing with the priority service and the electric vehicles, respectively, to service providers (usually SMEs) able to provide car-sharing services. TSPs can be utilizers of POCITYF solutions (i.e. local business, tourism operators, construction demolition industry, Local Authorities etc), facilitators (I.e. investors, financial institutions, banks) or providers (i.e. Associations/NGOs/umbrella organizations, Knowledge institutes and universities, Waste collection and recycling industry, Housing Association).

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3.3.2.4 Policy-Making Bodies and Governance

Policy-making bodies and multilevel governance represent end-users, but also an important stakeholder group which can foster and ensure an efficient and rational decarbonization process. They are responsible for ensuring a connected infrastructure, a normal and steady operation of the energy market and a regulatory framework that determines the quality standards adapting quickly to opportunities offered by novel validated technologies that increase energy efficiency and grid stability. In POCITYF ETT#1, the policy making and municipal authorities are responsible for providing the necessary infrastructure and services that facilitate the implementation of energy efficient solutions giving the opportunity for socio-economic development of the district or city while resulting in the reduction of carbon emissions. In ETT#2, the municipality acts as an enabler for the increase of grid flexibility and for increasing citizen awareness for the new services provided by the energy providers. In ETT#3, the policy making and governance authorities are responsible for providing mobility services to the citizens trying to reduce pollution and increase air quality. Policy-making bodies should also make sure that the vast amount of data generated during the implementation and monitoring of smart city solutions are organized and utilized in such a way that enhances their decision-making capacity (TT#4) while the governance should increase its ability to get in touch and motivate a considerable number of end-users, mainly domestic and SMEs, in order to increase adoption rates.

3.3.2.5 Representative Citizen Groups

Citizens as end users i.e. residents, visitors/tourists, building owners/tenants, commuters, drivers, are all seeking ways to elevate quality of life. Encouraged by the revised EPBD and the recast of Electricity Markets Directive they are becoming more and more involved in the energy system. They are beginning to act both individually and collectively (in Citizen Energy and Renewable Energy Communities[28]), but certainly much more decisively, also on climate mitigation initiatives. Citizen engagement in the development of **innovative** services towards a **healthy** and **sustainable** urban environment nurtures open innovation and accelerates the adoption of energy efficiency measures and solutions.

Representative Citizen groups represent groups of citizens with various activities related to POCITYF actions and objectives. They include actors such as residents, non-residential agents with high interest, citizen associations, professional associations (e.g. Engineers, taxi drivers etc), neighbouring cities/towns as well as citizen ambassadors. Their perspective is of utmost importance towards the citizen-centric approach of POCITYF. Citizen ambassadors are specifically important as individuals who have the willingness and the capacity in creating global fluency, building relationships at local, national and global level and driving social change. They are recognized by POCITYF as a catalysing human asset in communicating the benefits of deploying the Integrated Solutions and driving citizen adoption towards new technological paradigms that brings energy efficiency, environmental neutrality and socioeconomic prosperity. These citizen groups are characterised by a high level of engagement with the initiatives and/or with an active steering role in communicating to the wider public intervention in POCITY target areas (ETT#4).

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3.4 Towards the POCITYF tailored KPIs

The specific section describes in more detail the process followed to implement Step 4 (initial KPI pool development) Step 5 (Selection of KPIs based on pre-defined criteria), Step 6 (Iterate with partners towards a finalized KPI list) and respective outcomes.

The review of existing KPIs frameworks (Section 3.2) led to a vast amount of KPIs included in POCITYF's KPI pool – a total of 1928 indicators. Indicators that: a) their definition was not available or clear; b) are addressing issues that cannot be significantly and directly affected by the implementation of the project (e.g. employment at a national level); c) are too technology or site-specific (e.g. efficiency of a defined type of heat pump) were excluded from the analysis. The reason for applying this "screening" process, is to facilitate the next step which includes the detailed evaluation of each indicator by a panel of experts for ensuring that a filtered pool, including only highly relevant indicators will be assessed. Moreover, similar indicators (e.g. using different terminology and/or utilizing different units of measurement) were included only once in the pool. This highly reduced the total number of indicators included in the pool, since it was observed that a lot of frameworks were building upon previous frameworks (and especially SCIS) thus repeating relevant information.

This initial screening process resulted to a pool of 258 indicators that can potentially be adopted by smart city projects covering the selected dimensions. Since adopting all these KPIs, would make the monitoring process quite overwhelming and nearly impossible to be applied in practice, there was a need to define a clear selection/filtering procedure to narrow down the most appropriate KPIs for inclusion into the final POCITYF's KPIs repository. To address this issue, POCITYF built upon the selection criteria proposed by the CIVITAS framework[29] (also adopted by several other projects like CITYkeys) to achieve having a shortlist of indicators.

More specifically the following iterative evaluation procedure towards the POCITYF KPIs list was adopted (points 1-3 are referring to Step 5, whereas point 4 is referring to Step 6 of the methodological approach applied in this study, see Section 2.1):

1. Assessment of every KPI included in the pool using a 3-point scoring system per criterion (0: The indicator does not satisfy this criterion adequately, 1: The indicator satisfies this criterion sufficiently, 2: The indicator fully satisfies this criterion). The evaluation was performed by a carefully selected panel of experts who are members of the POCITYF consortium and have extensive experience in the design of smart city projects and they also oversee POCITYF implementation of the project. The following criteria were applied:
    - **Relevance**: Indicator should have a significant importance for the evaluation process. That means that the indicators should serve as much as possible the objectives of the project and LH and FC cities, to support their planned strategies. Furthermore, the indicators should be selected and defined in such a way that the implementation of the smart city project provides a clear signal in the change of the indicator value. Indicators that are influenced by other factors than the implementation of POCITYF are not suited. Indicators that provide an ambiguous signal (if there is doubt on the interpretation of e.g. an increase in the indicator value) are equally not suited.
    - **Availability**: Data for measuring the indicator should be easily available (limited time and effort needed). Indicators should be based if possible, on data that either: a) are available from the solution providers or others involved in the innovation case that is being evaluated; b) or can easily be compiled from public sources, and c) or can easily be gathered from interviews, maps, or terrain observations. Indicators that require, for instance, interviews of users or dwellers received a lower score as the large amounts of data needed are too expensive to gather. The same holds for indicators that require

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extensive recalculations and additional data, such as footprint indicators, and some financial indicators.
   - **Measurability**: The indicator should be capable of being measured, preferably as objectively as possible.
   - **Reliability**: The definition of the indicator (and the calculation method) should be clear and not open to different interpretations.
   - **Familiarity**: The indicator should be easily understood by users – non experts. POCITYF has relied on indicators from existing indicator sets that generally comply with this requirement, however for a number of cases the indicator's definition was not clear especially for non-experts.

   Resulting from this process each indicator received a score from 0 (minimum score) to 10 (maximum score).
2. Selection of the indicators with the highest score. A cut-off rule of a minimum score of 7 points was set for all indicators in order to be considered for selection. In case two indicators served the same purpose, the one with the highest score was selected, whereas in case of equal scores the indicator with the highest score in relevance was selected. The following criteria were further taken into account while selecting indicators:
   - **Completeness**: The set of indicators should consider all aspects of the implementation of smart city projects. In that respect indicators had to be selected to cover all defined dimensions and stakeholders' perspectives as described in Section 3.3
   - **Non-redundancy**: The set of indicators should not measure the same aspect of a subtheme. Extra care was given as to not include indicators that assess the same parameter (double counting) even if the score was higher in comparison with other indicators.
   - **Independence**: Small changes in the measurements of an indicator should not influence preferences assigned to other indicators in the evaluation.

   Resulting from this process, the number of indicators to be included into the final POCITYF repository was reduced to 68 from the initial 258.
3. Configure, if necessary, the scope and the unit of measurement of indicators in order to improve the effectiveness of evaluation and comply with the principles of sustainable development. In many cases, absolute units (e.g. kWh consumed) had to be altered into relative ones (e.g. kWh consumed per m^2) to strengthen decision making.
4. Iterate with partners towards finalized KPI list. Although the above-mentioned criteria are especially important for KPIs prioritization, it is also of major significance that these KPIs reflect the opinion and needs of the POCITYF ecosystem and especially LHs. To ensure this, outcomes from the above described steps were shared and iteratively discussed with LH managers and key technology providers of POCITYF for their review. In this way, indicators that presented an interest for the LHs were integrated or excluded by the framework, leading to the finalized POCITYF's KPI list. The finalized list includes a total of 63 indicators. On a first level and during the KPI selection process, the KPIs have been classified into two general categories: **Core and Supporting KPIs**. Core indicators have been identified as extremely relevant to POCITYF - they should be able to be reported on by all cities, provide a basic outline of smartness and sustainability and higher levels of performance can generally be achievable. Supporting indicators provide a more in-depth view of a city and measure progress on more advanced/specific initiatives and they are highly recommended; however, they may be beyond the current capabilities of some cities to report or too specific for POCITYF scope. The KPI list includes 35 Core and 28 Supporting KPIs.

The finalized POCITYF's KPI list is presented in Section 4. ***We note that this KPI list is subject to changes/updates in the following tasks of WP2 (especially T2.2, T2.3) as measuring methodology, data collection and ownership are to be refined - leaving room for improvement and potential exclusion of KPIs with high-risk of proper evaluation. We note***

also that in addition to the finalized KPI list created through this process, an extra set of 10 Project Success Indicators (PSIs) have been included to reflect specific objectives of POCITYF and envisioned impact of the project, as defined during the proposal preparation phase. These SPIs have not been part of the selection process as their evaluation is on the one hand imperative to meet some of the project's specific impact as established in the proposal stage and on the other hand simplified and specific, falling outside of the frameworks reviewed and dimensions chosen (see subsection 4.10 for more details).

3.4.1 Analytics on evaluation process

The initial screening process of the 1928 indicators presented in Section 3.2 resulted to a pool of 258 indicators, which can potentially be adopted by smart city projects covering the dimensions *Energy, Environmental, Economic, ICT, Mobility, Social, Governance,* and *Propagation*. A breakdown of the percentage of indicators reflecting each dimension is presented in Figure 5. The *Energy* dimension included the highest number of indicators (46), followed by the *Economic* (40), *Mobility (38), Governance* (36), *Environmental* (29), *ICT* (27), *Social* (26) and *Propagation* (16). The *Energy* dimension has a central importance as technology is the motor towards achieving the ambitious goals of smart cities whereas energy transition is at the core of EU strategy for climate change mitigation. Then, technology-driven economic development can be supported by the Smart City paradigm if seen as the top of a hierarchy that includes versatile benefits, such as cost savings, security, liveability, convenience, satisfaction and citizen involvement, all of which can be associated with economic prosperity[30], the reason why many indicators are scored as important in this dimension. Mobility has also a central role as it has always been important for moving people and goods. Especially nowadays, that traffic and communication is of increased importance for facilitating the optimization of existing systems, as well as for finding alternative means of transport[31]. Finally, the smart cities potential to meet climate and sustainability goals make the *Governance* as the necessary catalyser for realizing smart city projects and the *Environmental* dimension the next two most important ones followed by: the *ICT* as the backbone for collecting and delivering information at different end users[32]; the *Social* dimension which reflects how individual behaviours can assist in embracing the concept of smart city; and P*ropagation* seen as the catalyst for successful exploitation and roll out of smart city solutions. The complete indicator pool is available in ANNEX A.

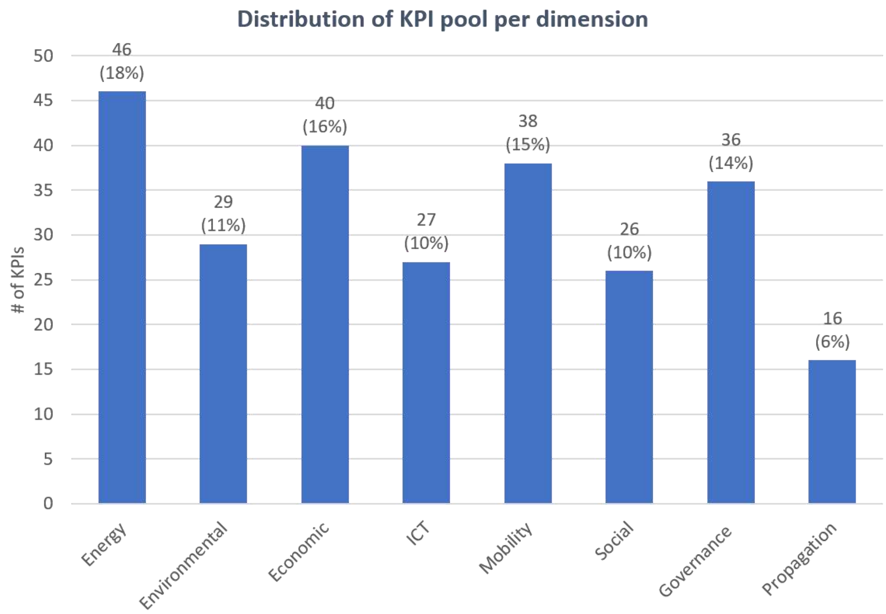

Figure 5. Percentage of indicators (%) included in the eight dimensions of the KPI pool.

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The evaluation process of the KPIs in the repository against the criteria *Relevance*, *Availability*, *Measurability*, *Reliability*, *Familiarity* showed that the *Energy* and the *ICT* dimensions scored high in the *Relevance* criterion (1.8-1.9) as both have an increased role in the realization of smart city projects and they can both demonstrate a clear change mainly in the outputs and the optimization of the energy systems. In terms of the *Availability* criterion, the dimensions that scored high were *Governance* (1.5), *Mobility (1.39)*, and *Economic (1.38)* as the data for calculating indicators in these three dimensions were considered relatively easily obtainable. The dimension of *Mobility (1.87), Energy (1.65) and Environmental (1.72)* scored high in terms of the criterion *Measurability* as all of them can be measured quantitively. In terms of the criterion *Reliability*, the *Mobility* dimension scored the highest (1.63), whereas in terms of the *Familiarity* criterion the highest scores were observed in the dimension of *Propagation (1.56)*. The lowest score (0.92) was related to the *Social* dimension against the criterion of *Reliability* and this is explained by the fact that most KPIs in the *Social* dimension are measured with a ratio Likert scale which may reduce reliability in the measurements. Finally, *ICT* has scored low (1.04) on familiarity since the integration and cross-functional operation of the systems can raise the difficulty in aggregating the measurements. The results are illustrated in Figure 6.

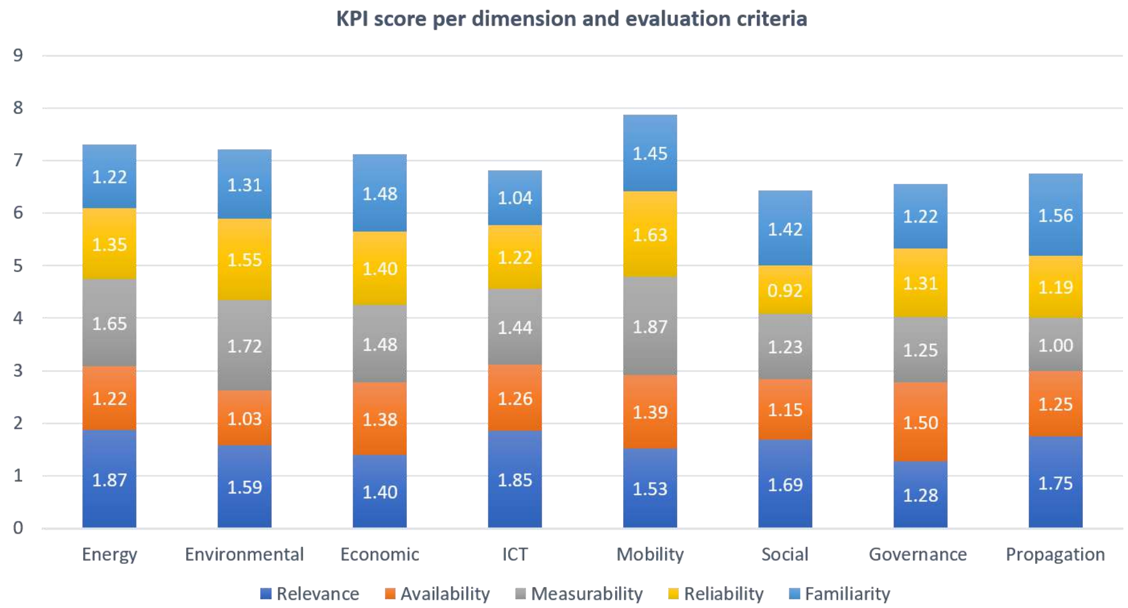

Figure 6. Score of KPIs including in the pool against evaluation criteria

3.4.2 The finalized KPI list

After the above thorough analysis and evaluation through the assessment criteria as well as taking into account more horizontal reasons like directly the existence of an indicator in SCIS platform, as previously mentioned, a representative number of the most appropriate indicators related with smart city projects towards energy transition and PEDs was decided to be included in POCITYF's KPI Repository. Typically, KPIs that have a total score of 7 out of 10 satisfying also common city needs and targeted objectives and impacts have been selected. Figure 7 depicts a detailed breakdown of the KPIs.

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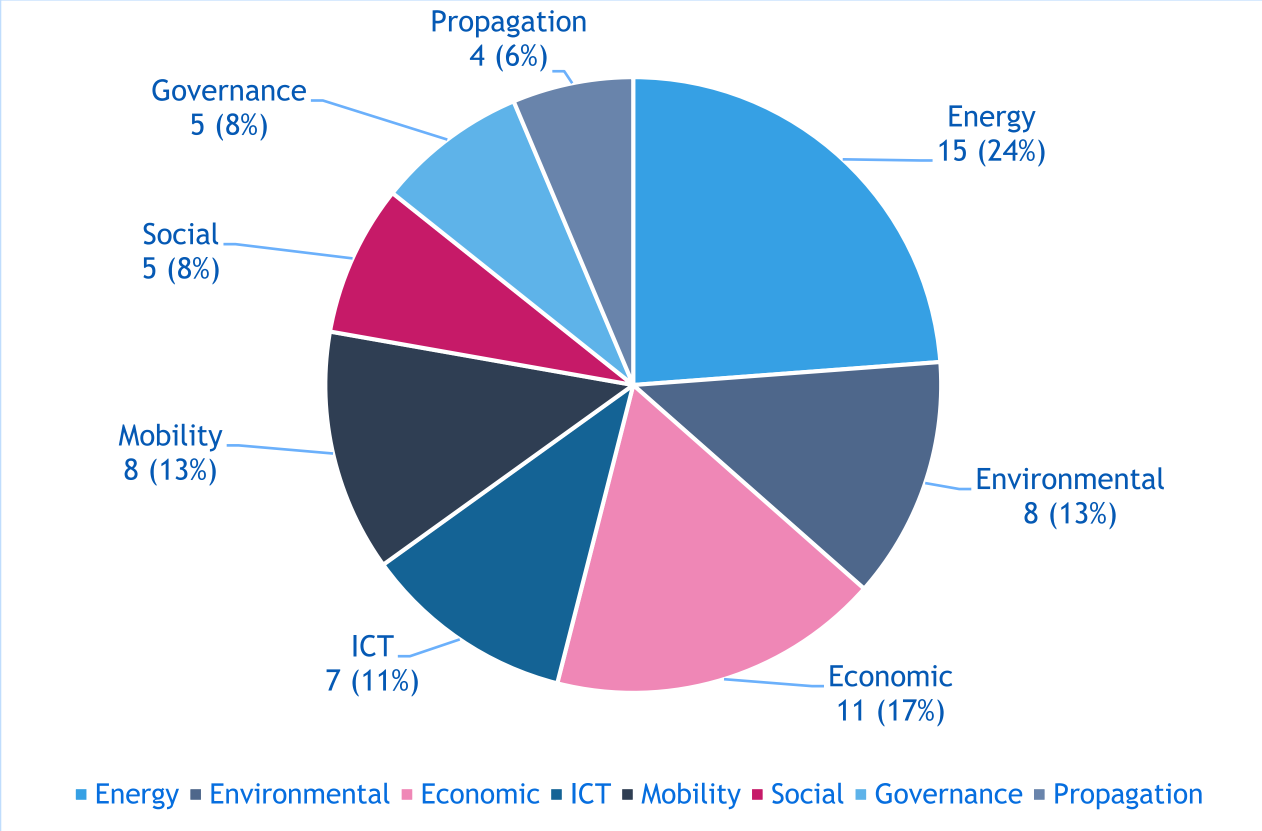

Figure 7. Number of selected indicators included in the 8 dimensions of the finalized KPI list

Table 8 illustrates the final set of KPIs adopted. The list contains 63 indicators categorized per dimension (E: Energy, EN: Environmental, EC: Economic, ICT: ICT, M: Mobility, S: Social, G: Governance, P: Propagation), providing also relevant information for each KPI about the various sources pertaining to monitoring and evaluation frameworks for smart cities in which the indicator was identified, as well as a short KPI description. It should be noted that for the analysis carried out, some KPIs were modified accordingly to express in a more meaningful way and exact purpose the project specific needs. In addition, a number of KPIs can be quantified capitalizing on a KPI formula whereas other specific KPIs are based on a qualitative measuring and assessment process. A detailed description of the KPI cards is provided in Sec. 4.

Table 8. Finalized KPI list of POCITYF smart city project.

KPI Name	KPI Sources	KPI Definition
E.1 Energy Demand and Consumption (CORE)	•SCIS; •Angelakoglou et al. (2019); •Hara at al. (2016); •Lombardi et al. (2012); •REPLICATE; •MATCHUP •ETSI; •U4SCC	This indicator assesses the energy efficiency of a system for each sector of buildings, transport, industry, public services (e.g. lighting), ICT, etc., also broken down into energy sources (electricity, heating, natural gas, etc.) The energy demand and consumption correspond to the energy entering the system in order to keep operation parameters (e.g. comfort levels).

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KPI Name	KPI Sources	KPI Definition
E.2 Degree of energetic self-supply by RES (CORE)	•SCIS; Angelakoglou et al. (2019); • Li et al. (2017); •Lombardi et al. (2012); •mySMARTLIFE; •U4SSC; •SDG	The degree of energetic self-supply by RES is defined as ratio of locally produced energy from RES and the energy consumption over a period of time (e.g. month, year).
E.3 Self Sufficiency Ratio (CORE)	Luthander et al. (2015)	The degree to which the on-site generation is sufficient to fill the final energy needs of the building/system.
E.4 Energy Savings (CORE)	•SCIS; •ITU-T •Angelakoglou et al. (2019); •Li et al. (2017); •mySMARTLIFE	This KPI determines the reduction of the energy consumption to reach the same services (e.g. comfort levels) after the interventions.
E.5 Reduced energy curtailment of RES and DER (CORE)	•SCIS; •Angelakoglou et al. (2019); •+CityxChange	The indicator assesses the reduction of energy curtailment due to technical and operational problems such as over voltage, over frequency, local congestion, etc.
E.6 kWp photovoltaic installed per 100 inhabitants (CORE)	•Dall'O et al. (2017)	Installed capacity of photovoltaic interpolated to 100 inhabitants
E.7 Smart Storage Capacity (CORE)	•Angelakoglou et al. (2019); •+CityxChange	The KPI includes all the energy storage technologies integrated in the city smart grid containing electricity, heating and mobility, presenting the impact of the project on the use of smart energy storage systems.
E.8 Heat Recovery Ratio (CORE)	•GrowSmarter	The KPI refers to the percentage ratio of the total thermal energy output of the system (MWh) to the thermal energy recovered through a waste heat recovery technology (MWh).
E.9 Integrated Building Management Systems (BMS) in Buildings (CORE)	•U4SCC; •ITU-T	Percentage of buildings using integrated ICT systems to automate building management and create flexible, effective, comfortable and secure environment.
E.10 Percentage of buildings in the city with smart energy meters (CORE)	•ISO/FDIS 37122: 2019	Percentage of buildings using smart energy meters to record and display the consumption of energy in real time, thus providing energy providers data to better plan and conserve energy.
E.11 Specific Yield (SUPPORTING)	•SmartEnCity	Metered output energy of a supply system related to the size (capacity) of the system.

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KPI Name	KPI Sources	KPI Definition
E.12 Storage Energy Losses (SUPPORTING)	•Angelakoglou et al. (2019); •Li et al. (2017)	This KPI illustrates the energy losses because of battery storage, including the added voltage transformations.
E.13 Thermal Load Reduction (SUPPORTING)	•Li et al. (2017)	Reduction of heating/cooling load caused by envelope insulation in specific thermal zone.
E.14 Peak load reduction (SUPPORTING)	•Li et al. (2017)	The indicator compares the peak demand before the r implementation (baseline) with the peak demand after; per final consumer, per feeder, per network.
E.15 Percentage of street lighting managed by a light performance management system (SUPPORTING)	•ISO/FDIS 37122: 2019	Percentage of street lighting managed by a light performance management system
EN.1 Greenhouse Gas Emissions (CORE)	•SCIS; •Hara et al. (2016); •Lombardi et al. (2012); •MATCHUP; •U4SCC; •ETSI; •ITU-T; •+CityxChange	The KPI calculates the amount of emissions for six major GHGs; carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and Sulphur hexafluoride (SF_6);
EN.2 Carbon Dioxide Emission Reduction (CORE)	•SCIS; •CITYkeys; •Angelakoglou et al. (2019); •Li et al. (2017); •Tan et al. (2017); •Dall'O et al. (2017); •IRIS; •SmartEnCity; •REPLICATE; •+CityxChange	CO_2 emissions can be considered a useful indicator to assess the contribution of urban development on climate change. The main sources are processes related to energy generation and transport.
EN.3 Air Quality Index (CORE)	•CITYkeys; •MATCHUP; •U4SCC; •ETSI	The indicator provides a relative measure of the annual average air quality in relation to the European limit values (annual air quality standards and objectives from EU directives).
EN.4 Primary Energy Demand and Consumption (SUPPORTING)	•SCIS; •MATCHUP; •mySMARTLIFE	The indicator of the primary energy demand/consumption of every metered system encompasses all the naturally available energy that is consumed in the supply chain of the used energy carriers.
EN.5 Climate Resilience Strategy (SUPPORTING)	•CITYkeys; •ETSI	This indicator assesses to what extent the city has a resilience strategy and action plan to adapt/respond to climate change, by providing a qualitative measure.

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KPI Name	KPI Sources	KPI Definition
EN.6 Noise Pollution (SUPPORTING)	•CITYkeys; •Angelakoglou et al. (2019); •Akande et al. (2019); •IRIS; •REPLICATE; •MATCHUP; •ISO 37120: 2018; •U4SCC; •ETSI;	This KPI refers to the measurement of noise in level of decibels (dB) before and after the activities of the project.
EN.7 Municipal Solid Waste (SUPPORTING)	•CITYkeys; •Tan et al. (2017); Dall'O et al. (2017); •Hara et al. (2016); •REPLICATE; •ISO 37120: 2018; •ETSI	This indicator provides a measure of how much waste a city is producing and the level of service a city is providing for its collection.
EN.8 Recycling Rate of Solid Waste (SUPPORTING)	•CITYkeys; •Akande et al. (2019); •Tan et al. (2017); •Dall'O et al. (2017); •Lombardi et al. (2012); •REPLICATE; •ISO 37120: 2018; •ETSI; •ITU-T	This KPI estimates the percentage of city's solid waste that is recycled, calculated as the total amount of the city's solid waste that is recycled in tons divided by the total amount of solid waste produced.
EC.1 Total Investments (CORE)	•SCIS; •Angelakoglou et al. (2019); •+CityxChange	The KPI is defined as the amount of cumulated payments relevant to the energy aspects of the systems (e.g. highly efficient envelope in a building) including also business as usual cases investments.
EC.2 Total Annual Costs (CORE)	•SCIS; •Angelakoglou et al. (2019)	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).
EC.3 Payback Period (CORE)	•SCIS; •Angelakoglou et al. (2019); •CITYkeys; •+CityxChange	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.

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KPI Name	KPI Sources	KPI Definition
EC.4 Return on Investment (ROI) (CORE)	•SCIS; •Angelakoglou et al. (2019); •+CityxChange	The return on investment (ROI) is defined as the ratio between the total incomes/net profit and the total investment of the project/product etc.
EC.5 Average Electricity Price for Companies and Consumers (SUPPORTING)	•TRIANGULUM	The indicator represents the average minimum cost at which electricity must be sold, so as to balance the costs with profits.
EC.6 Percentage of the Total Distributed Energy Resources Capacity Traded (SUPPORTING)	• +CityxChange	This KPI measures the amount of Distributed Energy Resources (DERs) capacity traded as a percentage of the total DERs capacity available.
EC.7 Local Job Creation (SUPPORTING)	•CITYkeys; •MATCHUP; •mySMARTLIFE; •Angelakoglou et al. (2019); •+CityxChange	This indicator assesses the creation of direct jobs from the implementation and operation of smart city project solutions.
EC.8 Energy Poverty (SUPPORTING)	•CITYkeys; •ETSI; •Angelakoglou et al. (2019); •REPLICATE	The KPI evaluates the extent to which households are at risk of poverty or deprivation, by calculating the change in percentage points of (gross) household income spent on energy bills.
EC.9 Carbon Dioxide Reduction Cost Efficiency (SUPPORTING)	•CITYkeys; •Angelakoglou et al. (2019); •mySMARTLIFE	The specific KPI estimates the costs in euros per ton of CO_2 saved per year. This KPI can be estimated capitalizing on information already available in other KPIs (carbon dioxide emission reduction and total annual costs).
EC.10 New Business Creation (SUPPORTING)	•CITYkeys; •ETSI	The indicator assesses the number of new businesses created (including start-ups) as one point of overall business climate in a jurisdiction and entrepreneurship.
EC.11 Expenditures by the municipality for a transition towards a smart city	•CITYkeys; •REPLICATE; •MATCHUP; • ETSI; •ITU-T	Smart city expenditures include process relevant expenditures and findings. Estimates should also include the percentage of municipal budget allocated to the ICT facilities.
ICT.1 Increased System Flexibility for Energy Players (CORE)	•SCIS; •Angelakoglou et al. (2019)	The indicator determines the increased system flexibility for the energy utilities as an effective way to exploit all resources to respond to a set of diversions (e.g. demand changes in a specific time interval) and maintain the power balance, in terms of load or cost.
ICT.2 Increased hosting capacity for RES, electric vehicles and other new loads (CORE)	•SCIS; •Angelakoglou et al. (2019)	The indicator determines the improvement of hosting capacity with regards to additional loads and installations in the network when

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KPI Name	KPI Sources	KPI Definition
		R&I solutions are applied, and also compared to the baseline scenario.
ICT.3 Improved Data Privacy (CORE)	•CITYkeys; •Angelakoglou et al. (2019); •ETSI; ITU-T	This indicator refers to the level of improvement of data privacy and safety analysing the extent to which data collected by the project is protected, for instance, by following regulations on data protection and implementing proper procedures to protect personal or private data.
ICT.4 Quality of Open Data (CORE)	•Angelakoglou et al. (2019)	Percentage of data that uses DCAT standards.
ICT.5 ICT Response Time (SUPPORTING)	•SmartEnCity; •mySMARTLIFE	The response time of ICT infrastructure is related to the services developed and the payload (information exchanged) between them, applicable to the various ICT actions and services in the project.
ICT.6 Improved Cybersecurity (SUPPORTING)	•CITYkeys; •MATCHUP; •ETSI	The indicator refers to the extent to which the project ensures cybersecurity of its systems.
ICT.7 Platform Downtime (SUPPORTING)	•Angelakoglou et al. (2019)	The indicator quantifies the platform downtime per selected timeframe/ time-unit.
M.1 Electric Vehicles & Low-Carbon Emission Vehicles deployed in the area (CORE)	•SCIS; •Angelakoglou et al. (2019); •ISO/FDIS 37122: 2019; •U4SSC; •MATCHUP; •REPLICATE	Number of electric vehicles (EV) and low-carbon vehicles (PHEV & hydrogen) registered in the area, in relation to the total number of motorized vehicles (four and two wheels).
M.2 Number of EV charging stations and solar powered V2G charging stations deployed in the area (CORE)	•Angelakoglou et al. (2019) •SCIS; •Dall'O et al. (2017); •REPLICATE	Number of e-charging and V2G stations, public and private and fast chargers. The indicator refers to the following measurements; Number of total stations deployed; along with their locations; e-charging stations deployed; V2G stations deployed; They could also be expressed as a percentage compared to total number of stations.
M.3 Annual Energy delivered by charging points (CORE)	•SmartEnCity; •MATCHUP; •mySMARTLIFE	The KPI refers to the level of use of the EV charging infrastructure implemented in the city, calculating the total kWh recharged by all types of EVs during a year in the public charging stations.

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KPI Name	KPI Sources	KPI Definition
M.4 Annual number of passengers using the new vehicles and/or infrastructure (CORE)	•mySMARTLIFE	The level of utilization of the new vehicles or infrastructure should be expressed by the number of passengers or users travelling during a year with the new vehicles (e.g. EVs and e-buses) or on the new infrastructure deployed.
M.5 Shared Electric Vehicles and Bicycles Penetration Rate (CORE)	•mySMARTLIFE •Dall'O et al. (2017) •ISO/FDIS 37122 2019 •U4SSC	Number of e-vehicles and bicycles that operate in the platform and in the community car/bike-sharing concept.
M.6 Clean mobility utilization (SUPPORTING)	•SCIS; •+CityxChange	The indicator assesses the amount of km in clean vehicles, and number of trips in clean vehicles, concerning as a means of sustainable mobility.
M.7 Modal Split (Passengers/Vehicles/Trips) (SUPPORTING)	•SCIS;	The indicator determines the distribution of transport over the modalities of public and collective transport, private vehicles, biking and walking.
M.8 Yearly km of Shared Vehicles and Bicycles (SUPPORTING)	•U4SSC; •Angelakoglou et al. (2019)	The indicator assesses the yearly km made through the e-car and bike sharing system instead of private conventional cars and bicycles.
S.1 People Reached (CORE)	•CITYkeys; •Angelakoglou et al. (2019); •mySMARTLIFE	Percentage of people in the target group that have been reached and/or are activated by the project.
S.2 Connection to the existing cultural heritage (CORE)	•CITYkeys; •mySMARTLIFE	The extent to which making a connection to the existing cultural heritage was considered in the design of the project.
S.3 Local community involvement in the implementation and planning phase (CORE)	•Angelakoglou et al. (2019)	The extent to which residents/users have been involved in the implementation process.
S.4 Degree of satisfaction (CORE)	•mySMARTLIFE. •Hara et al. (2016)	The level of satisfaction and acceptance of people affected by the actions in the project, from a technical point of view; perceived adequateness, benefit (e.g. comfort), usefulness, ease of use, aesthetics; economic point of view; cost, risk, benefit.
S.5 Percentage of citizens' participation in online decision-making (SUPPORTING)	•MATCHUP;	The indicator assesses the percentage of citizens that take part in online decision-making.

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KPI Name	KPI Sources	KPI Definition
G.1 Online visits to the municipal open data portal per 100 000 population (CORE)	•ISO/FDIS 37122: 2019	Number of visits to the municipal open data portal in a year per 100 000 population.
G.2 Percentage of city services accessible and that can be requested online (e-Governance) (CORE)	•ISO/FDIS 37122: 2019; •U4SCC; •Lombardi et al. (2012); •Dall'O et al. (2017); •ITU-T	The total number of city services offered to people and businesses through a centralized Internet interface compared to the total number of city services offered by the city.
G.3 Monitoring and evaluation (SUPPORTING)	•CITYkeys; •ETSI	The extent to which the progress towards a smart city and compliance with requirements is being monitored and reported.
G.4 Legal Framework Compatibility (SUPPORTING)	•Angelakoglou et al. (2019)	The level of suitability of the legal framework for the integration of; a) RES generation b) symbiotic waste-heat c) energy flexibility, d) private and public EV penetration and e-mobility e) CIPs for energy management and citizen engagement; policies
G.5 Open government dataset (SUPPORTING)	•MATCHUP; •mySMARTLIFE; •U4SCC; •ETSI	The indicator measures the number of open government datasets per 100.000 inhabitants, showing how involved is the local government in building a smart city.
P.1 Social compatibility (CORE)	•CITYkeys; •Angelakoglou et al. (2019)	The extent to which the project's solution fits with people's 'frame of mind' and does not negatively challenge people's values or the ways they are used to do things.
P.2 Technical compatibility (CORE)	•CITYkeys;	The extent to which the smart city solution fits with the current existing technological standards/infrastructures.
P.3 Market demand (CORE)	•CITYkeys	The extent to which there is a general market demand for the solution. An important characteristic is if the innovation meets the needs of its potential adopters.
P.4 Diffusion to other locations (CORE)	•CITYkeys	The extent to which the project is copied in other cities and regions.

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3.5 KPIs clustering and granularity evaluation levels

This section describes the clustering of KPIs and defined granularity evaluation levels. The aggregation performed facilitates the monitoring procedure and increases the transparency of the assessment to be performed.

3.5.1 From implementations' output to project's outcome and impact

KPIs defined through the aforementioned process (section 3.1-3.4) target both the technologies to be implemented as well as the impact goals of POCITYF. KPIs focusing on the ISs are essential for the proper monitoring and evaluation of each integrated technology's effectiveness and progress. Additionally, in the core of POCITYF´s vision and planned actions are its expected impacts in accordance with the SCC1 call. The chosen KPIs are obliged to provide metrics on these impacts which should assess the benefits deriving from the solutions implementation. Thus, the selected KPIs are categorized in two (2) levels based on their orientation:

Output-oriented KPIs: These KPIs are concrete indicators for monitoring the progress and effectiveness of implementation (e.g. Specific yield, Improved data privacy) The assessment level can be performed under the IS and ETT clustering as described in subsection 3.5.2.

Impact (outcome) oriented KPIs: These indicators should assess the benefits of interventions as well as the higher-level goals to which POCITYF will contribute (e.g. Energy Savings, Greenhouse gas emissions). The KPIs assessing the impact-oriented evaluation level are extremely important as they can be considered as the end-result POCITYF is pursuing, through its implementation activities.

Multiple output oriented KPIs can monitor the contribution towards one impact target, to be assessed by the impact oriented KPI. Figure 8 provides an illustrative scheme of this linkage between the two KPI orientations.

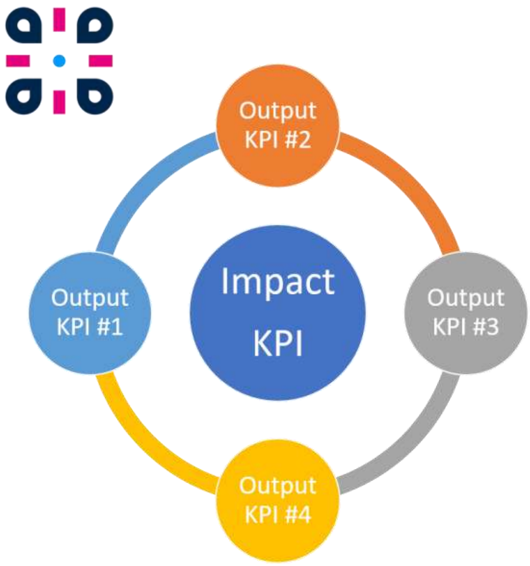

Figure 8 Connection between Output and Impact oriented KPIs

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3.5.2 From Integrated Solutions to Energy Transition Tracks

The individual technologies to be demonstrated in POCITYF LH cities form integrated solutions targeting specific project objectives which are interlinked with POCITYF's Energy Transition Tracks. The KPIs defined through the process detailed in the previous subsections, must therefore provide metrics for monitoring both the performance and impact of each IS (and any specific technology therein if necessary) as well as a more holistic picture of the progress, performance and impact attributes of the ETT into which, ISs are aggregated. Figure 2 presents POCITYF's ETTs and ISs.

As POCITYF ISs are interdisciplinary and complementary, each ETT formed by the aggregation of these solutions targets a more holistic advancement. This advancement directly links to specific project objectives. Thus, the evaluation in ETT level can be performed by KPIs relevant to these specific project objectives. These indicators provide a higher-level integrated system of the total ISs contribution towards the objectives and assessing POCITYF's impact. Figure 9 provides an illustration on the ETT evaluation level fed by the IS level indicators for ETT #1. Note that the reference to ETTs and especially related ISs does not strictly mean that a specific KPI should be monitored and evaluated under the specific IS. It rather serves as an indication that technology elements pertaining to the specific IS could influence and/or feed the KPI and thus the IS evaluation can also be assessed partially through this indicator.

Figure 9 ETT evaluation level fed by the IS level (example for ETT #1)

Table 9 presents POCITYF's ETTs along with the linked objectives which form the basis for the KPI evaluation on ETT level.

Table 9 POCITYF ETTs and linked Objectives

ETT #1	Objective 1
Innovative Solutions for Positive Energy (CH) Buildings and Districts	Demonstrate solutions at building and district level that enable the increase of energy self-consumption, energy savings and high share of locally produced renewable energy - leading to energy positive districts, located in mixed use urban districts including that of cultural heritage ones

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ETT #2	Objective 2
P2P Energy Management and Storage Solutions for Grid Flexibility	Demonstrate P2P energy management and storage solutions supporting grid flexibility and curtailment reduction
ETT #3	**Objective 3**
e-Mobility Integration into the Smart Grid & City Planning	Demonstrate the integration of electro-mobility solutions as an enabler to grid flexibility
ETT #4	**Objective 5**
Citizen-Driven Innovation in Co-creating Smart City Solutions	Demonstrate active citizen engagement services and solutions providing an open innovation ecosystem for citizens to participate in co-creation, decision making, planning and problem solving within the Smart Cities

3.5.3 From a building to the city – spatial scale

POCITYF aims to create positive energy building blocks and districts while advancing on issues such as integrated planning, implementations on cultural heritage buildings, social engagement, circular economy and green financing. In relation to LC-SC3-SCC-1-2019 work program scope as well as POCITYF expected impact #3 (*Lead the way towards wide scale rollout of Positive Energy Districts – The higher the replicability of the solutions across Europe, the better)*, the solutions developed need to be not only replicated but also gradually scaled up to city level. Scalability is of utmost importance and a key requirement for the wide scale rollout of the innovative solutions. It refers to the possibility of increasing the size of the project without compromising its efficiency and effectiveness. Cities that can apply and scale-up POCITYF's solutions will become more attractive in terms of living conditions, contributing to novel business models and eventually more local jobs creation towards sustainable growth. In this light, the envisioned interventions must be assessed in different spatial granularity levels in order to properly monitor their progress and performance and comply the aforementioned scalability requirement. Therefore, KPIs should include a spatial scaling component and they should be selected keeping always in mind their necessary expanding character. In POCITYF four (4) spatial levels of evaluation have been determined with the help of SCIS:

Building level: According to EN 15603, the energy performance of the building is the balance of: a) the delivered energy required to meet the energy needs and b) the exported energy. The assessment boundary in the building level integrate the energy needs per area of application (heating, cooling, DHW, etc.), energy technologies supplying these energy needs, energy storage units, delivered energy to each energy supply unit per energy carrier, ICT measures at the building level, mobility measures at the building level and socioeconomic measures at the building level.

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Building Block (set of buildings/PEB) level: The assessment for a set of buildings is done by aggregation of building units. The indicators can then be calculated for the sum of the buildings as a group.

District (PED) level: The level of district is composed by the aggregation of different entities. Indicators can be calculated for the sum of these entities along with district specific KPIs relevant to mobility, ICT measures, socioeconomic and environmental aspects. The boundary of the district and corresponding energy flows must be defined properly. Following SCIS, the information is required to define the energy system comprises : a) Energy carriers used at the implementation area level and the primary energy factors corresponding to this area b) Demonstration units involved (buildings, energy supply units (ESU), storage units and distribution systems) c) Delivered energy to each ESU and building allocated to the corresponding energy carrier d) Output energy of each ESU and, if applicable, output energy exported out of the boundary allocated to the amount of delivered energy carrier e) Energy flows between technologies and buildings (which ESU is supplying which building or ESU). Due to the complexity of these systems, indicators can only be calculated if a full set of data is available.

City level: The scaling to a city level is a complicated procedure as POCITYF solutions target building blocks and districts. Nevertheless, a generalised evaluation on city level can be performed by focusing on the previous granularity levels and projecting impact on a city level. Similar to the description for the District (PED) level, the boundary must be defined properly including all dimensional indicators. Aggregation and averaging methods can be used towards this evaluation.

The spatial aggregation of KPIs is illustrated in Figure 10.

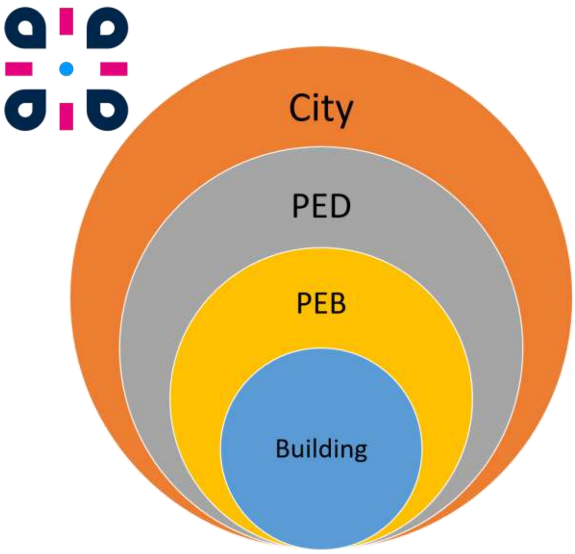

Figure 10 POCITYF's spatial evaluation levels

3.5.4 From present to future – temporal scale

POCITYF solutions aim to stand the test of time and provide ground for replication activities in other cities. To make sure that the project delivers long-term impact to the cities, POCITYF focuses on citizen needs and embraces **citizen-centric design.** As POCITYF lasts for only five (5) years, the assessment of the innovative solutions performance and mainly impact in the local societies cannot be exclusively determined during its duration. Each city is a dynamic ecosystem with evolving needs and continuous development and thus KPIs need to take this time-component into account when assessing the technologies implemented. From an economic/business-related perspective, the performance of solutions in different timeframes is also extremely important lowering financial risks and promoting long-term investment. Moreover, POCITYF aims to develop bold city-visions covering urban planning, technical, financial and social aspects. Towards this goal, indicators should provide the required temporal perspective to help cities determine optimal solutions. POCITYF expected strategic impact is also structured in different temporal granularity levels. In this light and in relative accordance with the expected strategic impact temporal granulation POCITYF defines three (3) temporal frames:

In-project (short-term): In this temporal level, indicators should be evaluated during the project duration. This temporal level of evaluation provides important information on the progress of a solution/service during the project and its performance relative to the main Objectives of POCITYF. The smart-city evolution of the LHs during POCITYF lifetime can be easily assessed by evaluation in such short-term intervals.

End of project (2024 - mid-term): The assessment of technologies at the end of the project provide information on the project's overall performance and impact in the local societies. Aggregation of the short-term level can be used to calculate the indicators by summation, averaging etc. whenever this is applicable.

Post-project (2025 and beyond - long-term): The post-project assessment falls outside of POCITYF duration. Nevertheless, cities can continue monitoring the performance of solutions and their impact towards their bold city-visions. The solutions to be implemented during POCITYF are not static and their interaction with other city solutions as well as performance in the long run should be evaluated in such temporal scale to assess their long-standing success and provide feedback for future projects. Scaling up smart solutions -derived at district scale- to the wide range of city scale is a rather challenging task. In POCITYF's KPI framework, an attempt was made to align the defined KPIs with city vision of LH cities to support the post implementation phase.

The temporal aggregation of KPIs is illustrated in Figure 11.

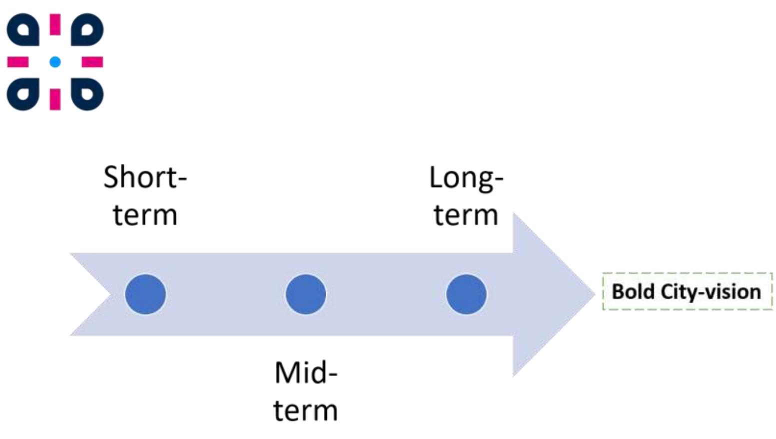

Figure 11 POCITYF's temporal evaluation levels towards bold city-visions

3.5.5 Analytics on clustering and evaluation levels

The POCITYF KPI repository includes indicators that pertain into various levels of granularity as well as orientation as previously described in detail (Sec. 3.5). The clustering procedure has been performed by the authors and selected POCITYF partners (LH managers, ETT leaders) in order to aggregate KPIs into the different evaluation levels necessary for a transparent, all-inclusive and

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properly defined monitoring and evaluation process. Each KPI has been assessed individually in order to specify:

1. Is it oriented towards the project impact or is it a focused on the output (progress and performance) of a specific action? A binary choice has been made.
2. Should it be evaluated multiple times during the project lifetime, only once at the end of project or evaluation should be performed in the years following the project end? Multiple (more than one) choices for this temporal-scale of evaluation were possible.
3. Does it apply on a building, PEB, PED or City level? Multiple (more than one) choices for this spatial scale of evaluation were possible.

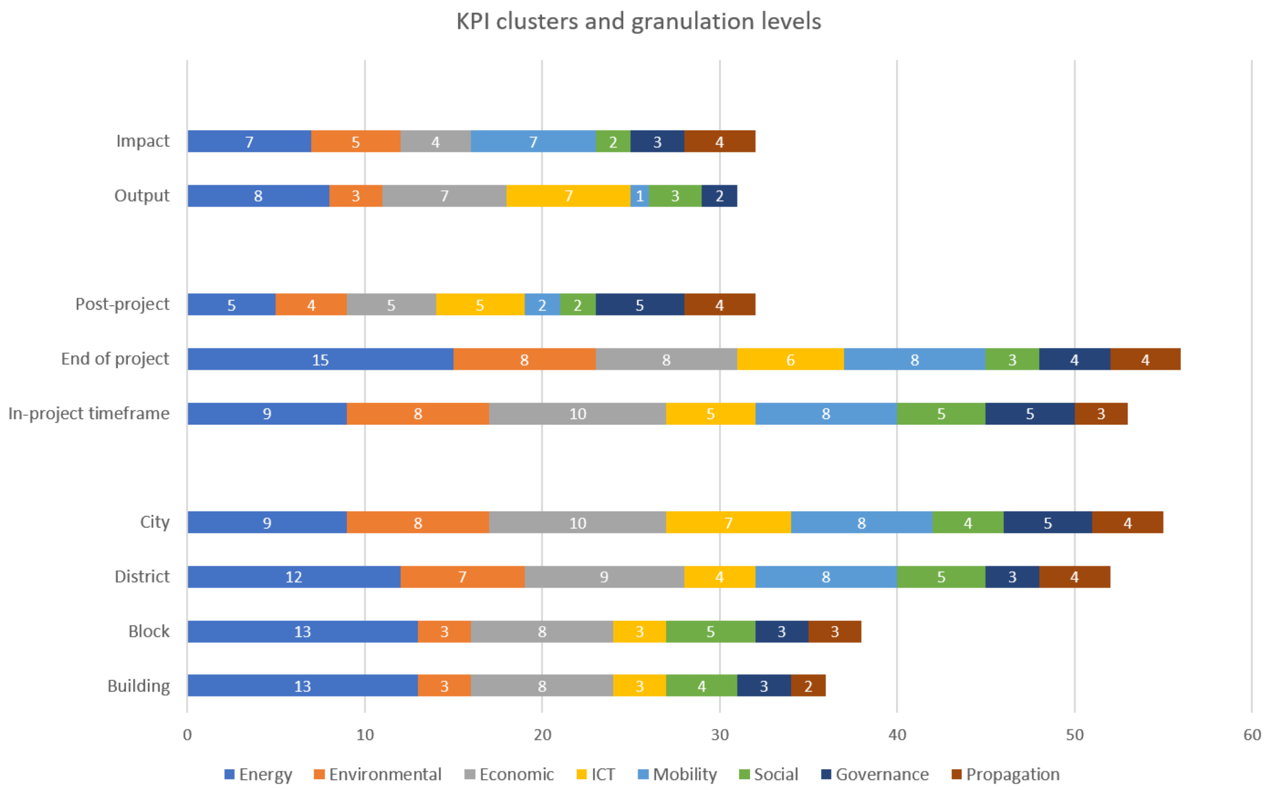

Figure 12. KPI evaluation levels and clusters

Figure 12 shows the evaluation levels and clusters along with the number of KPIs belonging to each per dimension. We summarize the population of each level and cluster along with some specific attributes extracted from this procedure as follows:

- From the total of 63 KPIs, 32 are impact-oriented while 31 are output-oriented. We note thus a great balance between KPIs that showcase POCITYF's global impact and KPIs that assess progress and performance. This balance is greatly pronounced in the Technical (7 impact-oriented vs 8 output-oriented), Environmental (5 vs 3), Social (2 vs 3) and Governance (3 vs 2) dimensions. KPIs dealing with Propagation are all impact-oriented (4 vs 0) as they assess compatibility, scalability and diffusion potential of solutions. These KPIs are balanced by ICT ones which are purely output-oriented (0 vs 7) as they focus on ICT progress and performance while the impact of ICT is mainly assessed indirectly under other dimensions (e.g. resulting energy savings).
- In the temporal scale of evaluation, 53 KPIs are to be evaluated during the project, 56 at the end of the project and 32 after the end of the project. The post-project evaluation level contains the least number of KPIs but all KPIs under the Governance (100%) and Propagation (100%) dimensions deal with important indicators that should be projected in

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time. 26 (41%) KPIs are to be evaluated on all three temporal levels, 26 (41%) on two out of three while 11 (17%) KPIs on only one temporal level. For example, KPI - E.1 Energy Demand and Consumption is to be continuously evaluated during the project, at the end of the project to reflect its success as well as post-project in order to adjust and evaluate the performance of interventions as demand might change. On the other hand, KPI - E.15 Percentage of street lighting managed by a light performance management system should be evaluated only once at the end of the project as it reflects the successful installations due to the project.

- In the spatial scale of evaluation, 36 (57%) KPIs are to be evaluated on a building level, 38 (60%) on a PEB level, 52 (82%) on a PED level and 55 (87%) on a city level. We note that KPIs dealing with Mobility are to be evaluated only on a district and city level, owing to their broader granularity of application. 29 (46%) KPIs are to be evaluated on all four spatial levels, 7 (11%) on three out of four, 17 (27%) on two out of four while 10 (16%) KPIs on only one spatial level. For example, KPI - E.4 Energy Savings applies to all spatial granules as energy related interventions might be applicable on a building (e.g. BMS), PEB (e.g. PV systems), PED (e.g. DHC) or city (e.g. V2G). Contrarily, KPI - EN.5 Climate Resilience Strategy can and should be evaluated only on a city level as it assesses to what extent the city has a resilience strategy and action plan.

The clustering and evaluation levels are included in the KPI cards presented in Section 4. The distribution/clustering of the finalized KPIs into Energy Transition Tracks and Integrated Solutions is presented in table formats in Annex B.

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4 POCITYF KPI cards

The finalized list of POCITYF KPI cards derived through the process described in Section 3.4 is presented below. The KPI cards include details on the KPI definition, owner (to be further assessed in T2.2-2.3), formulas, recommended measuring process, evaluation interval and data collection sources (to be further assessed in T2.2-2.3), units of measurement, relevant stakeholders and various aggregations as defined in section 3. The threshold/target values will be further detailed in following tasks of WP2, but a link of specific KPIs to pre-defined thresholds (defined as impact KPIs in the GA/proposal stage or Project Success Indicators – SPIs here) has been made and presented in section 4.10.2. In the KPI cards, we also include the correspondence to SCIS KPIs whenever such reporting is relevant. Figure 13 presents an example of a KPI card along with a short description/explanation of the information included in each field.

KPI Name (CORE or SUPPORTING)					
KPI Description	*Definition of the indicator and relevant details*				
KPI Owner	*POCITYF partner responsible for measurement/calculation (see note below)*				
KPI Formula	*The mathematical (if applicable) formula to be used for the KPI calculation*				
Recommended Measurement Process and Data Sources	*Recommendations on the measurement process and the sources for data collection*				
Recommended Monitoring Interval	*Recommendation on the necessary monitoring time interval*		Reporting to SCIS	YES *Is this a SCIS KPI?* NO	
Unit of Measurement	*The unit of measurement (based on the KPI formula if applicable)*		Threshold Target Value	*The baseline/threshold values. To Be Defined (TBD) in most cases, see intro text above*	
Relevant Stakeholders *The stakeholders associated to this KPI*	Energy Utilities		Spatial Scale of Evaluation *The spatial granules in which the KPI should be evaluated*	Building Level	
	Consumers (end-users)			Building Block Level (PEB)	
	Technology and Services Providers			District Level (PED)	
	Policy-making Bodies/Governance			City Level	
	Representative Citizen Groups				
	Citizen Ambassadors				
Type of Indicator *The indicator type assessment*	Output		Temporal Scale of Evaluation *The temporal granules in which the KPI should be evaluated*	In-project timeframe	
	Impact			End of project	
				Post-project	
The ETT and especially IS references below, link the specific KPI to the interventions and objectives of each transition track and integrated solution. This association does not strictly mean that the KPI should be monitored and evaluated under each ETT/IS marked but rather that some solutions included in these groups explicitly or implicitly refer also to this KPI.					

ETT-reference	ETT#1		ETT#2		ETT#3		ETT#4			
IS-reference	IS-1.1		IS-1.2		IS-1.3		IS-2.1		IS-2.2	
	IS-3.1		IS-3.2		IS-4.1		IS-4.2		IS-4.3	

Figure 13. Example of a POCITYF KPI card. Comments in red or yellow color

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Note on the KPI ownership: The KPI Owner is a single partner from each LH city who will ensure that the specific KPI is measured and calculated according to the methodology provided in the KPI Card for the particular action. If this KPI Owner needs technical support, a complementary "Supporting" partner next to the KPI Owner should be assigned too. If a specific KPI is to be measured in different sectors (energy, ICT, mobility) and/or aggregated in different levels (Building, PEB, PED, City), the KPI Owner will need to assign necessary "Supporting" partners to support the overall management of KPI. The overall KPI Owner will be used as a contact point for further actions in POCITYF such as data analytics, impact assessment, SCIS inputs, etc. **In this first assessment of the KPI ownership, a first round of feedback from Evora LH has been incorporated into the KPI cards. This feedback and initial assessment will be further detailed in subsequent WP2 tasks and it is thus modifiable. The KPI owners for Alkmaar LH have been assigned by CERTH at this stage and once again will be adjusted accordingly in the following months.** In the KPI owner slot of the KPI cards, the partner marked in **bold** letters is recommended to be the Owner followed by the recommended Supporting partners.

Sections 4.1-4.9 present the KPI cards per dimension. In each dimension/subsection, the list of KPIs is structured with the Core KPIs first followed by the Supporting ones. The KPI list includes 35 Core and 28 Supporting KPIs. **Core KPIs have been identified as extremely relevant to POCITYF - they should be able to be reported by all cities, providing a basic outline of smartness and sustainability and showing that higher levels of performance can generally be achievable. Supporting indicators provide a more in-depth view of a city and measure progress on more advanced/specific initiatives and they are highly recommended; however, they may be beyond the current capabilities of some cities to report or are too specific for the scope of POCITYF.** ***The finalized KPI list and associated cards are subject to changes/updates in the following tasks of WP2 (especially T2.2, T2.3) as measuring methodology, data collection and ownership are to be refined – leaving room for improvement and potential exclusion of KPIs with high-risk of proper evaluation***. Section 4.10 contains the POCITYF's Project Success Indicators, associated cards and correspondence with KPIs.

4.1 KPIs in Energy Dimension

4.1.1.1 E.1 Energy Demand and Consumption (CORE)

Energy Demand and Consumption (CORE)	
KPI Description	The energy demand/consumption corresponds to the final energy needed/ consumed by the end users or system in order to ensure system operation in providing certain energy services (e.g. comfort levels). The **final** energy excludes energy used by the energy sector, including for delivery, and transformation. It also excludes fuel transformed in the electrical power stations of industrial auto-producers and coke transformed into blast-furnace gas where this is not part of overall industrial consumption but of the transformation sector. This differs to the **primary** energy consumption which measures the total energy demand of a country. It covers consumption of the energy sector itself, losses during transformation (for example, from oil or gas into electricity) and distribution of energy, and the final consumption by end users. This also differs to the building related useful energy which disaggregates the final energy by end-use category (space heating, cooling, water heating, cooking, process heat, motive power and appliances). The final energy demand is based on the calculated (e.g. simulated) figures and the final energy consumption is based on the monitored data. To enable the comparability between systems, the total final energy demand/consumption is related to the size of the system (when applicable) and the time interval. This indicator can be used to assess the energy efficiency of a system.

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<table>
<tr><td></td><td colspan="6">All forms of energy need to be taken into account, including electricity, natural gas or thermal energy for heating and cooling and fuels. These will be given in different units of energy (kWh, GJ, m3), but they all have to be calculated or converted to kWh of energy in order to be able to sum up the separately calculated energy consumptions and achieve the total energy consumption of the area.

The energy consumption of other sectors such as buildings, transport, industry, public services (e.g. lighting) especially related to POCITYF demonstration activities should be considered when calculating the total final energy consumption and demand.</td></tr>
<tr><td>KPI Owner</td><td colspan="6">Evora: EDPL; INESCTEC (HEMS and Bidirectional Smart Inverters), SE (BMS), UNINOVA (Energy Routers); CME, SONAE, UÉvora, PACT and DECSIS (as building owners)

Alkmaar: GA; ALI (plus relevant partners with energy systems and building owners)</td></tr>
<tr><td>KPI Formula</td><td colspan="6"><u>At Building Level</u>
$$E_d = \frac{TE_d + EE_d}{A_d}$$
E_d = Final Energy demand (simulated)
TE_d = Final Thermal energy demand (simulated) [kWh/ (month); kWh/ (year)]
EE_d = Final Electrical energy demand (simulated) [kWh/ (month); kWh/(year)]
A_b = Floor area of the building [m^2]
**In case natural gas is to be monitored, the specific final demand should be added too[units of m3 should be converted to kWh by multiplying with the energy potential of the gas during the period in question)
$$E_C = \frac{TE_C + EE_C}{A_b}$$
E_C = Final Energy consumption (monitored)
TE_C = Final Thermal energy consumption (monitored) [kWh/(month) ; kWh/(year)]
EE_C = Final Electrical energy consumption (monitored) [kWh/(month) ; kWh/(year)]
A_b = Floor area of the building [m^2]
**In case natural gas is to be monitored, the specific final consumption should be added to [units of m3 should be converted to kWh by multiplying with the energy potential of the gas during the period in question)
<u>At district level</u>
$$E_{district\ demand} = \sum E_d$$
$$E_{district\ consumption} = \sum E_c$$
The total final energy consumption and demand should be also provided in absolute values (kWh/year) especially in systems where the normalization is not relevant (ICT, transport, etc). Baseline values should be provided too.</td></tr>
<tr><td>Recommended Measurement Process and Data Sources</td><td colspan="6">1. Data collection (e.g. from energy meters or/and simulations or/and database)
2. KPI calculation</td></tr>
<tr><td>Recommended Monitoring Interval</td><td>Hourly; monthly ; yearly (depending on the system and refinement level needed)</td><td>Reporting to SCIS</td><td>YES</td><td>X (SCIS KPI 2.1.1, 2.5.1)</td><td>NO</td><td></td></tr>
<tr><td>Unit of Measurement</td><td>kWh/ (m^2·month); kWh/(m^2·year); kWh/year</td><td>Threshold Target Value</td><td colspan="4">TBD</td></tr>
</table>

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Relevant Stakeholders	Energy Utilities	X	Spatial Scale of Evaluation	Building Level	X
	Consumers (end-users)	X		Building Block Level (PEB)	X
	Technology and Services Providers	X		District Level (PED)	X
	Policy-making Bodies/Governance	X		City Level	X
	Representative Citizen Groups				
	Citizen Ambassadors				
Type of Indicator	Output		Temporal Scale of Evaluation	In-project timeframe	X
	Impact	X		End of project	X
				Post-project	X

ETT-reference	ETT#1	X	ETT#2	X	ETT#3	X	ETT#4			
IS-reference	IS-1.1	X	IS-1.2	X	IS-1.3	X	IS-2.1	X	IS-2.2	X
	IS-3.1	X	IS-3.2	X	IS-4.1		IS-4.2		IS-4.3	

4.1.1.2 E.2 Degree of energetic self-supply by RES (CORE)

Degree of energetic self-supply by RES (CORE)					
KPI Description	The degree of energetic self-supply by RES is defined as ratio of locally produced energy from RES and the final energy consumption over a period of time (e.g. month, year). The degree of energetic self-supply (DE) is separately determined for thermal (heating or cooling) and electrical energy. The quantity of locally produced energy is interpreted as by renewable energy sources (RES) produced energy.				
KPI Owner	Evora: **EDPL;** CME, INESCTEC (HEMS and Bidirectional Smart Inverters), SE (BMS), UNINOVA (Energy Routers) Alkmaar: **GA**; ALI (plus relevant partners with energy systems and building owners)				
KPI Formula	$$DE_T = \frac{LPE_T}{TE_C} \cdot 100$$ DE_T = Degree of thermal energy self-supply based on RES LPE_T = Locally produced thermal energy [kWh/month; kWh/year] TE_C = Final thermal energy consumption (monitored) [kWh/(month); kWh/(year)] $$DE_E = \frac{LPE_E}{EE_C} \cdot 100$$ 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)]				
Recommended Measurement Process and Data Sources	1. Data collection (e.g. from energy meters or/and simulations or/and database) 2. KPI calculation				
Recommended Monitoring Interval	Hourly; monthly ; yearly (depending on the system and refinement level needed)	Reporting to SCIS	*YES*	*X (SCIS KPI 2.1.3)*	*NO*
Unit of Measurement	%	Threshold Target Value	TBD		
Relevant	Energy Utilities X		Building Level X		

Stakeholders	Consumers (end-users)	X	**Spatial Scale of Evaluation**	Building Block Level (PEB)	X
	Technology and Services Providers	X		District Level (PED)	X
	Policy-making Bodies/Governance			City Level	X
	Representative Citizen Groups				
	Citizen Ambassadors				
Type of Indicator	Output		**Temporal Scale of Evaluation**	In-project timeframe	X
	Impact	X		End of project	X
				Post-project	X

ETT-reference	ETT#1	X	ETT#2	X	ETT#3	X	ETT#4			
IS-reference	IS-1.1	X	IS-1.2	X	IS-1.3		IS-2.1	X	IS-2.2	X
	IS-3.1	X	IS-3.2		IS-4.1		IS-4.2		IS-4.3	

4.1.1.3 E.3 Self sufficiency ratio (CORE)

Self sufficiency ratio (CORE)	
KPI Description	Self-Sufficiency refers to the degree to which the on-site generation is sufficient to fill the final energy needs of the building/system. It measures the amount of the building/system's electricity/heating demand that is instantaneously matched by the building/system's on-site generation over a certain period of time. It should be separately determined for thermal (heating or cooling) and electrical energy. The self sufficiency ratio has to be provided also broken down into energy consumption of each sectors: buildings, transport, industry, public services (e.g. lighting).
KPI Owner	Evora: **EDPL**; CME, INESCTEC (HEMS and Bidirectional Smart Inverters), SE (BMS), UNINOVA (Energy Routers) Alkmaar: **GA**; ALI (plus relevant partners with energy systems and building owners)
KPI Formula	Self-Sufficiency is given by the ratio: $$Self-sufficiency = \frac{C}{A+C} \cdot 100$$ C = RES power that is utilized directly within the system (building etc) A = Net energy demand A schematic taken from Ref.[33] is given below to ease understanding of each variable (PV example).

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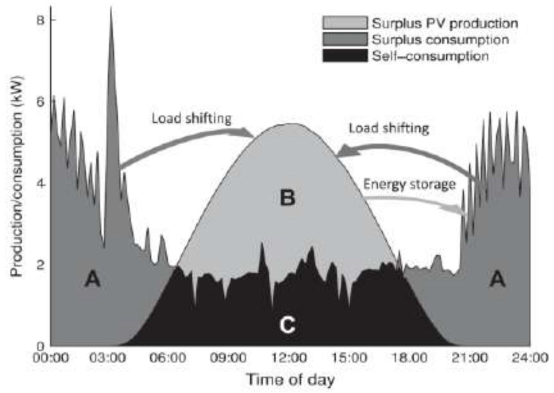

Fig. 1. Schematic outline of daily net load (A + C), net generation (B + C) and absolute self-consumption (C) in a building with on-site PV. It also indicates the function of the two main options (load shifting and energy storage) for increasing the self-consumption.

More formally, denoting the instantaneous building power consumption L(t) and the instantaneous onsite PV power generation P(t), the power generation utilized on-site is limited by whichever of the load and the generation profiles is the smallest, which can be expressed as:

M(t) = min{L(t), P(t)}

where M(t) is the instantaneously overlapping part of the generation and load profiles. In the case of energy storage (battery or heat storage) in the building this can be extended to

M(t) = min{L(t), P(t) + S(t)}

where S(t) is the power to and from the storage unit, with S(t) < 0 when charging and S(t) > 0 when discharging. This takes the losses due to charging, storing and discharging of the energy storage into account.

Self-sufficiency can then be defined and calculated as:

$$Self - sufficiency = \frac{\int_{t1}^{t2} M(t)dt}{\int_{t1}^{t2} L(t)dt} \cdot 100$$

Recommended Measurement Process and Data Sources	1. Data collection (e.g. from energy meters or/and simulations or/and database) 2. KPI calculation

Recommended Monitoring Interval	Hourly; monthly ; yearly (depending on the system and refinement level needed)	Reporting to SCIS	YES		NO	X
Unit of Measurement	%	Threshold Target Value	TBD			

Relevant Stakeholders	Energy Utilities	X	Spatial Scale of Evaluation	Building Level	X
	Consumers (end-users)	X		Building Block Level (PEB)	X
	Technology and Services Providers	X		District Level (PED)	X
	Policy-making Bodies/Governance	X		City Level	X
	Representative Citizen Groups				
	Citizen Ambassadors				
Type of Indicator	Output		Temporal Scale of Evaluation	In-project timeframe	X
	Impact	X		End of project	X
				Post-project	X

ETT-reference	ETT#1	X	ETT#2	X	ETT#3	X	ETT#4			
IS-reference	IS-1.1	X	IS-1.2	X	IS-1.3	X	IS-2.1	X	IS-2.2	X
	IS-3.1	X	IS-3.2	X	IS-4.1		IS-4.2		IS-4.3	

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4.1.1.4 E.4 Energy Savings (CORE)

<table>
<tr><th colspan="8">Energy Savings (CORE)</th></tr>
<tr><td>KPI Description</td><td colspan="7">This KPI determines the reduction of the final energy consumption to reach the same services (e.g. comfort levels) after the interventions, taking into consideration the final energy consumption from the reference period. It may be calculated separately determined for thermal (heating or cooling) energy and electricity, or as an addition of both to consider the total savings. It might be also be calculated as a percentage. The energy savings have to be provided also broken down into each sector: buildings, transport, industry, public services (e.g. lighting), etc.</td></tr>
<tr><td>KPI Owner</td><td colspan="7">Evora: CME; EDPL, INESCTEC (HEMS and Bidirectional Smart Inverters), SE (BMS), UNINOVA (Energy Routers)

Alkmaar: GA; ALI (plus relevant partners with energy systems and building owners)</td></tr>
<tr><td>KPI Formula</td><td colspan="7">$$ES_T = ER_T - TE_C$$ $$or\ in\ \%: ES_T = 1 - \frac{TE_C}{ER_T}$$ ES_T = Thermal energy savings
TE_C = Thermal energy consumption of the demonstration-site [kWh/(m^2 year) ; MWh/(year)]]
ER_T = Thermal energy reference demand or consumption (simulated or monitored) of demonstration-site [kWh/(m^2 year) ; MWh/(year)]].
$$ES_E = ER_E - EE_C$$ $$or\ in\ \%: ES_E = 1 - \frac{EE_C}{ER_E}$$ ES_E = Electric energy savings
EE_C = Electric energy consumption of the demonstration-site [kWh/(m^2 year) ; MWh/(year)]
ER_E = Electric energy reference demand or consumption (simulated or monitored) of demonstration-site [kWh/(m^2 year) ; MWh/(year)]].
$$ES_{total} = ER_E + ER_T - TE_C - EE_C$$ $$or\ in\ \%: ES_{total} = 1 - \frac{TE_C + EE_C}{ER_T + ER_E}$$</td></tr>
<tr><td>Recommended Measurement Process and Data Sources</td><td colspan="7">1. Data collection : Data for consumption (as well as reference values) can be provided by energy utilities from energy meters
2. KPI calculation
3. Comparison with threshold target value</td></tr>
<tr><td>Recommended Monitoring Interval</td><td colspan="2">monthly ; yearly</td><td>Reporting to SCIS</td><td>YES</td><td>X (SCIS KPI 2.1.2)</td><td>NO</td><td></td></tr>
<tr><td>Unit of Measurement</td><td colspan="2">kWh/ (m^2·year); MWh/(year); %</td><td>Threshold Target Value</td><td colspan="4">TBD</td></tr>
<tr><td rowspan="6">Relevant Stakeholders</td><td>Energy Utilities</td><td>X</td><td rowspan="6">Spatial Scale of Evaluation</td><td colspan="3">Building Level</td><td>X</td></tr>
<tr><td>Consumers (end-users)</td><td>X</td><td colspan="3">Building Block Level (PEB)</td><td>X</td></tr>
<tr><td>Technology and Services Providers</td><td>X</td><td colspan="3">District Level (PED)</td><td>X</td></tr>
<tr><td>Policy-making Bodies/Governance</td><td>X</td><td colspan="3">City Level</td><td>X</td></tr>
<tr><td>Representative Citizen Groups</td><td></td><td colspan="3"></td><td></td></tr>
<tr><td>Citizen Ambassadors</td><td></td><td colspan="3"></td><td></td></tr>
<tr><td></td><td>Output</td><td></td><td></td><td colspan="3">In-project timeframe</td><td>X</td></tr>
</table>

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Type of Indicator	Impact	X	Temporal Scale of Evaluation	End of project	X
				Post-project	

ETT-reference	ETT#1	X	ETT#2	X	ETT#3	X	ETT#4			
IS-reference	IS-1.1	X	IS-1.2	X	IS-1.3	X	IS-2.1	X	IS-2.2	X
	IS-3.1	X	IS-3.2		IS-4.1		IS-4.2		IS-4.3	

4.1.1.5 E.5 Reduced energy curtailment of RES and DER (CORE)

Reduced energy curtailment of RES and DER (CORE)					
KPI Description	Reduction of energy curtailment due to technical and operational problems such as over voltage, over frequency, local congestion, etc. The integration of ICT and monitoring will have an impact on producers, as the time for curtailment will be reduced, and the operative range will be wider. This indicator can be measured as the percentage of GWh electricity curtailment from DER reduction of R&I solution compared to BaU for a period of time, i.e. a year.				
KPI Owner	Evora: **EDPL**; CME, INESCTEC (HEMS and Bidirectional Smart Inverters), SE (BMS), UNINOVA (Energy Routers)) Alkmaar: **GA**; ALI (plus relevant partners with energy systems and building owners)				
KPI Formula	$$EnI = \frac{EnI_{baseline} - EnI_{measured}}{EnI_{baseline}} \cdot 100$$ Where: EnI is the percentage reduction in energy not injected in network due to technical and operational problems conditions [% in MWh]. $EnI_{baseline}$ is the total energy not injected in network due to technical and operational problems under baseline condition [MWh]. $EnI_{measured}$ measured is the total energy not injected in network due to technical and operational problems under new measured condition [MWh]				
Recommended Measurement Process and Data Sources	1. Calculation/determination of baseline 2. Data collection from energy meters and monitoring devices 3. KPI calculation				
Recommended Evaluation Interval	yearly		Reporting to SCIS	*YES*	*X (SCIS Supporting KPI)* / *NO*
Unit of Measurement	%		Threshold Target Value	TBD	
Relevant Stakeholders	Energy Utilities	X	Spatial Scale of Evaluation	Building Level	X
	Consumers (end-users)			Building Block Level (PEB)	X
	Technology and Services Providers	X		District Level (PED)	X
	Policy-making Bodies/Governance			City Level	
	Representative Citizen Groups				
	Citizen Ambassadors				
Type of Indicator	Output		Temporal Scale of Evaluation	In-project timeframe	X
	Impact	X		End of project	X
				Post-project	X

ETT-reference	ETT#1	X	ETT#2	X	ETT#3	X	ETT#4	

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N° 864400.

IS-reference	IS-1.1	X	IS-1.2	X	IS-1.3	X	IS-2.1	X	IS-2.2	X
	IS-3.1	X	IS-3.2		IS-4.1		IS-4.2		IS-4.3	

4.1.1.6 E.6 kWp photovoltaic installed per 100 inhabitants (CORE)

kWp photovoltaic installed per 100 inhabitants (CORE)							
KPI Description	Installed capacity of photovoltaic interpolated to 100 inhabitants To be assessed per sector (residential, tertiary, industrial and public)						
KPI Owner	Evora: **EDPL; CME** Alkmaar: **GA**; ALI						
KPI Formula	$$PVInt = \frac{PV_{installed} * 100}{N_{inh}}$$ $PVInt$ = Interpolated value of kWp of photovoltaic installed per 100 inhabitants $PV_{installed}$ = kWp of photovoltaic installed in area/sector N_{inh} = Number of inhabitants in area/sector						
Recommended Measurement Process and Data Sources	1. Data collection (e.g. provided by municipalities along with energy utilities and providers) 2. KPI calculation						
Recommended Evaluation Interval	yearly		Reporting to SCIS	*YES*		*NO*	*X*
Unit of Measurement	kWp/100 inhabitants		Threshold Target Value	TBD			
Relevant Stakeholders	Energy Utilities	X	Spatial Scale of Evaluation	Building Level			
	Consumers (end-users)	X		Building Block Level (PEB)	X		
	Technology and Services Providers	X		District Level (PED)	X		
	Policy-making Bodies/Governance	X		City Level	X		
	Representative Citizen Groups						
	Citizen Ambassadors						
Type of Indicator	Output	X	Temporal Scale of Evaluation	In-project timeframe			
	Impact			End of project	X		
				Post-project			

ETT-reference	ETT#1	X	ETT#2		ETT#3	X	ETT#4			
IS-reference	IS-1.1	X	IS-1.2	X	IS-1.3		IS-2.1		IS-2.2	
	IS-3.1	X	IS-3.2		IS-4.1		IS-4.2		IS-4.3	

4.1.1.7 E.7 Smart Storage Capacity (CORE)

Smart Storage Capacity (CORE)	
KPI Description	With the need for increased RES penetration in the energy mix, energy storage is essential due to the mismatch between RES generation and demand/consumption f. 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.

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	It should be reported separately for Thermal, Battery and V2G storage in order to address the Project's Impact KPIs														
KPI Owner	Evora: **EDPL**; CME, INESCTEC (Smart inverters, V2G chargers), Betteries, UW Alkmaar: **GA; ALI**														
KPI Formula	Calculated separately for Thermal, Battery and V2G storage in order to address the Impact KPIs 2.4-2.6 as well as in total as an addition of the aforementioned. The installed storage capacity should also be provided for the same reasons (units of MWh). In case of baseline storage capacity > 0, the KPI can be calculated as a percentage increase as: $$Storage\ capacity\ installed = \frac{SCI_{R\&I} - SCI_{baseline}}{SCI_{baseline}} \cdot 100$$ $SCI_{R\&I}$ = storage capacity installed due to R&I activities during the project in the area [MWh] $SCI_{baseline}$ = baseline value of storage capacity installed in the area [MWh]														
Recommended Measurement Process and Data Sources	1. Baseline calculation 2. Data collection KPI calculation Sources from energy utilities and relevant stakeholders														
Recommended Evaluation Interval	Once		Reporting to SCIS	YES		NO	X								
Unit of Measurement	MWh; %		Threshold Target Value	TBD											
Relevant Stakeholders	Energy Utilities	X	Spatial Scale of Evaluation	Building Level	X										
	Consumers (end-users)			Building Block Level (PEB)	X										
	Technology and Services Providers	X		District Level (PED)	X										
	Policy-making Bodies/Governance	X		City Level	X										
	Representative Citizen Groups														
	Citizen Ambassadors														
Type of Indicator	Output		Temporal Scale of Evaluation	In-project timeframe											
	Impact	X		End of project	X										
				Post-project											
ETT-reference	ETT#1	X	ETT#2	X	ETT#3	X	ETT#4								
IS-reference	IS-1.1	X	IS-1.2		IS-1.3		IS-2.1	X	IS-2.2	X					
	IS-3.1	X	IS-3.2		IS-4.1		IS-4.2		IS-4.3						

4.1.1.8 E.8 Heat Recovery Ratio (CORE)

Heat Recovery Ratio (CORE)	
KPI Description	Effectiveness of the heat recovery system. The KPI can be calculated as the percentage ratio of the total thermal energy output of the system (MWh) to the thermal energy recovered through a waste heat recovery technology (MWh). It should also be assessed as the total recovered thermal energy (in MWh).
KPI Owner	Alkmaar: **GA**;
KPI Formula	

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	$HRR = \frac{TE_{recovered}}{TE_{output}} \cdot 100$ TE_{output} = Thermal energy output of the system $TE_{recovered}$ = Thermal energy (waste heat) recovered from the system The recovered waste heat should be calculated separately too (to assess Project Impact KPI) in units of MWh.						
Recommended Measurement Process and Data Sources	1. Data collection (e.g. from energy meters) 2. KPI calculation						
Recommended Evaluation Interval	Montlhy		Reporting to SCIS	*YES*		*NO*	X
Unit of Measurement	%, MWh		Threshold Target Value	TBD			
Relevant Stakeholders	Energy Utilities	X	Spatial Scale of Evaluation	Building Level	X		
	Consumers (end-users)			Building Block Level (PEB)	X		
	Technology and Services Providers	X		District Level (PED)			
	Policy-making Bodies/Governance			City Level			
	Representative Citizen Groups						
	Citizen Ambassadors						
Type of Indicator	Output	X	Temporal Scale of Evaluation	In-project timeframe	X		
	Impact			End of project	X		
				Post-project			

ETT-reference	ETT#1	X	ETT#2	X	ETT#3		ETT#4			
IS-reference	IS-1.1		IS-1.2	X	IS-1.3	X	IS-2.1		IS-2.2	X
	IS-3.1		IS-3.2		IS-4.1		IS-4.2		IS-4.3	

4.1.1.9 E.9 Integrated Building Management Systems in Buildings (CORE)

Integrated Building Management Systems in Buildings (CORE)	
KPI Description	Number of buildings using integrated ICT systems to automate building management and create flexible, effective, comfortable and secure environments. This indicator intends to give an overview of the level of BMS integration. ICT systems include building management, communication, and control systems for parameters like energy, water, etc. Buildings with ICT systems have the capacity to provide citizens with a secure living and working environment by ensuring aspects like energy efficiency are maintained at acceptable levels. Additionally, such buildings also account for the dynamic utilization of building space based on need and availability. Smart buildings can significantly reduce energy consumption and facilitate cost saving; offer comfort to inhabitants, ensure safety, protect health and improve the quality of life especially of elderly or disabled people.
KPI Owner	Evora: **EDPL**; SE Alkmaar: **GA**; ALI
KPI Formula	The indicator can be quantified by means of Number of buildings using integrated ICT systems in the area. Alternatively, the following percentages can be calculated:

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	$\frac{Floor\ area\ of\ buildings\ using\ ICT\ based\ BMS(m^2)}{Total\ floor\ area\ of\ buildings\ (m^2)} \cdot 100\%$ (Number of buildings using integrated ICT systems/ number of all buildings)*100%								
Recommended Measurement Process and Data Sources	Step 1: Data collection. Step 2: KPI Calculation. Data should be collected from the municipality. Data can be obtained from the department of urban planning or city buildings councils or associations. This information can be gathered from: (i) buildings registry of the city; and (ii) smart buildings programs. To be assessed per sector; residential, industrial, etc.								
Recommended Evaluation Interval	Once;		**Reporting to SCIS**	*YES*		*NO*	X		
Unit of Measurement	#; %		**Threshold Target Value**	TBD					
Relevant Stakeholders	Energy Utilities	X	**Spatial Scale of Evaluation**	Building Level	X				
	Consumers (end-users)	X		Building Block Level (PEB)	X				
	Technology and Services Providers	X		District Level (PED)	X				
	Policy-making Bodies/Governance	X		City Level	X				
	Representative Citizen Groups								
	Citizen Ambassadors								
Type of Indicator	Output		**Temporal Scale of Evaluation**	In-project timeframe (short-term)					
	Impact	X		End of project (mid-term)	X				
				Post-project (long-term)					
ETT-reference	ETT#1	X	ETT#2	X	ETT#3		ETT#4		
IS-reference	IS-1.1	X	IS-1.2		IS-1.3		IS-2.1	X	IS-2.2	X
	IS-3.1		IS-3.2		IS-4.1		IS-4.2		IS-4.3	

4.1.1.10 E.10 Percentage of buildings in the city with smart energy meters (CORE)

Percentage of buildings in the city with smart energy meters (CORE)	
KPI Description	A smart energy meter shall refer to an energy meter that includes real-time digital displays or that is available through a real-time online application, so a customer can better understand their energy usage. Also, a smart energy meter can digitally send meter readings to an energy supplier for more accurate energy bills, and for better planning and conservation of energy by providers. These can include electricity, heating etc. Smart energy meters record and display the consumption of energy in real time. Smart meter data can be sent to a central location wirelessly, thus providing energy providers with the means to understand how and when power is being used to better plan and conserve energy. Also, smart meter data help consumers better understand and monitor energy usage.
KPI Owner	Evora: **EDPL**; CME Alkmaar: **GA**; ALI

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KPI Formula	The indicator can be quantified by means of Number of buildings using smart energy meters in the area. Also, as the following percentage: $\frac{Number\ of\ buildings\ in\ the\ area/city\ with\ smart\ energy\ meters}{Total\ number\ of\ buildings\ in\ the\ area/city} \cdot 100\%$				
Recommended Measurement Process and Data Sources	Data for public and commercial and industrial buildings shall be included and listed individually. Data should be sourced from local or regional energy providers, or the municipality e.g. LH managers or city departments that have data on local smart energy meters.				
Recommended Monitoring Interval	yearly		**Reporting to SCIS**	*YES* /	*NO* / X
Unit of Measurement	#; %		**Threshold Target Value**	TBD	
Relevant Stakeholders	Energy Utilities	X	**Spatial Scale of Evaluation**	Building Level	X
	Consumers (end-users)			Building Block Level (PEB)	X
	Technology and Services Providers	X		District Level (PED)	X
	Policy-making Bodies/Governance	X		City Level	X
	Representative Citizen Groups				
	Citizen Ambassadors				
Type of Indicator	Output	X	**Temporal Scale of Evaluation**	In-project timeframe (short-term)	X
	Impact			End of project (mid-term)	X

ETT-reference	ETT#1	X	ETT#2	X	ETT#3	X	ETT#4		
IS-reference	IS-1.1	X	IS-1.2	X	IS-1.3		IS-2.1		IS-2.2
	IS-3.1		IS-3.2		IS-4.1		IS-4.2		IS-4.3

4.1.1.11 E.11 Specific Yield (SUPPORTING)

Specific Yield (SUPPORTING)	
KPI Description	Metered output energy of a supply system related to the size (capacity) of the system The specific yield is the calculated or metered output energy of a supply system related to the size (capacity) of the system. It is often provided as an annual or monthly value - for more refined evaluation a higher resolution is adequate. All energy supply units have a peak power load, heat exchangers all have a surface area, and so these are taken as the related size of the system. The system size is either described by the surface area (e.g. collector area of solar thermal systems) or the peak power (e.g. electrical power of a wind turbine).
KPI Owner	Evora: **EDPL;** CME (plus relevant partners with energy systems) Alkmaar: **GA**; ALI (plus relevant partners with energy systems)
KPI Formula	$FEc = \frac{E_{out}}{S_{size}}$ E_{out} = Output energy of supply system S_{size} = Size (capacity) of supply system

Recommended Measurement Process and Data Sources	1. Data collection (from energy meters) 3. KPI calculation											
Recommended Evaluation Interval	Monthly; yearly					Reporting to SCIS	YES		NO	X		
Unit of Measurement	W/kWp; W/m2					Threshold Target Value	TBD					
Relevant Stakeholders	Energy Utilities				X	Spatial Scale of Evaluation	Building Level					X
	Consumers (end-users)						Building Block Level (PEB)					X
	Technology and Services Providers				X		District Level (PED)					X
	Policy-making Bodies/Governance						City Level					
	Representative Citizen Groups											
	Citizen Ambassadors											
Type of Indicator	Output				X	Temporal Scale of Evaluation	In-project timeframe					
	Impact						End of project					X
							Post-project					
ETT-reference	ETT#1	X	ETT#2	X	ETT#3	X	ETT#4					
IS-reference	IS-1.1	X	IS-1.2	X	IS-1.3		IS-2.1	X	IS-2.2	X		
	IS-3.1	X	IS-3.2	X	IS-4.1		IS-4.2		IS-4.3			

4.1.1.12 E.12 Storage Energy Losses (SUPPORTING)

Storage Energy Losses (SUPPORTING)							
KPI Description	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.						
KPI Owner	Evora: **EDPL**; CME; Alkmaar: **ALI**; GA;						
KPI Formula	$$SEL = \frac{E_{input} - E_{output}}{E_{input}} \cdot 100$$ E_{input} = the energy input in a piece of energy storage equipment E_{output} = the energy output of a piece of energy storage equipment						
Recommended Measurement Process and Data Sources	1. Data collection 2. KPI calculation Sources from energy utilities and relevant stakeholders						
Recommended Evaluation Interval	Yearly		Reporting to SCIS	YES		NO	X
Unit of Measurement	%		Threshold Target Value	TBD			
Relevant	Energy Utilities	X		Building Level			X

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Stakeholders	Consumers (end-users)		Spatial Scale of Evaluation	Building Block Level (PEB)	X
	Technology and Services Providers	X		District Level (PED)	X
	Policy-making Bodies/Governance			City Level	
	Representative Citizen Groups				
	Citizen Ambassadors				
Type of Indicator	Output	X	Temporal Scale of Evaluation	In-project timeframe	X
	Impact			End of project	X
				Post-project	X

ETT-reference	ETT#1	X	ETT#2	X	ETT#3	X	ETT#4			
IS-reference	IS-1.1	X	IS-1.2		IS-1.3		IS-2.1	X	IS-2.2	X
	IS-3.1	X	IS-3.2		IS-4.1		IS-4.2		IS-4.3	

4.1.1.13 E.13 Thermal Load Reduction (SUPPORTING)

Thermal Load Reduction (SUPPORTING)						
KPI Description	Reduction of heating/cooling load caused by envelope insulation in specific thermal zone.					
KPI Owner (data provider)	Alkmaar: **GA**; DBL					
KPI Formula	$\Phi = U_{Envelope} \times A_{Envelope} \times (T_{Indoor} - T_{Outdoor})$ $$\Phi = U_{env} \times A_{env} \times (T_{in} - T_{out})$$ Φ = heat flow rate [W] U_{env} = thermal transmittance of thermal envelope[W/(m2·K)] T_{in}=indoors temperature T_{out}=outdoors temperature A_{env} =area of thermal envelope [m2]					
Recommended Measurement Process and Data Sources	1. Data collection (Thermal transmittances of most walls and roofs can be calculated using ISO 6946, unless there is metal bridging the insulation in which case it can be calculated using ISO 10211. For most ground floors it can be calculated using ISO 13370. For most windows the thermal transmittance can be calculated using ISO 10077 or ISO 15099. These data should be provided mostly by tech providers in case of glass technology) 2. KPI calculation					
Recommended Evaluation Interval	yearly		Reporting to SCIS	*YES*		*NO* X
Unit of Measurement	W		Threshold Target Value	TBD		
Relevant Stakeholders	Energy Utilities		Spatial Scale of Evaluation	Building Level	X	
	Consumers (end-users)	X		Building Block Level (PEB)		
	Technology and Services Providers	X		District Level (PED)		
	Policy-making Bodies/Governance			City Level		
	Representative Citizen Groups					
	Citizen Ambassadors					
	Output	X		In-project timeframe		

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Type of Indicator	Impact		Temporal Scale of Evaluation	End of project	X
				Post-project	

ETT-reference	ETT#1	X	ETT#2		ETT#3		ETT#4			
IS-reference	IS-1.1	X	IS-1.2		IS-1.3		IS-2.1		IS-2.2	
	IS-3.1		IS-3.2		IS-4.1		IS-4.2		IS-4.3	

4.1.1.14 E.14 Peak load reduction (SUPPORTING)

Peak Load Reduction (SUPPORTING)							
KPI Description	Comparing the peak demand before the implementation (baseline) with the peak demand after the 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 and therefore reduce the dimensioning of the supply system. In SCIS, the indicator is used to analyze the maximum power demand of a system in comparison with the average power.						
KPI Owner	Evora: **EDPL**; CME Alkmaar: **GA**; ALI						
KPI Formula	$$PL_{REDUCTION} = \left(1 - \frac{P_{peak,R\&I}}{P_{BaU}}\right) * 100$$ $P_{peak,R\&I}$: Peak load after the implementation P_{BaU}: Peak load before the implementation (baseline)						
Recommended Measurement Process and Data Sources	1. Data collection (e.g. from energy meters) 2. KPI calculation						
Recommended Monitoring Interval	Hourly (peak demand/load needs a fine interval of monitoring to avoid averaging out peaks).		Reporting to SCIS	*YES*	*X* (SCIS KPI 2.4.4)	*NO*	
Unit of Measurement	%		Threshold Target Value	TBD			
Relevant Stakeholders	Energy Utilities	X	Spatial Scale of Evaluation	Building Level			X
	Consumers (end-users)			Building Block Level (PEB)			X
	Technology and Services Providers	X		District Level (PED)			
	Policy-making Bodies/Governance			City Level			
	Representative Citizen Groups						
	Citizen Ambassadors						
Type of Indicator	Output	X	Temporal Scale of Evaluation	In-project timeframe			X
	Impact			End of project			X
				Post-project			

ETT-reference	ETT#1	X	ETT#2	X	ETT#3	X	ETT#4			
IS-reference	IS-1.1	X	IS-1.2	X	IS-1.3		IS-2.1	X	IS-2.2	
	IS-3.1	X	IS-3.2		IS-4.1		IS-4.2		IS-4.3	

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4.1.1.15 E.15 Percentage of street lighting managed by a light performance management system (SUPPORTING)

Percentage of street lighting managed by a light performance management system (SUPPORTING)							
KPI Description	A light performance management system shall be able to monitor light points, set schedules for switching off/on and adjust light levels by dimming. This means a light point can be changed individually and remotely with an ICT-based system, which is connected via a communication network to the light points. This system shall also be able to accurately measure the electrical energy consumed by the light point and indicate via the ICT-based system to the operator any occurring failure affecting the light performance of the light point. Remotely managed light points contribute to higher energy efficiency and can be optimised and adapted to switch on and off and to dim in any area of the city. Also, remotely managed lights can potentially improve safety in the city, where any failure of a light point which leads to insufficiently illuminated streets can be immediately monitored and localized to ensure fast repair. Lastly, real energy consumption per light point can be measured and reported accurately with the light management system, to better monitor energy cost and CO2 reduction schemes.						
KPI Owner	Evora: **CME**; Alkmaar: **GA**;						
KPI Formula	The percentage of street lighting managed by a light performance management system shall be calculated as: $\frac{\#\text{ of light points controlled by a light performance management system}}{\#\text{ of total light points in the city}} \cdot 100\%$						
Recommended Measurement Process and Data Sources	Step 1: Data collection Step 2: KPI Calculation. Data should be sourced from municipality and city departments responsible for street lighting inventory and streetlight management. Could be derived from project documentation or interviews with project leader and LH managers.						
Recommended Evaluation Interval	Once		Reporting to SCIS	*YES*		*NO*	X
Unit of Measurement	%		Threshold Target Value	TBD			
Relevant Stakeholders	Energy Utilities		Spatial Scale of Evaluation	Building Level			
	Consumers (end-users)			Building Block Level (PEB)			
	Technology and Services Providers	X		District Level (PED)	X		
	Policy-making Bodies/Governance	X		City Level	X		
	Representative Citizen Groups						
	Citizen Ambassadors						
Type of Indicator	Output	X	Temporal Scale of Evaluation	In-project timeframe			
	Impact			End of project	X		
				Post-project			

ETT-reference	ETT#1	X	ETT#2		ETT#3	X	ETT#4	

IS-reference	IS-1.1		IS-1.2	X	IS-1.3		IS-2.1		IS-2.2	
	IS-3.1	X	IS-3.2		IS-4.1		IS-4.2		IS-4.3	

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4.2 KPIs in Environmental Dimension

4.2.1.1 EN.1 Greenhouse Gas Emissions (CORE)

<table>
<tr><th colspan="8">Greenhouse Gas Emissions (CORE)</th></tr>
<tr><td>KPI Description</td><td colspan="7">The greenhouse gas, particulate matter, NOx and SO2 emissions of a system correspond to the emissions that are caused by different areas of application. In different variants of this indicator the emissions caused by the production of the system components are included or excluded. SCIS only excludes these emissions. To enable the comparability between systems, the emissions can be related to the size of the system (e.g. gross floor area or net floor area, heated floor area) and the considered interval of time (e.g. month, year). The greenhouse gases are considered as unit of mass (tones, kg.) of CO2 or CO2 equivalents.</td></tr>
<tr><td>KPI Owner</td><td colspan="7">Evora: EDPL; PACT; SONAE; UNINOVA (sensors to be installed)

Alkmaar: GA; Inholland; Woonwaard; Van Alckmaer; HVC; ALI</td></tr>
<tr><td>KPI Formula</td><td colspan="7"><u>Building Level</u>:
$$GGE = \frac{TE_C \times GEF_T + EE_C \times GEF_E}{A_b}$$
GGE = Greenhouse gas emissions for building
TE_C = Thermal energy consumption (monitored) of the demonstration site [kWh/(month); kWh/ (year)]
EE_C = Electrical energy consumption (monitored) of the demonstration site [kWh/(month); kWh/ (year)]
GEF_T = Greenhouse gas emission factor for thermal energy (weighted average based on thermal energy production source/fuel mix) (kg CO_{2eq}/kWh consumed)
GEF_E = Greenhouse gas emission factor for electrical energy (weighted average based on electricity production source/fuel mix) (kg CO_{2eq}/kWh consumed)
A_b = Floor area of the building [m^2]
Different spatial scales of evaluation (Building, PEB, PED, City level) can be assessed by adding up the energy carriers per respective level. To enable the comparability between systems, the emissions can be related to the size of the system (e.g. gross floor area or net floor area, heated floor area) and the considered interval of time (e.g. month, year). A breakdown of buildings and transportation emissions is also highly suggested.
Results should also be compared to a baseline to extract the respective reduction (%) of energy consumption related GHG emissions emitted within PEBs.</td></tr>
<tr><td>Recommended Measurement Process and Data Sources</td><td colspan="7">1. Data collection→2. KPI calculation.
Relevant data can be extracted from LHs SEAP/SECAP. The updated default emission factors for fossil fuel combustion, RES, electricity by country as described in ANNEX I of the Covenant of Mayors for Climate and Energy Reporting Guidelines can be applied: https://www.covenantofmayors.eu/IMG/pdf/Covenant_ReportingGuidelines.pdf</td></tr>
<tr><td>Recommended Monitoring Interval</td><td colspan="2">Yearly
Note: Baseline Estimations are needed</td><td>Reporting to SCIS</td><td>YES</td><td>X (SCIS KPI 2.2.1)</td><td>NO</td><td></td></tr>
<tr><td>Unit of Measurement</td><td colspan="2">kg CO_{2eq}/(m^2*year), kg CO_{2eq}/(kWh*year), %</td><td>Threshold Target Value</td><td colspan="4">TBD</td></tr>
<tr><td rowspan="4">Relevant Stakeholders</td><td>Energy Utilities</td><td>X</td><td rowspan="4">Spatial Scale of Evaluation</td><td colspan="3">Building Level</td><td>X</td></tr>
<tr><td>Consumers (end-users)</td><td>X</td><td colspan="3">Building Block Level (PEB)</td><td>X</td></tr>
<tr><td>Technology and Services Providers</td><td>X</td><td colspan="3">District Level (PED)</td><td>X</td></tr>
<tr><td>Policy-making Bodies/Governance</td><td>X</td><td colspan="3">City Level</td><td>X</td></tr>
</table>

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	Representative Citizen Groups				
	Citizen Ambassadors				
Type of Indicator	Output		Temporal Scale of Evaluation	In-project timeframe	X
	Impact	X		End of project	X
				Post-project	X

ETT-reference	ETT#1	X	ETT#2	X	ETT#3	X	ETT#4			
IS-reference	IS-1.1	X	IS-1.2	X	IS-1.3		IS-2.1	X	IS-2.2	X
	IS-3.1	X	IS-3.2	X	IS-4.1		IS-4.2		IS-4.3	

4.2.1.2 EN.2 Carbon Dioxide Emission Reduction (CORE)

Carbon Dioxide Emission Reduction (CORE)	
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 (CO2), methane (CH4), nitrous oxide (N2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and Sulphur hexafluoride (SF6) (ISI/DIS 37120, 2013). The warming potential for these gases varies from several years to decades to centuries. CO2 accounts for a major share of Green House Gas emissions in urban areas. The main sources for CO2 emissions are combustion processes related to energy generation and transport. CO2 emissions can therefore be considered a useful indicator to assess the contribution of urban development on climate change.
KPI Owner	Evora: **CME**; PACT; SONAE; EDPL Alkmaar: **GA**; Inholland; Woonwaard; Van Alckmaer; HVC; ALI
KPI Formula	The emitted mass of CO_2 is calculated from the delivered and exported energy for each energy carrier: $$m_{CO_2} = \sum (E_{del,i} K_{del,i}) - \sum (E_{exp,i} K_{exp,i})$$ $E_{del,i}$ = the delivered energy for energy carrier i $E_{exp,i}$ = the exported energy for energy carrier i $K_{del,i}$ = the CO_2 coefficient for delivered energy carrier i $K_{exp,i}$ = the CO_2 coefficient for exported energy carrier i The indicator is calculated as the direct (operational) reduction of the CO_2 emissions over a period of time. The result may be expressed as a percentage when divided by the reference CO_2 emissions. To calculate the direct CO_2 emissions, the total energy reduced, can be translated to CO_2 emission figures by using conversion factors for different energy forms as described in the tables below: National and European emission factors for consumed electricity (source: Covenant of Mayors).

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National and European emission factors for

Country	Standard emission factor (t CO_2/MWh_e)
Austria	0.209
Belgium	0.285
Germany	0.624
Denmark	0.461
Spain	0.440
Finland	0.216
France	0.056
United Kingdom	0.543
Greece	1.149
Ireland	0.732
Italy	0.483
Netherlands	0.435
Portugal	0.369
Sweden	0.023
Bulgaria	0.819
Cyprus	0.874
Czech Republic	0.950
Estonia	0.908
Hungary	0.566
Lithuania	0.153
Latvia	0.109
Poland	1.191
Romania	0.701
Slovenia	0.557
Slovakia	0.252
EU-27	**0.460**

Standard CO2 emission factors (from IPCC, 2006) and CO2-equivalent LCA emission factors (from ELCD) for most common fuel types

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

a Lower value if wood is harvested in a sustainable manner, higher if harvesting is unsustainable.
b The figure reflects the production and local/regional transport of wood, representative for Germany, assuming: spruce log with bark; reforested managed forest; production mix entry to saw mill, at plant; and 44% water content. The local authority using this emission factor is recommended to check that it is representative for the local circumstances and to develop an own emission factor if the circumstances are different.

Recommended Measurement Process and Data Sources	1. Data collection→2. KPI calculation The updated default emission factors for fossil fuel combustion, RES, electricity by country as described in ANNEX I of the Covenant of Mayors for Climate and Energy Reporting Guidelines can be applied: https://www.covenantofmayors.eu/IMG/pdf/Covenant_ReportingGuidelines.pdf

Recommended Evaluation Interval	Yearly *Note: Baseline Estimations are needed*	**Reporting to SCIS**	*YES*	X (SCIS KPI 2.2.3)	*NO*	
Unit of Measurement	*tons/year, tons/capita/year, %*	**Threshold Target Value**				

Relevant Stakeholders	Energy Utilities	X	**Spatial Scale of Evaluation**	Building Level	X
	Consumers (end-users)	X		Building Block Level (PEB)	X
	Technology and Services Providers	X		District Level (PED)	X
	Policy-making Bodies/Governance	X		City Level	X
	Representative Citizen Groups				
	Citizen Ambassadors				
Type of Indicator	Output		**Temporal Scale of Evaluation**	In-project timeframe	X
	Impact	X		End of project	X
				Post-project	X

ETT-reference	ETT#1	X	ETT#2	X	ETT#3	X	ETT#4			
IS-reference	IS-1.1	X	IS-1.2	X	IS-1.3		IS-2.1	X	IS-2.2	X
	IS-3.1	X	IS-3.2	X	IS-4.1		IS-4.2		IS-4.3	

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4.2.1.3 *EN.3 Air Quality Index (SUPPORTING)*

<table>
<tr><th colspan="2">Air Quality Index (SUPPORTING)</th></tr>
<tr><td>KPI Description</td><td>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. Air quality is expressed in the concentration of major air pollutants. At this moment from a human health perspective most important are particulates (PM_{10}, $PM_{2.5}$), NO_2 (as indicator of traffic related air pollution) and ozone (important for summer smog). The concentration levels of these pollutants together define the air quality.
For the EU, the CiteAir Project has defined hourly, daily and yearly indices to express in one figure air quality (http://www.airqualitynow.eu/index.php). For this indicator the annual average air quality index suggested by CITYkeys Project is suggested. It is a distance to target indicator that provides a relative measure of the annual average air quality in relation to the European limit values (annual air quality standards and objectives from EU directives). If the index is higher than 1: for one or more pollutants the limit values are not met. If the index is below 1: on average the limit values are met.</td></tr>
<tr><td>KPI Owner</td><td>Evora: CME; UNINOVA

Alkmaar: GA</td></tr>
<tr><td>KPI Formula</td><td>For each pollutant a sub-index is calculated according to the scheme below:
<table>
<tr><td>Pollutant</td><td>Target value / limit value</td><td>Subindex calculation</td></tr>
<tr><td>NO_2</td><td>Year average is 40 µg/m^3</td><td>Year average / 40</td></tr>
<tr><td>PM_{10}</td><td>Year average is 40 µg/m^3</td><td>Year average / 40</td></tr>
<tr><td>$PM_{10daily}$</td><td>Max. number of daily averages above 50 µg/m^3 is 35 days</td><td>Log(number of days+1) / Log(36)</td></tr>
<tr><td>Ozone</td><td>25 days with an 8-hour average value ≥ 120 µg/m^3</td><td># days with 8-hour average ≥ 120 / 25</td></tr>
<tr><td>SO_2</td><td>Year average is 20 µg/m^3</td><td>Year average / 20</td></tr>
<tr><td>Benzene</td><td>Year average is 5 µg/m^3</td><td>Year average / 5</td></tr>
</table>
The overall city index is the average of the sub-indices for NO_2, PM_{10} (both year average and the number of days ≥50 µg/m^3 sub-index) and ozone for the city background index. For the traffic year average index, the averages of the sub-indices for NO_2 and PM_{10} (both) are being used. The other pollutants (including $PM_{2.5}$) are used in the presentation of the city index if data are available, but do not enter the calculation of the city average index. They are treated as additional pollutants like in the hourly and daily indices. The main reason is that not every city is monitoring this full range of pollutants.</td></tr>
</table>

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	Note#1: Potential users of the CAQI must notify the CITEAIR partners (at caqi@airqualitynow.eu) and establish a user agreement. This way, users can be kept informed in case of further developments concerning the index. The use of the CAQI is free of charge for non-commercial purposes (www.airqualitynow.eu/about_copyright.php#legal_agreement). **Note#2: In the case of POCITYF, Nitrogen oxides reduction and Sulfur dioxide reduction due to increased e-mobility, should be measured and reported as imposed by GA - Section 2 - Impact. The specific KPI should be adapted, if deemed necessary, to reflect the needs and capacities of the two LH cities.**						
Recommended Measurement Process and Data Sources	1. Data collection→2. KPI calculation. Concentrations are measured by monitoring equipment and reported to air quality monitoring authority (i.e., City Environment Office, National Environment Office, etc.). Many cities use a local or national variant of an air quality index, which can replace this indicator (but loosing EU comparability). Most pollutants are measured continuously in EU member states. See: http://www.airqualitynow.eu/comparing_home.php						
Recommended Monitoring Interval	Daily, Yearly *Note: Baseline Estimations are needed*		Reporting to SCIS	*YES*		*NO*	X
Unit of Measurement	Index (no unit) tons NO_X/year tons SO_2/year		Threshold Target Value	TBD			
Relevant Stakeholders	Energy Utilities		Spatial Scale of Evaluation	Building Level			
	Consumers (end-users)			Building Block Level (PEB)			
	Technology and Services Providers			District Level (PED)			
	Policy-making Bodies/Governance	X		City Level			X
	Representative Citizen Groups						
	Citizen Ambassadors						
Type of Indicator	Output		Temporal Scale of Evaluation	In-project timeframe			X
	Impact	X		End of project			X
				Post-project			X

ETT-reference	ETT#1	X	ETT#2	X	ETT#3	X	ETT#4			
IS-reference	IS-1.1	X	IS-1.2	X	IS-1.3	X	IS-2.1	X	IS-2.2	X
	IS-3.1	X	IS-3.2	X	IS-4.1		IS-4.2		IS-4.3	

4.2.1.4 EN.4 Primary Energy Demand and Consumption (SUPPORTING)

Primary Energy Demand and Consumption (SUPPORTING)	
KPI Description	The primary energy demand/consumption of a system encompasses all the naturally available energy that is consumed in the supply chain of the used energy carriers. To enable the comparability between systems, the total primary energy demand/consumption can be related to the size of the system (e.g. conditioned area) and the considered time interval (e.g. month, year). Demand is defined here as "designed consumption". Consumption is actual/monitored energy consumption.
KPI Owner	Evora: **CME**; Alkmaar: **GA**;
KPI Formula	*Building Level*:

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$$PE_d = \frac{TE_d \times PEF_T + EE_d \times PEF_E}{A_b}$$

PE_d = Primary energy demand (simulated)
TE_d = Thermal energy demand (simulated) [kWh/(month); kWh/(year)]
EE_d = Electrical energy demand (simulated) [kWh/(month); kWh/(year)]
PEF_T = Primary energy factor for thermal energy (weighted average based on source/fuel mix in production)
PEF_E = Primary energy factor for electrical energy (weighted average based on source/fuel mix in production)
A_b = Floor area of the building [m^2]

$$PE_c = \frac{TE_c \times PEF_T + EE_c \times PEF_E}{A_b}$$

PE_c = Primary energy consumption (monitored)
TE_c = Thermal energy consumption (monitored) [kWh/(month); kWh/(year)]
EE_c = Electrical energy consumption (monitored) [kWh/(month); kWh/(year)]
PEF_T = Primary energy factor for thermal energy (weighted average based on source/fuel mix in production)
PEF_E = Primary energy factor for electrical energy (weighted average based on source/fuel mix in production)
A_b = Floor area of the building [m^2]

PEB/District/City Level:

$$PE_{block-district-city/\,primary\ demand} = \sum PE_d$$

$$PE_{block-district-city\ primary\ consumption} = \sum PE_c$$

Recommended Measurement Process and Data Sources	1. Simulation→2. Data collection→3. KPI calculation. The calculation of the respective primary energy demand/consumption can be estimated with the application of default primary energy factors. According to Annex IV of the Directive 2012/27/EU a default coefficient of 2.5 can be applied for savings in kWh of electricity, whereas the respective value for fossil fuels can be taken as 1.1. Owners of this KPI may select the most appropriate means for simulation and data collection as well as local primary energy factors for if deemed necessary. Evaluation on a city scale is not a requisite within the project timeframe but is highly recommended.					
Recommended Monitoring Interval	Monthly, Yearly *Note: Baseline Estimations are needed*		**Reporting to SCIS**	*YES*	X (SCIS KPI 2.2.2)	*NO*
Unit of Measurement	kWh/(m^2*month; year)		**Threshold Target Value**	TBD		
Relevant Stakeholders	Energy Utilities	X	**Spatial Scale of Evaluation**	Building Level	X	
	Consumers (end-users)	X		Building Block Level (PEB)	X	
	Technology and Services Providers	X		District Level (PED)	X	
	Policy-making Bodies/Governance	X		City Level	X	
	Representative Citizen Groups					
	Citizen Ambassadors					
Type of Indicator	Output		**Temporal Scale of Evaluation**	In-project timeframe	X	
	Impact	X		End of project	X	
				Post-project	X	

ETT-reference	ETT#1	X	ETT#2	X	ETT#3		ETT#4			
IS-reference	IS-1.1	X	IS-1.2	X	IS-1.3		IS-2.1	X	IS-2.2	X
	IS-3.1		IS-3.2		IS-4.1		IS-4.2		IS-4.3	

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4.2.1.5 EN.5 Climate Resilience Strategy (SUPPORTING)

Climate Resilience Strategy (SUPPORTING)												
KPI Description	Urban areas in Europe and worldwide are increasingly experiencing the pressures arising from climate change and are projected to face aggravated climate-related impacts in the future. Cities and towns play a significant role in adapting to climate change in the EU. Several cities and towns across Europe are already pioneering adaptation actions and many others are taking first steps to ensure that European cities remain safe, liveable and attractive centres for innovation, economic activities, culture and social life. This indicator assesses to what extent the city has a resilience strategy and action plan.											
KPI Owner	Evora: **CME**; DECSIS Alkmaar: **GA**; SEV											
KPI Formula	The indicator provides a qualitative measure and is rated on a seven-point Likert scale. This Likert scale is based on the steps suggested by the "Mayors adapt" initiative for climate change adaptation in urban areas: *No action taken - 1 — 2 — 3 — 4 — 5 — 6 - 7 - implementation, monitoring and evaluation on the way* 1. No action has been taken yet; 2. The ground for adaptation has been prepared (the basis for a successful adaptation process); 3. Risks and vulnerabilities have been assessed; 4. Adaptation options have been identified; 5. Adaptation options have been selected; 6. Adaptation options are being implemented; 7. Monitoring and evaluation is being carried out. A specific reference to the implementation-monitoring of SEAP/SECAP should be made.											
Recommended Measurement Process and Data Sources	Record SEAP/SECAP plans and any other plans related to local sustainability. Relevant data can be extracted from project's documentation and interviews with the project leader, LH Managers and/or other stakeholders.											
Recommended Evaluation Interval	Yearly		Reporting to SCIS	*YES*		*NO*	X					
Unit of Measurement	Likert Scale (1-7)		Threshold Target Value	TBD								
Relevant Stakeholders	Energy Utilities		Spatial Scale of Evaluation	Building Level								
	Consumers (end-users)			Building Block Level (PEB)								
	Technology and Services Providers			District Level (PED)								
	Policy-making Bodies/Governance	X		City Level	X							
	Representative Citizen Groups	X										
	Citizen Ambassadors	X										
Type of Indicator	Output	X	Temporal Scale of Evaluation	In-project timeframe	X							
	Impact			End of project	X							
				Post-project								
ETT-reference	ETT#1		ETT#2		ETT#3		ETT#4	X				
IS-reference	IS-1.1		IS-1.2		IS-1.3		IS-2.1		IS-2.2			
	IS-3.1		IS-3.2		IS-4.1		IS-4.2	X	IS-4.3			

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4.2.1.6 EN.6 Noise Pollution (SUPPORTING)

Noise Pollution (SUPPORTING)							
KPI Description	Prolonged exposure to noise can lead to significant health effects. Urban environmental noise pollution relates a lot to noise caused by traffic. One of the advantages that EVs offer is the reduction of noise pollution. This KPI will measure the noise levels before and after the activities of the project.						
KPI Owner	Evora: **CME**; UNINOVA Alkmaar: **GA**						
KPI Formula	The indicator is measured in level of decibels (dB) whereas the respective reduction can be calculated as: ((dB level after – dB level before)/dB level before) * 100						
Recommended Measurement Process and Data Sources	1. Data collection→2. KPI calculation. The noise level should be measured (or modelled) at the object receiving the noise). Interviews may be conducted if deemed necessary.						
Recommended Monitoring Interval	Twice (before and after project implementation) *Note: Baseline Estimations are needed*		Reporting to SCIS	*YES*		*NO*	X
Unit of Measurement	*dB, %*		Threshold Target Value	TBD			
Relevant Stakeholders	Energy Utilities		Spatial Scale of Evaluation	Building Level			
	Consumers (end-users)	X		Building Block Level (PEB)			
	Technology and Services Providers			District Level (PED)			X
	Policy-making Bodies/Governance	X		City Level			X
	Representative Citizen Groups	X					
	Citizen Ambassadors	X					
Type of Indicator	Output		Temporal Scale of Evaluation	In-project timeframe			X
	Impact	X		End of project			X
				Post-project			

ETT-reference	ETT#1		ETT#2		ETT#3	X	ETT#4			
IS-reference	IS-1.1		IS-1.2		IS-1.3		IS-2.1		IS-2.2	
	IS-3.1	X	IS-3.2	X	IS-4.1		IS-4.2		IS-4.3	

4.2.1.7 EN.7 Municipal Solid Waste (SUPPORTING)

Municipal Solid Waste (SUPPORTING)	
KPI Description	The proper discharge, transportation and treatment of solid waste is one of the most important components of life in a city and one of the first areas in which governments and institutions should focus. Solid waste systems contribute in many ways to public health, the local economy, the environment, and the social understanding and education about the latter. A proper solid waste system can foster recycling practices that maximize the life cycle of landfills and create recycling micro-economies; and it provides alternative sources of energy that help reduce the consumption of electricity and/or petroleum-based fuels. This indicator provides a measure of how much waste a city is producing and the level of service a city is providing for its collection (ISO/DIS 37120, 2013). Municipal waste

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	shall refer to waste collected by or on behalf of municipalities. The data shall only refer to the waste flows managed under the responsibility of the local administration including waste collected on behalf of the local authority by private companies or regional associations founded for that purpose. Potential waste streams to be quantified under this KPI include among others: • Vegetables, fruit and garden waste (GFT) • Paper and cardboard • Plastic, metal and beverage cartons Each city should clearly define the waste streams to be included in the assessment according to its needs and its capacity.
KPI Owner	Evora: **CME**; UW Alkmaar: **GA**
KPI Formula	The total collected municipal solid waste per capita shall be expressed as the total municipal solid waste produced in the municipality per person. This indicator shall be calculated as the total amount of solid waste (household and commercial) generated in tons (numerator) divided by the total city population (denominator). The result shall be expressed as total municipal solid waste collected per capita in tons (ISO/DIS 37120, 2013). If possible, relevant values should be extracted on a district (demo) level.
Recommended Measurement Process and Data Sources	1. Data collection→2. KPI calculation. EU member countries are estimating their recycling rates and levels of municipal solid waste through measuring and model calculation methods. The urban audit database contains information on 'municipal waste generated (domestic and commercial)'. Local administration (e.g. environmental department, departments responsible for waste collection), private companies and regional associations could provide relevant data.

Recommended Monitoring Interval	Monthly, Yearly	Reporting to SCIS	*YES*		*NO*	X
Unit of Measurement	tons/capita/month;year	Threshold Target Value	TBD			

Relevant Stakeholders	Energy Utilities		Spatial Scale of Evaluation	Building Level	
	Consumers (end-users)			Building Block Level (PEB)	
	Technology and Services Providers	X		District Level (PED)	X
	Policy-making Bodies/Governance	X		City Level	X
	Representative Citizen Groups				
	Citizen Ambassadors				
Type of Indicator	Output	X	Temporal Scale of Evaluation	In-project timeframe	X
	Impact			End of project	X
				Post-project (long-term)	

ETT-reference	ETT#1	X	ETT#2		ETT#3		ETT#4	

IS-reference	IS-1.1		IS-1.2		IS-1.3	X	IS-2.1		IS-2.2	
	IS-3.1		IS-3.2		IS-4.1		IS-4.2		IS-4.3	

4.2.1.8 EN.8 Recycling Rate of Solid Waste (SUPPORTING)

Recycling Rate of Solid Waste (SUPPORTING)	
KPI Description	Many cities generate more solid waste than they can dispose of (ISO/DIS 37120, 2013). Even when municipal budgets are adequate for collection, the safe disposal of

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<table>
<tr><td></td><td colspan="7">collected waste often remains a problem. Diverting recyclable materials from the waste stream is one strategy for addressing this municipal issue. Higher levels of municipal waste contribute to greater environmental problems and therefore levels of collection, and also methods of disposal of municipal solid waste are an important component of municipal environmental management. Solid waste systems contribute in many ways to public health, the local economy, the environment, and the social understanding and education about the latter. A proper solid waste system can foster recycling practices that maximize the life cycle of landfills and create recycling microeconomies; and it provides alternative sources of energy that help reduce the consumption of electricity and/or petroleum-based fuels.</td></tr>
<tr><td>KPI Owner</td><td colspan="7">Evora: CME; UW

Alkmaar: GA</td></tr>
<tr><td>KPI Formula</td><td colspan="7">The percentage of city's solid waste that is recycled shall be calculated as the total amount of the city’s solid waste that is recycled in tons (numerator) divided by the total amount of solid waste produced in the city in tons (denominator). The result shall then be multiplied by 100 and expressed as a percentage (ISO/DIS 37120, 2013). Recycled materials shall denote those materials diverted from the waste stream, recovered, and processed into new products following local government permits and regulations. Hazardous waste that is produced in the city and is recycled shall be reported separately.</td></tr>
<tr><td>Recommended Measurement Process and Data Sources</td><td colspan="7">1. Data collection→2. KPI calculation.
This information can be obtained from municipal bodies, public services and major private contractors dealing with solid waste collection and disposal. Data may be obtained from specific studies carried out on solid waste for specific projects. Information on selected disposal methods should be gathered from municipal facilities and operators, parastatal and private companies dealing with solid waste treatment. Solid waste experts, as well as NGOs working in this area, may be consulted. If possible, relevant values should be extracted on a district (demo) level.</td></tr>
<tr><td>Recommended Monitoring Interval</td><td colspan="2">Yearly</td><td>Reporting to SCIS</td><td>YES</td><td></td><td>NO</td><td>X</td></tr>
<tr><td>Unit of Measurement</td><td colspan="2">%</td><td>Threshold Target Value</td><td colspan="4">TBD</td></tr>
<tr><td rowspan="6">Relevant Stakeholders</td><td>Energy Utilities</td><td></td><td rowspan="6">Spatial Scale of Evaluation</td><td colspan="3">Building Level</td><td></td></tr>
<tr><td>Consumers (end-users)</td><td></td><td colspan="3">Building Block Level (PEB)</td><td></td></tr>
<tr><td>Technology and Services Providers</td><td>X</td><td colspan="3">District Level (PED)</td><td>X</td></tr>
<tr><td>Policy-making Bodies/Governance</td><td>X</td><td colspan="3">City Level</td><td>X</td></tr>
<tr><td>Representative Citizen Groups</td><td></td><td colspan="3"></td><td></td></tr>
<tr><td>Citizen Ambassadors</td><td></td><td colspan="3"></td><td></td></tr>
<tr><td rowspan="3">Type of Indicator</td><td>Output</td><td>X</td><td rowspan="3">Temporal Scale of Evaluation</td><td colspan="3">In-project timeframe</td><td>X</td></tr>
<tr><td>Impact</td><td></td><td colspan="3">End of project</td><td>X</td></tr>
<tr><td></td><td></td><td colspan="3">Post-project</td><td></td></tr>
</table>

<table>
<tr><td>ETT-reference</td><td>ETT#1</td><td>X</td><td>ETT#2</td><td></td><td>ETT#3</td><td></td><td>ETT#4</td><td></td><td></td><td></td></tr>
<tr><td rowspan="2">IS-reference</td><td>IS-1.1</td><td></td><td>IS-1.2</td><td></td><td>IS-1.3</td><td>X</td><td>IS-2.1</td><td></td><td>IS-2.2</td><td></td></tr>
<tr><td>IS-3.1</td><td></td><td>IS-3.2</td><td></td><td>IS-4.1</td><td></td><td>IS-4.2</td><td></td><td>IS-4.3</td><td></td></tr>
</table>

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4.3 KPIs in Economic Dimensions

4.3.1.1 EC.1 Total Investments (CORE)

<table>
<tr><th colspan="8">Total Investments (CORE)</th></tr>
<tr><td>KPI Description</td><td colspan="7">An investment is defined as an asset or item that is purchased or implemented 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. (grants are not subtracted). To be in accordance with SCIS, for POCITYF, total investments apply to the energy aspects of the system (e.g. highly efficient envelope in a building) and exclude investments non-energy related (e.g. refurbishment of bathrooms).In order to be more meaningful and provide more added value, within POCITYF, a comparison with the investments for a business as usual case is provided.</td></tr>
<tr><td>KPI Owner</td><td colspan="7">Evora: CME; RINA-C

Alkmaar: GA; RINA-C</td></tr>
<tr><td>KPI Formula</td><td colspan="7">$$EPI_{BR} = \frac{I_{BR}}{A_d}$$
EPI_{BR} = Total investment for all the interventions related to energy aspects in the district per conditioned area [€/m^2] (subscript BR means building retrofitting)

I_{BR} = Total investment for all the interventions related to energy aspects [€]
A_d = Total floor area of the system renovated [m^2]
$$EPI_{ER} = \frac{I_{ER}}{A_d}$$
EPI_{ER} = Total investment for all the interventions related to energy retrofitting (in the district) per conditioned area [€/m^2] (subscript BR means building retrofitting)
I_{ER} = Total investment for all the interventions related to energy retrofitting [€]
A_d = Total floor area of the district renovated [m^2]

It is also suggested to report the total amount of investments [€]. For building solutions, it is recommended to consider also the share of investment for energy solution to the total investment of building retrofitting.</td></tr>
<tr><td>Recommended Measurement Process and Data Sources</td><td colspan="7">1. Data collection→2. KPI calculation.
This information can be obtained from municipal bodies, public services, owners of the demo buildings, energy utilities and major technology providers related to energy aspects/retrofitting. Data may be obtained from specific studies carried out for other projects.</td></tr>
<tr><td>Recommended Monitoring Interval</td><td colspan="2">Yearly</td><td>Reporting to SCIS</td><td>YES</td><td>X (SCIS KPI 2.3.1)</td><td>NO</td><td></td></tr>
<tr><td>Unit of Measurement</td><td colspan="2">€/m^2, € (total)</td><td>Threshold Target Value</td><td colspan="4">TBD</td></tr>
<tr><td rowspan="5">Relevant Stakeholders</td><td>Energy Utilities</td><td>X</td><td rowspan="5">Spatial Scale of Evaluation</td><td colspan="3">Building Level</td><td>X</td></tr>
<tr><td>Consumers (end-users)</td><td>X</td><td colspan="3">Building Block Level (PEB)</td><td>X</td></tr>
<tr><td>Technology and Services Providers</td><td>X</td><td colspan="3">District Level (PED)</td><td>X</td></tr>
<tr><td>Policy-making Bodies/Governance</td><td>X</td><td colspan="3">City Level</td><td>X</td></tr>
<tr><td>Representative Citizen Groups</td><td></td><td colspan="3"></td><td></td></tr>
</table>

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	Citizen Ambassadors				
Type of Indicator	Output	X	Temporal Scale of Evaluation	In-project timeframe	X
	Impact			End of project	X
				Post-project	X

ETT-reference	ETT#1	X	ETT#2	X	ETT#3	X	ETT#4	X		
IS-reference	IS-1.1	X	IS-1.2	X	IS-1.3	X	IS-2.1	X	IS-2.2	X
	IS-3.1	X	IS-3.2	X	IS-4.1	X	IS-4.2	X	IS-4.3	X

4.3.1.2 EC.2 Total Annual Costs (CORE)

Total Annual Costs (CORE)	
KPI Description	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, i.e. maintenance) 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.
KPI Owner	Evora: **CME**; Alkmaar: **GA**;
KPI Formula	$$TAC_i = C_E + C_{O\&M} + C_F$$ TAC_i = Total annual 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 applies [€/year]
Recommended Measurement Process and Data Sources	1. Data collection→2. Simulation (if needed) →3. KPI calculation. This information can be obtained from municipal bodies, public services, owners of the demo buildings, energy utilities and major technology providers participating in the project. Data may be obtained from specific studies carried out for other projects.

Recommended Monitoring Interval	Yearly		Reporting to SCIS	*YES*	X (SCIS KPI 2.3.3)	*NO*
Unit of Measurement	€/year		Threshold Target Value	TBD		
Relevant Stakeholders	Energy Utilities	X	Spatial Scale of Evaluation	Building Level	X	
	Consumers (end-users)	X		Building Block Level (PEB)	X	
	Technology and Services Providers	X		District Level (PED)	X	
	Policy-making Bodies/Governance			City Level	X	
	Representative Citizen Groups					

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Type of Indicator	Citizen Ambassadors		Temporal Scale of Evaluation		
	Output	X		In-project timeframe	X
	Impact			End of project	X
				Post-project	X

ETT-reference	ETT#1	X	ETT#2	X	ETT#3	X	ETT#4	X		
IS-reference	IS-1.1	X	IS-1.2	X	IS-1.3	X	IS-2.1	X	IS-2.2	X
	IS-3.1	X	IS-3.2	X	IS-4.1	X	IS-4.2	X	IS-4.3	X

4.3.1.3 EC.3 Payback Period (CORE)

Payback Period (CORE)						
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. Therefore sometimes decisions that are based on payback periods are not optimal and it is recommended to also consult other indicators.					
KPI Owner	Evora: **CME**; RINA-C Alkmaar: **GA**; RINA-C					
KPI Formula	Economic payback, EPP, type A static: $EPP = \frac{EPI_{BR}}{m}$ m can be calculated as average total annual costs (TAC) in use savings (€/year) $m = TAC_{before} - TAC_{after}$ Type B dynamic: $EPP = \frac{ln(m \cdot (1+i)) - ln(EPI_{BR} - EPI_{BR} \cdot (1+i) + m)}{ln(1+i)} - 1$ Type C dynamic with energy price increase rate: $EPP = \frac{ln(m \cdot (1+i)) - ln(EPI_{BR}(1+p) - EPI_{BR} \cdot (1+i) + (1+p)m)}{ln(1+i) - ln(1+p)} - 1$ EPI_{BR} (€) = Energy-related investment i (%) = Discount rate p (%) = Energy price increase rate i should be unequal to p					
Recommended Measurement Process and Data Sources	1. Data collection→2. Simulation (if needed) →3. KPI calculation. This information can be obtained from municipal bodies, public services, owners of the demo buildings, energy utilities and major technology providers participating in the project. Data may be obtained from specific studies carried out for other projects.					
Recommended Monitoring Interval	Once (during project implementation)	Reporting to SCIS	YES	X ((SCIS KPI 2.3.4)	NO	
Unit of Measurement	Years	Threshold Target Value	TBD			
Relevant	Energy Utilities	X		Building Level	X	

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Stakeholders	Consumers (end-users)	X	Spatial Scale of Evaluation	Building Block Level (PEB)	X
	Technology and Services Providers	X		District Level (PED)	X
	Policy-making Bodies/Governance			City Level	X
	Representative Citizen Groups				
	Citizen Ambassadors				
Type of Indicator	Output	X	Temporal Scale of Evaluation	In-project timeframe	X
	Impact			End of project	
				Post-project	

ETT-reference	ETT#1	X	ETT#2	X	ETT#3	X	ETT#4	X		
IS-reference	IS-1.1	X	IS-1.2	X	IS-1.3	X	IS-2.1	X	IS-2.2	X
	IS-3.1	X	IS-3.2	X	IS-4.1	X	IS-4.2	X	IS-4.3	X

4.3.1.4 EC.4 Return on Investment (ROI) (CORE)

Return on Investment (ROI) (CORE)						
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 Owner	Evora: **CME**; PACT; SONAE; EDPL Alkmaar: **GA**; Inholland; Woonwaard; Van Alckmaer; HVC; ALI					
KPI Formula	$$ROI_T = \frac{\sum_{t=1}^{T}\left(In_t - TAC_{after_t}\right) - (I_{BR} + I_{ER})}{I_{BR} + I_{ER}}$$ ROI_T = Return on Investment [%] In_t = Income in year t T = Duration of the economic analysis period: T=10, 15 and 20 Years, depending on the common practice area					
Recommended Measurement Process and Data Sources	1. Data collection→2. Simulation (if needed) →3. KPI calculation. This information can be obtained from municipal bodies, public services, owners of the demo buildings, energy utilities and major technology providers participating in the project. Data may be obtained from specific studies carried out for other projects.					
Recommended Monitoring Interval	Once (during project implementation)		Reporting to SCIS	*YES*	X (SCIS KPI 2.3.5)	*NO*
Unit of Measurement	%		Threshold Target Value	TBD		
Relevant Stakeholders	Energy Utilities	X	Spatial Scale of Evaluation	Building Level	X	
	Consumers (end-users)	X		Building Block Level (PEB)	X	
	Technology and Services Providers	X		District Level (PED)	X	
	Policy-making Bodies/Governance			City Level	X	
	Representative Citizen Groups					
	Citizen Ambassadors					
Type of Indicator	Output	X		In-project timeframe	X	
	Impact			End of project		

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			Temporal Scale of Evaluation	Post-project	

ETT-reference	ETT#1	X	ETT#2	X	ETT#3	X	ETT#4	X		
IS-reference	IS-1.1	X	IS-1.2	X	IS-1.3	X	IS-2.1	X	IS-2.2	X
	IS-3.1	X	IS-3.2	X	IS-4.1	X	IS-4.2	X	IS-4.3	X

4.3.1.5 EC.5 Average Electricity Price for Companies and Consumers (SUPPORTING)

Average Electricity Price for Companies and Consumers (SUPPORTING)							
KPI Description	The indicator represents the average minimum cost at which electricity must be sold in order to balance costs and profits. All DSOs' costs for network losses should be considered in the calculation. Providing customers with price forecasts in several grades of accuracy, potentially with price guarantees for short periods of time could be a new revenue stream. The customers have some security by knowing the electricity prices enabling the optimal scheduling of energy consuming equipment.						
KPI Owner	Evora: **EDPL** Alkmaar: **ALI**						
KPI Formula	Average price per kilowatt hour calculated during the evaluation period resulting in average price per year. The average electricity price should be measured for residential and non-residential sector.						
Recommended Measurement Process and Data Sources	1. Data collection→2. Simulation (if needed) →3. KPI calculation. Data should be sourced from the energy providers of the city ecosystems.						
Recommended Monitoring Interval	Monthly, Yearly		Reporting to SCIS	*YES*		*NO*	X
Unit of Measurement	€/kWh		Threshold Target Value	TBD			
Relevant Stakeholders	Energy Utilities	X	Spatial Scale of Evaluation	Building Level	X		
	Consumers (end-users)	X		Building Block Level (PEB)	X		
	Technology and Services Providers			District Level (PED)	X		
	Policy-making Bodies/Governance			City Level	X		
	Representative Citizen Groups						
	Citizen Ambassadors						
Type of Indicator	Output	X	Temporal Scale of Evaluation	In-project timeframe	X		
	Impact			End of project			
				Post-project			

ETT-reference	ETT#1	X	ETT#2	X	ETT#3	X	ETT#4			
IS-reference	IS-1.1	X	IS-1.2	X	IS-1.3		IS-2.1	X	IS-2.2	
	IS-3.1	X	IS-3.2		IS-4.1		IS-4.2		IS-4.3	

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4.3.1.6 EC.6 Percentage of the Total Distributed Energy Resources Capacity Traded (SUPPORTING)

Percentage of the Total Distributed Energy Resources Capacity Traded (SUPPORTING)					
KPI Description	This KPI measures the amount of Distributed Energy Resources (DERs) capacity traded as a percentage of the total DERs capacity available. DERs are all resources within the PEB which can contribute with power generation or flexible capacity (production and consumption) independently from the centralized energy grid. DERs makes use of solar PV, wind, hydro, thermal and other renewable energy generation sources. All DER form part of a PEB and contribute to a micro-grid or larger community grid and is traded and regulated within the grid. Total DER energy traded is assessed at building, PEB, PED and city level.				
KPI Owner	Evora: **EDPL**; CME; KIMATICA; ENERSIS Alkmaar: **ALI**; GA; TNO; ENERSIS				
KPI Formula	The percentage of DER capacity traded is calculated by dividing the total DER capacity traded by the total DER capacity (combined systems), by means of the following formula: $Percentage\ of\ DERs\ Capacity\ traded = \frac{DERs\ Capacity\ traded\ (kWh)}{Total\ DERs\ Capacity\ (kWh)} * 100\%$ Total DER capacity refers to traded and non-traded capacity.				
Recommended Measurement Process and Data Sources	1. Data collection→2. KPI calculation. Data to be captured at building level, where DER systems are implemented and aggregated to district level. Data should be obtained from the energy provider or the department of energy of the municipality.				
Recommended Monitoring Interval	Monthly, Yearly		Reporting to SCIS	*YES*	*NO* X
Unit of Measurement	%		Threshold Target Value	TBD	
Relevant Stakeholders	Energy Utilities	X	Spatial Scale of Evaluation	Building Level	X
	Consumers (end-users)	X		Building Block Level (PEB)	X
	Technology and Services Providers			District Level (PED)	X
	Policy-making Bodies/Governance	X		City Level	X
	Representative Citizen Groups				
	Citizen Ambassadors				
Type of Indicator	Output	X	Temporal Scale of Evaluation	In-project timeframe	X
	Impact			End of project	X
				Post-project	

ETT-reference	ETT#1	X	ETT#2	X	ETT#3	X	ETT#4	
IS-reference	IS-1.1	X	IS-1.2	X	IS-1.3		IS-2.1	X	IS-2.2	X
	IS-3.1	X	IS-3.2		IS-4.1		IS-4.2		IS-4.3	

4.3.1.7 EC.7 Local Job Creation (SUPPORTING)

Local Job Creation (SUPPORTING)	
KPI Description	One of the pillars of the smart city projects is to improve the economy by reducing costs and energy, but also by fostering the local economy and the local eco-systems. This indicator will assess the creation of direct jobs from the implementation and operation of the POCITYF solutions.

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KPI Owner	Evora: **CME,** DECSIS, PACT, SONAE; RINA-C Alkmaar: **GA;** RINA-C; SEV														
KPI Formula	Number of jobs created by the project.														
Recommended Measurement Process and Data Sources	1. Data collection→2. KPI calculation. Data can derive from project documentation or interviews with the project leader and/or statistical authorities. Additionally, average data (e.g. average ratio of new jobs per million of euros invested in the building sector) can be applied for estimations.														
Recommended Monitoring Interval	Once (in the end of the project)		Reporting to SCIS	*YES*		*NO*	X								
Unit of Measurement	# of jobs		Threshold Target Value	TBD											
Relevant Stakeholders	Energy Utilities	X	Spatial Scale of Evaluation	Building Level											
	Consumers (end-users)			Building Block Level (PEB)											
	Technology and Services Providers	X		District Level (PED)	X										
	Policy-making Bodies/Governance	X		City Level											
	Representative Citizen Groups														
	Citizen Ambassadors														
Type of Indicator	Output		Temporal Scale of Evaluation	In-project timeframe											
	Impact	X		End of project (mid-term)	X										
				Post-project (long-term)	X										
ETT-reference	ETT#1	X	ETT#2	X	ETT#3	X	ETT#4	X							
IS-reference	IS-1.1	X	IS-1.2	X	IS-1.3	X	IS-2.1	X	IS-2.2	X					
	IS-3.1	X	IS-3.2	X	IS-4.1	X	IS-4.2	X	IS-4.3	X					

4.3.1.8 EC.8 Energy Poverty (SUPPORTING)

Energy Poverty (SUPPORTING)	
KPI Description	A significant part of a household's income is consumed by housing costs and related expenditures. As such, both are determinants of the extent to which households are at risk of poverty or deprivation. As a large share of the European housing stock consists of buildings in need of refurbishment, particularly in lower income low-energy-efficiency buildings with residents living in fuel poverty, the key to alleviate fuel poverty is to renovate the stock into more energy efficient buildings. Avoiding energy poverty has therefore become an important policy aim in many European countries. The assessor may need to determine a hypothetical baseline in case of a new construction development. This KPI assesses the change in percentage points of (gross) household income spent on energy bills.
KPI Owner	Evora: **CME**; PACT; SONAE; Kimatica; EDPL Alkmaar: **GA**; SEV
KPI Formula	$percentage\ point\ change\ in\ income\ spent\ on\ energy = \left(\frac{Energy\ costs\ before\ project}{Gross\ household\ income} \cdot 100\% - \frac{Energy\ costs\ after\ project}{Gross\ household\ income} \cdot 100\%\right)$ Note: The energy costs include all building related energy, i.e. for heating/cooling, warm water and electricity.

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Recommended Measurement Process and Data Sources	1. Data collection→2. KPI calculation. Data on the (average or median) household income may be obtained from the city statistical office if not available for the immediate context of the project. If the project had as an aim to decrease energy consumption or CO2 emissions, the numbers on the reference situation and after completion of the project can serve as the basis for calculating the change in energy costs. Energy prices (metered prices) can be obtained from the local energy provider(s)						
Recommended Monitoring Interval	Twice (before and after project implementation) *Note: Baseline Estimations are needed*		Reporting to SCIS	*YES*		*NO*	X
Unit of Measurement	%		Threshold Target Value	TBD			
Relevant Stakeholders	Energy Utilities	X	Spatial Scale of Evaluation	Building Level	X		
	Consumers (end-users)	X		Building Block Level (PEB)	X		
	Technology and Services Providers			District Level (PED)	X		
	Policy-making Bodies/Governance			City Level	X		
	Representative Citizen Groups						
	Citizen Ambassadors						
Type of Indicator	Output		Temporal Scale of Evaluation	In-project timeframe	X		
	Impact	X		End of project	X		
				Post-project			

ETT-reference	ETT#1	X	ETT#2	X	ETT#3		ETT#4	X		
IS-reference	IS-1.1	X	IS-1.2	X	IS-1.3		IS-2.1	X	IS-2.2	X
	IS-3.1		IS-3.2		IS-4.1	X	IS-4.2		IS-4.3	

4.3.1.9 EC.9 Carbon Dioxide Reduction Cost Efficiency (SUPPORTING)

Carbon Dioxide Reduction Cost Efficiency (SUPPORTING)						
KPI Description	Many smart city projects are intrinsically aimed at reducing the amount of CO_2 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. The specific KPI estimates costs in euros per ton of CO_2 saved per year.					
KPI Owner	Evora: **CME** Alkmaar: **GA**					
KPI Formula	This indicator is calculated on an annual basis, taking the annual reduction in CO_2 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/CO_2 related measures (to the extent discernible) are taken into account in the total cost calculation.					
Recommended Measurement Process and Data Sources	1. Data collection→2. KPI calculation. Data can be extracted from interviews with the project leader and/or project documentation. This KPI can be estimated capitalizing on information already available in other KPIs (carbon dioxide emission reduction and total annual costs).					
Recommended Monitoring Interval	Yearly	Reporting to SCIS	*YES*		*NO*	X

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Unit of Measurement	€/(ton CO_2 saved/year)		Threshold Target Value	TBD	
Relevant Stakeholders	Energy Utilities	X	Spatial Scale of Evaluation	Building Level	X
	Consumers (end-users)			Building Block Level (PEB)	X
	Technology and Services Providers	X		District Level (PED)	X
	Policy-making Bodies/Governance			City Level	X
	Representative Citizen Groups	X			
	Citizen Ambassadors				
Type of Indicator	Output		Temporal Scale of Evaluation	In-project timeframe	X
	Impact	X		End of project	X
				Post-project	

ETT-reference	ETT#1	X	ETT#2	X	ETT#3	X	ETT#4			
IS-reference	IS-1.1	X	IS-1.2	X	IS-1.3		IS-2.1	X	IS-2.2	X
	IS-3.1	X	IS-3.2	X	IS-4.1		IS-4.2		IS-4.3	

4.3.1.10 EC.10 New Business Ideas Generated (SUPPORTING)

New Business Ideas Generated (SUPPORTING)					
KPI Description	The number of businesses can inform a city's level of economic activity and economic performance. It provides one indication of the overall business climate in a jurisdiction, and attitudes towards entrepreneurship. Strong entrepreneurial activity is closely associated with a dynamic and growing economy. The number of businesses is also used to inform competitiveness of a city. This indicator measures the number of new ideas generated during POCITYF, as a result of spillover effects, inspired by and/or capitalizing its outcomes.				
KPI Owner	Evora: **CME;** DECSIS; RINA Alkmaar: **GA;** RINA; SEV				
KPI Formula	Number of new ideas generated.				
Recommended Measurement Process and Data Sources	1. Data collection→2. KPI calculation. Keep track during the organization of bootcamps, accelerators and start up events especially those that support the thematic priority of energy transition. City statistics office and/or economic board and the chamber of commerce might be able to provide relevant information.				
Recommended Monitoring Interval	Yearly		Reporting to SCIS	*YES*	*NO* X
Unit of Measurement	#		Threshold Target Value	TBD	
Relevant Stakeholders	Energy Utilities	X	Spatial Scale of Evaluation	Building Level	
	Consumers (end-users)	X		Building Block Level (PEB)	
	Technology and Services Providers	X		District Level (PED)	
	Policy-making Bodies/Governance	X		City Level	X
	Representative Citizen Groups				
	Citizen Ambassadors				
Type of Indicator	Output			In-project timeframe	X
	Impact	X		End of project	X

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				Temporal Scale of Evaluation			Post-project				X
ETT-reference	ETT#1	X	ETT#2		X	ETT#3		X	ETT#4		X
IS-reference	IS-1.1	X	IS-1.2	X	IS-1.3	X	IS-2.1	X	IS-2.2		X
	IS-3.1	X	IS-3.2	X	IS-4.1	X	IS-4.2	X	IS-4.3		X

4.3.1.11 EC.11 Expenditures by the municipality for a transition towards a smart city (SUPPORTING)

Expenditures by the municipality for a transition towards a smart city (SUPPORTING)							
KPI Description	One of the ways in which the municipality can support the transition towards a smart city, next to a supportive framework, establishment within the administration and cross-departmental integration, is by providing financial resources. Smart city expenditures include process relevant expenditures and findings. Estimates should also include the percentage of municipal budget allocated to the ICT facilities. ICT is considered as a significant parameter for the improvement of existing governance practices, establishment and integration of open databases and services as well as the effectiveness of other related systems and technologies.						
KPI Owner	Evora: **CME;** RINA Alkmaar: **GA;** RINA						
KPI Formula	Total annual expenditures by the municipality for a transition towards a Smart City/total population.						
Recommended Measurement Process and Data Sources	1. Data collection→2. KPI calculation. Information on city budgets should be easy to retrieve from the city administration, but allocation of the expenditures to smart city objectives might proof more difficult. In this case, to be derived from project documentation or interviews with project leader, the municipalities and LH managers.						
Recommended Monitoring Interval	Yearly		Reporting to SCIS	*YES*		*NO*	X
Unit of Measurement	€/capita, €, %		Threshold Target Value	TBD			
Relevant Stakeholders	Energy Utilities		Spatial Scale of Evaluation	Building Level			
	Consumers (end-users)			Building Block Level (PEB)			
	Technology and Services Providers			District Level (PED)			
	Policy-making Bodies/Governance	X		City Level			X
	Representative Citizen Groups	X					
	Citizen Ambassadors	X					
Type of Indicator	Output	X	Temporal Scale of Evaluation	In-project timeframe			X
	Impact			End of project			X
				Post-project			X

ETT-reference	ETT#1	X	ETT#2	X	ETT#3	X	ETT#4	X		
IS-reference	IS-1.1	X	IS-1.2	X	IS-1.3	X	IS-2.1	X	IS-2.2	X
	IS-3.1	X	IS-3.2	X	IS-4.1	X	IS-4.2	X	IS-4.3	X

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4.4 KPIs in ICT Dimension

4.4.1.1 ICT.1 Increased System Flexibility for Energy Players (CORE)

Increased System Flexibility for Energy Players (CORE)	
KPI Description	The indicator determines the increased system flexibility for the energy utilities as an effective way to exploit all resources to respond to a set of diversions (e.g. demand changes in a specific time interval) and maintain the power balance, in terms of load or cost. The progress brought by R&I activities relative to the new clusters and functional objectives is measured assessing the additional electrical power that can be modulated in the selected framework, such as the connection of new RES generation, enhancing an interconnection, mitigating congestion, or even modifying all the transmission capacity of a TSO. The KPI refers to the ability of the system to respond to - as well as stabilize and balance - supply and demand in real time, as a measure of the demand side participation in energy markets and in energy efficiency intervention. Stability relies on the maintaining of voltage and frequency of a given power system within acceptable levels.
KPI Owner	Evora: **UNINOVA** Alkmaar: **ALI**
KPI Formula	$$\Delta SF = \frac{SF_{R\&I} - SF_{BAU}}{P_{peak}}$$ SF is the amount of load capacity participating in demand side management [MW]. It can also be expressed related to cost as: $$SF_{AC} = \frac{\Delta SF}{AC}$$ Where SF_{AC} refers to the system flexibility pertinent to average costs (AC) stemming from grid operations of increased load and/or new/additional installations.
Recommended Measurement Process and Data Sources	1. Data collection→2. KPI calculation. Data to be captured at district and city level. Data should be gathered from the department of energy of the municipality or the energy provider.

Recommended Monitoring Interval	daily/monthly/yearly	Reporting to SCIS	*YES*	X (SCIS KPI 2.4.3)	*NO*	
Unit of Measurement	%, MW/€	Threshold Target Value	TBD			

Relevant Stakeholders	Energy Utilities	X	Spatial Scale of Evaluation	Building Level	
	Consumers (end-users)			Building Block Level (PEB)	
	Technology and Services Providers	X		District Level (PED)	X
	Policy-making Bodies/Governance			City Level	X
	Representative Citizen Groups				
	Citizen Ambassadors				
Type of Indicator	Output	X	Temporal Scale of Evaluation	In-project timeframe	X
	Impact			End of project	
				Post-project	X

ETT-reference	ETT#1	X	ETT#2	X	ETT#3	X	ETT#4			
IS-reference	IS-1.1	X	IS-1.2	X	IS-1.3		IS-2.1	X	IS-2.2	X
	IS-3.1	X	IS-3.2		IS-4.1		IS-4.2		IS-4.3	

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4.4.1.2 ICT.2 Increased hosting capacity for RES, electric vehicles and other new loads (CORE)

Increased hosting capacity for RES, electric vehicles and other new loads (CORE)						
KPI Description	The indicator determines the improvement of hosting capacity with regards to additional loads and installations. This KPI is intended to give a statement about the additional loads that can be installed in the network, when R&I solutions are applied, and also compared to the baseline scenario.					
KPI Owner	Evora: **EDPL**; CME Alkmaar: **GA**; ALI					
KPI Formula	This improvement can be quantified by means of the following percentage: $EHC_{\%} = \frac{HC_{R\&I} - HC_{BAU}}{HC_{BAU}} \cdot 100\%$ EHC: the enhanced hosting capacity of new loads when R&I solutions are applied with respect to BAU scenario. HC: the additional hosting capacity of new loads applied with respect to currently connected generation (GW or MW).					
Recommended Measurement Process and Data Sources	1. Data collection→2. KPI calculation. Data to be captured at all levels where RES are implemented and aggregated to city level. Data should be gathered from the department of energy of the municipality or the energy provider.					
Recommended Monitoring Interval	yearly	Reporting to SCIS	*YES*	X (SCIS KPI 2.4.6)	*NO*	
Unit of Measurement	%	Threshold Target Value	TBD			

Relevant Stakeholders			Spatial Scale of Evaluation		
	Energy Utilities	X		Building Level	X
	Consumers (end-users)	X		Building Block Level (PEB)	X
	Technology and Services Providers	X		District Level (PED)	X
	Policy-making Bodies/Governance			City Level	X
	Representative Citizen Groups				
	Citizen Ambassadors				
Type of Indicator	Output	X	**Temporal Scale of Evaluation**	In-project timeframe (short-term)	X
	Impact			End of project (mid-term)	X
				Post-project (long-term)	X

ETT-reference	ETT#1	X	ETT#2	X	ETT#3	X	ETT#4			
IS-reference	IS-1.1	X	IS-1.2	X	IS-1.3	X	IS-2.1	X	IS-2.2	X
	IS-3.1	X	IS-3.2		IS-4.1		IS-4.2		IS-4.3	

4.4.1.3 ICT.3 Improved Data Privacy (CORE)

Improved Data Privacy (CORE)	
KPI Description	This indicator refers to the level of improvement of data privacy and safety analysing the extent to which data collected by the project is protected, for instance, by following regulations on data protection and implementing proper procedures to protect personal or private data. Data privacy, or information privacy, is the privacy of personal information and usually relates to personal data stored on computer systems. Privacy concerns exist wherever personally identifiable information or other sensitive information is collected and

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	stored - in digital form or otherwise. 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. Citizens should be able to trust that their data is stored and used securely. Data protection refers to the tools and processes used to store data relevant to a certain ICT system or environment, as well as recover lost data in case of an incident - be it fraudulent, accidental or caused by a natural disaster.
KPI Owner	Evora: CME, EDPL, Ubiwhere (platform partners could lead) Alkmaar: **GA**
KPI Formula	Not at all -- 1 — 2 — 3 — 4 — 5 — Very high level of data privacy 1. Project involves use of personal or private data but national regulations/laws on its protection are not followed. 2. National regulations/laws on protection of personal data are followed. 3. National regulations on protection of personal data and EU Directive on the Protection of Personal Data (95/46/EG), EU General Data Protection Regulation 679/2017 (GDPR) are followed. 4. Relevant national and European regulations on data protection are followed and written agreements are made for use of end-users' private/personal data. 5. Relevant national and European regulations on data protection are followed and written agreements are made for use of end-users' private/personal data. Possibly collected personal/private data is accessed only by agreed persons and is heavily protected from others (e.g. locked or database on internal server with firewalls and restricted access).
Recommended Measurement Process and Data Sources	1. Data collection→2. KPI calculation. Data should be collected from city's security or IT department. Authorizations from the end-users need to be acquired. Data should be gathered from the last year with available data. The values must be reported with the corresponding year.

Recommended Monitoring Interval	twice		Reporting to SCIS	*YES*		*NO*	X
Unit of Measurement	5-point Likert scale (No Unit)		Threshold Target Value	TBD			
Relevant Stakeholders	Energy Utilities	X	Spatial Scale of Evaluation	Building Level	X		
	Consumers (end-users)	X		Building Block Level (PEB)	X		
	Technology and Services Providers	X		District Level (PED)	X		
	Policy-making Bodies/Governance	X		City Level	X		
	Representative Citizen Groups	X					
	Citizen Ambassadors	X					
Type of Indicator	Output	X	Temporal Scale of Evaluation	In-project timeframe	X		
	Impact			End of project	X		
				Post-project	X		

ETT-reference	ETT#1	X	ETT#2	X	ETT#3	X	ETT#4	X		
IS-reference	IS-1.1	X	IS-1.2	X	IS-1.3	X	IS-2.1	X	IS-2.2	X
	IS-3.1	X	IS-3.2	X	IS-4.1	X	IS-4.2	X	IS-4.3	X

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4.4.1.4 ICT.4 Quality of Open Data (CORE)

Quality of Open Data (CORE)							
KPI Description	Quality of Open Data is assessed as the percentage of data that uses DCAT standards. Data Catalog Vocabulary (DCAT) is designed to facilitate interoperability between data catalogs. The quality of open data is better if standardized. Processes get easier when data standards are applied. The DCAT standard allows municipal employees to produce data in a standardized way. Aggregated DCAT metadata can serve as a manifest file to facilitate digital preservation. DCAT enables decentralized publishing of catalogs, facilitates federated dataset search across catalogs (public sector datasets) by the exchange of descriptions of datasets among data portals (via DCAT-AP) making public sector data better searchable across borders and sectors in Europe.						
KPI Owner	Evora: **CME**, DECSIS, EDPL, Ubiwhere Alkmaar: **GA**						
KPI Formula	Percentage of data that uses DCAT standards.						
Recommended Measurement Process and Data Sources	1. Data collection→2. KPI calculation. The information could be collected with manual monitoring/ research to calculate the number of standardized datasets. Data should be sourced from the municipalities in collaboration with CIP managers.						
Recommended Monitoring Interval	Once (in the end of the project)		Reporting to SCIS	*YES*		*NO*	X
Unit of Measurement	%		Threshold Target Value	TBD			
Relevant Stakeholders	Energy Utilities		Spatial Scale of Evaluation	Building Level			
	Consumers (end-users)			Building Block Level (PEB)			
	Technology and Services Providers			District Level (PED)			
	Policy-making Bodies/Governance	X		City Level			X
	Representative Citizen Groups						
	Citizen Ambassadors						
Type of Indicator	Output	X	Temporal Scale of Evaluation	In-project timeframe			
	Impact			End of project			X
				Post-project			

ETT-reference	ETT#1		ETT#2		ETT#3		ETT#4	X				
IS-reference	IS-1.1		IS-1.2		IS-1.3		IS-2.1		IS-2.2			
	IS-3.1		IS-3.2		IS-4.1	X	IS-4.2	X	IS-4.3	X		

4.4.1.5 ICT.5 ICT Response Time (SUPPORTING)

ICT Response Time (SUPPORTING)	
KPI Description	The response time of ICT infrastructure is related to the services developed and the payload (information exchanged) between them. The indicator is applicable to the various urban platform and ICT deployment actions and services in the project. For some ICT services response times need to be in milliseconds while for other services seconds or minutes are perfectly acceptable.
KPI Owner	Evora: **CME**, Ubiwhere

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	Alkmaar: **GA**						
KPI Formula	Transaction time / payload						
Recommended Measurement Process and Data Sources	1. Data collection→2. KPI calculation. Data should be collected from the CIP and Urban platform logs. To be assessed for representative ICT services.						
Recommended Monitoring Interval	daily		**Reporting to SCIS**	*YES*		*NO*	X
Unit of Measurement	ms/byte; sec/byte; min/byte (Depends on the system)		**Threshold Target Value**	TBD			
Relevant Stakeholders	Energy Utilities	X	**Spatial Scale of Evaluation**	Building Level	X		
	Consumers (end-users)	X		Building Block Level (PEB)	X		
	Technology and Services Providers	X		District Level (PED)	X		
	Policy-making Bodies/Governance	X		City Level	X		
	Representative Citizen Groups						
	Citizen Ambassadors						
Type of Indicator	Output	X	**Temporal Scale of Evaluation**	In-project timeframe	X		
	Impact			End of project	X		
				Post-project	X		

ETT-reference	ETT#1	X	ETT#2	X	ETT#3	X	ETT#4	X		
IS-reference	IS-1.1	X	IS-1.2	X	IS-1.3	X	IS-2.1	X	IS-2.2	X
	IS-3.1	X	IS-3.2		IS-4.1	X	IS-4.2		IS-4.3	X

4.4.1.6 ICT.6 Improved Cybersecurity (SUPPORTING)

Improved Cybersecurity (SUPPORTING)	
KPI Description	The indicator refers to the extent to which the project ensures cybersecurity of its systems. This indicator analyses the effort made in the project to ensure and/or improve cybersecurity, for instance the extent to which the project is prepared to handle risks in cybersecurity (i.e. has made a risk assessment), is prepared to manage possible disturbances (has a contingency plan and means to implement it) and use secure information systems (certified and accredited prior to deployment). The indicator gives an overview of the contribution of the project to the preparedness of the city to risks of cybersecurity (use of proper security procedures) and its ability to manage and mitigate possible disturbances, e.g. cyberattacks.
KPI Owner	Evora: **CME**, EDPL, Ubiwhere Alkmaar: **GA**
KPI Formula	Not at all -- 1 — 2 — 3 — 4 — 5 — Very high level of Cybersecurity 1. Not at all: Cybersecurity hasn't received any attention in the project planning, even though the project involves the use of ICT. 2. Low: A risk assessment on cybersecurity has been made for the project but there is either no contingency plan or high risks remain present. 3. Moderate: A risk assessment on cybersecurity has been made for the project and there is contingency plan for it.

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	4. High: A risk assessment on cybersecurity has been made for the project and there is a contingency plan for it. Risks on cybersecurity are low. 5. Very high: A risk assessment on cybersecurity has been made for the project and there is a contingency plan for it. Risks on cyber security are low. The project uses only information systems with security assessment approvals (certified and accredited prior to deployment).						
Recommended Measurement Process and Data Sources	1. Data collection→2. KPI calculation. To be derived from project documentation or interviews with project leader and LH managers.						
Recommended Monitoring Interval	Once (in the end of the project)		Reporting to SCIS	*YES*		*NO*	X
Unit of Measurement	5-point Likert scale (No Unit)		Threshold Target Value	TBD			
Relevant Stakeholders	Energy Utilities		Spatial Scale of Evaluation	Building Level			
	Consumers (end-users)			Building Block Level (PEB)			
	Technology and Services Providers	X		District Level (PED)			
	Policy-making Bodies/Governance	X		City Level	X		
	Representative Citizen Groups						
	Citizen Ambassadors						
Type of Indicator	Output	X	Temporal Scale of Evaluation	In-project timeframe			
	Impact			End of project	X		
				Post-project	X		

ETT-reference	ETT#1		ETT#2		ETT#3		ETT#4	X		
IS-reference	IS-1.1		IS-1.2		IS-1.3		IS-2.1		IS-2.2	
	IS-3.1		IS-3.2		IS-4.1		IS-4.2		IS-4.3	X

4.4.1.7 ICT.7 Platform Downtime (SUPPORTING)

Platform Downtime (SUPPORTING)	
KPI Description	ICT platform downtime refers to a time period that CIP is unavailable thus failing to provide or perform its primary function as a result of an unplanned (e.g. electricity outage, internet disconnection) or planned event (e.g. maintenance, updates, reboots). To run a stable platform, monitoring is required to fix bugs and quickly improve the software environments. To successfully test CIP operation, it must have a large range of conformance test data and protocol decodes for analysis of unavailability problems allowing also the best compatibility with new interconnected systems. The indicator quantifies the downtime of the platform per selected timeframe. It can be measured in minutes and alongside with a percentage.
KPI Owner	Evora: **CME,** Ubiwhere Alkmaar: **GA**
KPI Formula	The KPI can be quantified by measuring the downtime per selected time-horizon. A simple KPI formula can be expressed as follows: $$Downtime = \frac{Total\ Time\ of\ CIP\ unavailability}{Total\ \ time\ of\ CIP\ operation\ (in\ hours\ or\ days\ etc.)}$$

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Recommended Measurement Process and Data Sources	1. Data collection→2. KPI calculation. Data should be extracted from the integrated ICT systems, e.g. The CIP will keep detailed usage statistics.						
Recommended Monitoring Interval	daily		**Reporting to SCIS**	*YES*		*NO*	X
Unit of Measurement	Minutes / (h, d, w, m)		**Threshold Target Value**	TBD			
Relevant Stakeholders	Energy Utilities	X	**Spatial Scale of Evaluation**	Building Level			
	Consumers (end-users)			Building Block Level (PEB)			
	Technology and Services Providers	X		District Level (PED)			
	Policy-making Bodies/Governance	X		City Level	X		
	Representative Citizen Groups						
	Citizen Ambassadors						
Type of Indicator	Output	X	**Temporal Scale of Evaluation**	In-project timeframe	X		
	Impact			End of project	X		
				Post-project			

ETT-reference	ETT#1	X	ETT#2	X	ETT#3	X	ETT#4	X		
IS-reference	IS-1.1	X	IS-1.2	X	IS-1.3	X	IS-2.1	X	IS-2.2	X
	IS-3.1	X	IS-3.2	X	IS-4.1	X	IS-4.2	X	IS-4.3	X

4.5 KPIs in Mobility Dimension

4.5.1.1 M.1 Electric Vehicles & Low-Carbon Emission Vehicles deployed in the area (CORE)

Electric Vehicles & Low-Carbon Emission Vehicles deployed in the area (CORE)	
KPI Description	Number of electric vehicles (EV) and low-carbon vehicles (hydrogen) registered in the area, in relation to the total number of motorized vehicles (four and two wheels). Clean/Low-emission vehicles shall refer to vehicles that emit low levels of emissions such as a) pure electric vehicles (EV) incl. private, public, service (taxi and first mile) and motorbikes, and b) hydrogen fuel-cell driven vehicles. Low-emission vehicles shall be certified under appropriate exhaust emission standards and the vehicle shall meet other special requirements applicable to conventional or clean-fuel vehicles and their fuels. The indicator must report mainly in EV, while, hydrogen vehicles can be also reported in a separate way.
KPI Owner	Evora: **CME** Alkmaar: **GA**, Van Alckmaer, CONNEXION
KPI Formula	The indicator refers to the calculation of the following figures: • # of e-vehicles (e-cars, e-buses, e-bikes) rolled-out by the end of the project • # of hydrogen vehicles rolled-out by the end of the project Numbers could also be expressed as a percentage compared to the total number of vehicles: • (# of electric vehicles / total # of vehicles) *100% and • (# of low carbon-hydrogen vehicles / total # of vehicles) *100%

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Recommended Measurement Process and Data Sources	1. Data collection→2. KPI calculation. To be derived from project documentation or interviews with project leader and LH managers. Data should be gathered from city's transport department. To be assessed before and after.					
Recommended Monitoring Interval	yearly		Reporting to SCIS	*YES*	X (SCIS KPI 2.5.4)	*NO*
Unit of Measurement	[number], %		Threshold Target Value	TBD		
Relevant Stakeholders	Energy Utilities		Spatial Scale of Evaluation	Building Level		
	Consumers (end-users)	X		Building Block Level (PEB)		
	Technology and Services Providers	X		District Level (PED)	X	
	Policy-making Bodies/Governance	X		City Level	X	
	Representative Citizen Groups					
	Citizen Ambassadors					
Type of Indicator	Output		Temporal Scale of Evaluation	In-project timeframe	X	
	Impact	X		End of project	X	
				Post-project		

ETT-reference	ETT#1		ETT#2		ETT#3	X	ETT#4			
IS-reference	IS-1.1		IS-1.2		IS-1.3		IS-2.1		IS-2.2	
	IS-3.1	X	IS-3.2	X	IS-4.1		IS-4.2		IS-4.3	

4.5.1.2 M.2 Number of EV charging stations/points and solar powered V2G charging stations/points deployed in the area (CORE)

Number of EV charging stations/points and solar powered V2G charging stations/points deployed in the area (CORE)	
KPI Description	Number of e-charging and V2G stations, public and private, normal and fast chargers. Charging infrastructure development is critical for the promotion of electromobility and the deployment of EVs. This indicator assesses the level of service with regards to charging capabilities offered by measuring the number of electric vehicles charging stations and the number of solar powered V2G stations registered in the area. Additionally, the indicator compares these numbers with the total number of stations. Regarding the e-charging and V2G stations, information provided should contain the number of charging stations (and charging points) on the streets and in parking garages in the city as well as the locations of the e-charging stations and points. The number of conventional and fast charging stations/points could also be reported.
KPI Owner	Evora: **CME**, EDPL, INESCTEC, Ubiwhere, DECSIS Alkmaar: **GA**, CONNEXION, Alliander
KPI Formula	The indicator refers to the following measurements: • <u>Number of total stations/points deployed; along with their locations</u> • <u>e-charging stations/points deployed; V2G stations/points deployed;</u> Numbers could also be expressed as a percentage compared to total number of stations/points: • (Number of EV charging stations/points deployed/total stations/points deployed) * 100% • (Number of solar powered V2G stations/points deployed/total stations deployed) * 100%

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<table>
<tr><td>Recommended Measurement Process and Data Sources</td><td colspan="7">1. Data collection→2. KPI calculation.
Data should be gathered from city's transport department.
To be assessed before the project and after.</td></tr>
<tr><td>Recommended Monitoring Interval</td><td colspan="2">yearly</td><td>Reporting to SCIS</td><td>YES</td><td>X (SCIS KPI 2.5.5)</td><td>NO</td><td></td></tr>
<tr><td>Unit of Measurement</td><td colspan="2">[number], %</td><td>Threshold Target Value</td><td colspan="4">TBD</td></tr>
<tr><td rowspan="6">Relevant Stakeholders</td><td>Energy Utilities</td><td>X</td><td rowspan="6">Spatial Scale of Evaluation</td><td colspan="3">Building Level</td><td></td></tr>
<tr><td>Consumers (end-users)</td><td>X</td><td colspan="3">Building Block Level (PEB)</td><td></td></tr>
<tr><td>Technology and Services Providers</td><td>X</td><td colspan="3">District Level (PED)</td><td>X</td></tr>
<tr><td>Policy-making Bodies/Governance</td><td>X</td><td colspan="3">City Level</td><td>X</td></tr>
<tr><td>Representative Citizen Groups</td><td></td><td colspan="3"></td><td></td></tr>
<tr><td>Citizen Ambassadors</td><td></td><td colspan="3"></td><td></td></tr>
<tr><td rowspan="3">Type of Indicator</td><td>Output</td><td></td><td rowspan="3">Temporal Scale of Evaluation</td><td colspan="3">In-project timeframe</td><td>X</td></tr>
<tr><td>Impact</td><td>X</td><td colspan="3">End of project</td><td>X</td></tr>
<tr><td></td><td></td><td colspan="3">Post-project</td><td></td></tr>
</table>

ETT-reference	ETT#1	X	ETT#2		ETT#3	X	ETT#4			
IS-reference	IS-1.1		IS-1.2	X	IS-1.3		IS-2.1		IS-2.2	
	IS-3.1	X	IS-3.2		IS-4.1		IS-4.2		IS-4.3	

4.5.1.3 M.3 Annual Energy delivered by charging points (CORE)

<table>
<tr><th colspan="7">Annual Energy delivered by charging points (CORE)</th></tr>
<tr><td>KPI Description</td><td colspan="6">Information should be provided about the level of use of the EV charging infrastructure implemented in the city, calculating the total kWh recharged by all types of electric vehicles during a year in the public charging stations. Additional analysis can be done using the particular kWh recharged over the city, showing information about what charging point is used more intensively, giving useful information to municipalities in order to optimize the charging network. In that respect, the recorded kWh/month per public e-charging point in the city, could be used to identifying the charging stations recorded the best performance in terms of kWh, e.g. top 10. Data could be gathered also for day, month and year of using an e-charging station.</td></tr>
<tr><td>KPI Owner</td><td colspan="6">Evora: CME; EDPL, INESCTEC, Ubiwhere, DECSIS

Alkmaar: GA; ALI, CONNEXION, Alliander</td></tr>
<tr><td>KPI Formula</td><td colspan="6">This indicator can be quantified by recording the kWh recharged per month per charging station and aggregated resulting in the total average annual energy (AE) delivered.
AE: total annual energy of charging stations per year (KWh/year)</td></tr>
<tr><td>Recommended Measurement Process and Data Sources</td><td colspan="6">1. Data collection→2. KPI calculation.
Data should be gathered from the municipality or energy provider.
Values must be reported with the corresponding year.</td></tr>
<tr><td>Recommended Monitoring Interval</td><td>monthly, yearly</td><td>Reporting to SCIS</td><td>YES</td><td></td><td>NO</td><td>X</td></tr>
</table>

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Unit of Measurement	KWh/year; KWh/month		Threshold Target Value	TBD	
Relevant Stakeholders	Energy Utilities	X	Spatial Scale of Evaluation	Building Level	
	Consumers (end-users)			Building Block Level (PEB)	
	Technology and Services Providers	X		District Level (PED)	X
	Policy-making Bodies/Governance	X		City Level	X
	Representative Citizen Groups				
	Citizen Ambassadors				
Type of Indicator	Output		Temporal Scale of Evaluation	In-project timeframe	X
	Impact	X		End of project	X
				Post-project	X

ETT-reference	ETT#1	X	ETT#2	X	ETT#3	X	ETT#4			
IS-reference	IS-1.1		IS-1.2	X	IS-1.3		IS-2.1	X	IS-2.2	
	IS-3.1	X	IS-3.2		IS-4.1		IS-4.2		IS-4.3	

4.5.1.4 *M.4 Annual number of passengers using the new vehicles and/or infrastructure (CORE)*

Annual number of passengers using the new vehicles and/or infrastructure (CORE)							
KPI Description	The level of utilization of the new vehicles or infrastructure should be expressed by the number of passengers or users travelling during a year with the new vehicles (e.g. EVs and e-buses) or on the new infrastructure deployed.						
KPI Owner	Evora: **CME** Alkmaar: **GA**						
KPI Formula	Number of users per year						
Recommended Measurement Process and Data Sources	1. Data collection→2. KPI calculation. Data should be gathered from city's mobility department or energy provider.						
Recommended Monitoring Interval	daily, monthly, yearly		Reporting to SCIS	*YES*		*NO*	X

Unit of Measurement	#/year		Threshold Target Value	TBD	
Relevant Stakeholders	Energy Utilities	X	Spatial Scale of Evaluation	Building Level	
	Consumers (end-users)	X		Building Block Level (PEB)	
	Technology and Services Providers	X		District Level (PED)	X
	Policy-making Bodies/Governance	X		City Level	X
	Representative Citizen Groups				
	Citizen Ambassadors				
Type of Indicator	Output		Temporal Scale of Evaluation	In-project timeframe	X
	Impact	X		End of project	X
				Post-project	X

ETT-reference	ETT#1		ETT#2		ETT#3	X	ETT#4			
IS-reference	IS-1.1		IS-1.2		IS-1.3		IS-2.1		IS-2.2	
	IS-3.1	X	IS-3.2	X	IS-4.1		IS-4.2		IS-4.3	

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4.5.1.5 M.5 Shared Electric Vehicles and Bicycles Penetration Rate (CORE)

Shared Electric Vehicles and Bicycles Penetration Rate (CORE)							
KPI Description	Number of e-vehicles that operate in the platform and in the community car-sharing concept; as well as number of bicycles available through provided bicycle-sharing services and e-sharing schemes. This indicator allows to appreciate the evolution of the share of e-vehicles and bikes in these initiatives. Car-sharing contributes to an accessible, green and healthy neighbourhood, fewer need for parking space, less vehicles on the road and less pollution. Bike-sharing is key for sustainable urban mobility aiming to become the best alternative of public transport systems.						
KPI Owner	Evora: **CME;** UW, INESCTEC Alkmaar: **GA**, Van Alckmaer						
KPI Formula	*Number of EVs operating in shared-mobility services.* [(Number of e-vehicles in companies' fleets)/(Total number of vehicles fleet)] *100% *Number of bicycles and e-bicycles operating in shared-mobility services.*						
Recommended Measurement Process and Data Sources	1. Data collection→2. KPI calculation. Potential data collection sources should be the urban platform manager of the city, logistics companies or the company that operates the service of the EV sharing scheme.						
Recommended Monitoring Interval	yearly		Reporting to SCIS	*YES*		*NO*	*X*
Unit of Measurement	[number], %		Threshold Target Value	TBD			
Relevant Stakeholders	Energy Utilities		Spatial Scale of Evaluation	Building Level			
	Consumers (end-users)			Building Block Level (PEB)			
	Technology and Services Providers	X		District Level (PED)	X		
	Policy-making Bodies/Governance	X		City Level	X		
	Representative Citizen Groups						
	Citizen Ambassadors						
Type of Indicator	Output		Temporal Scale of Evaluation	In-project timeframe	X		
	Impact	X		End of project	X		
				Post-project			

ETT-reference	ETT#1		ETT#2		ETT#3	X	ETT#4			
IS-reference	IS-1.1		IS-1.2		IS-1.3		IS-2.1		IS-2.2	
	IS-3.1		IS-3.2	X	IS-4.1		IS-4.2		IS-4.3	

4.5.1.6 M.6 Clean mobility utilization (SUPPORTING)

Clean mobility utilization (SUPPORTING)	
KPI Description	*Amount of km in clean vehicles, and number of trips in clean vehicles.* The indicator refers to the use of clean vehicles in the city as a means of sustainable mobility.
KPI Owner	Evora: **CME**, INESCTEC, Ubiwhere Alkmaar: **GA**, CONNEXION, Alliander

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KPI Formula	*km, # of trips*						
Recommended Measurement Process and Data Sources	1. Data collection→2. KPI calculation. The information should be obtained by project measurements and interviews. To be assessed before and after.						
Recommended Monitoring Interval	Monthly; yearly		**Reporting to SCIS**	*YES*	X (SCIS KPI 2.5.8)	*NO*	
Unit of Measurement	[km] / [number]		**Threshold Target Value**	TBD			
Relevant Stakeholders	Energy Utilities		**Spatial Scale of Evaluation**	Building Level			
	Consumers (end-users)	X		Building Block Level (PEB)			
	Technology and Services Providers			District Level (PED)	X		
	Policy-making Bodies/Governance	X		City Level	X		
	Representative Citizen Groups						
	Citizen Ambassadors						
Type of Indicator	Output		**Temporal Scale of Evaluation**	In-project timeframe	X		
	Impact	X		End of project	X		
				Post-project			

ETT-reference	ETT#1		ETT#2		ETT#3	X	ETT#4			
IS-reference	IS-1.1		IS-1.2		IS-1.3		IS-2.1		IS-2.2	
	IS-3.1	X	IS-3.2	X	IS-4.1		IS-4.2		IS-4.3	

4.5.1.7 M.7 Modal Split (Passengers/Vehicles/Trips) (SUPPORTING)

Modal Split (Passengers/Vehicles/Trips) (SUPPORTING)						
KPI Description	The average modal split refers to the percentage of km or trips; by all types of transport, allowing to know how citizens travel in the city. The indicator determines the distribution of transport over the modalities public and collective transport, private vehicles, biking and walking. Transport Modes: walk, bicycle, bus, tram, metro, train, car (driver and passenger), motorbike.					
KPI Owner	Evora: **CME** Alkmaar: **GA**					
KPI Formula	Percentage of passenger-km, vehicle-km and number of trips of each mode.					
Recommended Measurement Process and Data Sources	1. Data collection→2. KPI calculation. Data should be extracted from city own measurements or statistics. The information could be sourced from the transport department of the municipalities. Data should be gathered from the last year with available data. The value must be reported with the corresponding year. To be assessed before and after.					
Recommended Monitoring Interval	Yearly	**Reporting to SCIS**	*YES*	X (SCIS KPI 2.5.9)	*NO*	
Unit of Measurement	% of vkm, % of passenger.km, % of trips	**Threshold Target Value**	TBD			

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Relevant Stakeholders	Energy Utilities		Spatial Scale of Evaluation	Building Level	
	Consumers (end-users)			Building Block Level (PEB)	
	Technology and Services Providers			District Level (PED)	X
	Policy-making Bodies/Governance	X		City Level	X
	Representative Citizen Groups				
	Citizen Ambassadors				
Type of Indicator	Output	X	Temporal Scale of Evaluation	In-project timeframe (short-term)	X
	Impact			End of project (mid-term)	X
				Post-project (long-term)	

ETT-reference	ETT#1		ETT#2		ETT#3	X	ETT#4			
IS-reference	IS-1.1		IS-1.2		IS-1.3		IS-2.1		IS-2.2	
	IS-3.1	X	IS-3.2	X	IS-4.1		IS-4.2		IS-4.3	

4.5.1.8 M.8 Yearly km of Shared Vehicles and Bicycles (SUPPORTING)

Yearly km of Shared Vehicles and Bicycles (SUPPORTING)							
KPI Description	Yearly km made through the e-car and bike sharing systems instead of private conventional cars and bicycles. The key element of a vehicle-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 and bike-sharing services.						
KPI Owner	Evora: **CME** Alkmaar: GA, **Van Alckmaer**						
KPI Formula	Number of kilometres done by the car-sharing fleet. Number of kilometres done by the bike-sharing fleet.						
Recommended Measurement Process and Data Sources	1. Data collection→2. KPI calculation. To be assessed by monitoring and measurements from vehicles.						
Recommended Monitoring Interval	yearly		Reporting to SCIS	*YES*		*NO*	X
Unit of Measurement	[Km/year]		Threshold Target Value	TBD			
Relevant Stakeholders	Energy Utilities		Spatial Scale of Evaluation	Building Level			
	Consumers (end-users)	X		Building Block Level (PEB)			
	Technology and Services Providers	X		District Level (PED)	X		
	Policy-making Bodies/Governance	X		City Level	X		
	Representative Citizen Groups						
	Citizen Ambassadors						
Type of Indicator	Output		Temporal Scale of Evaluation	In-project timeframe (short-term)	X		
	Impact	X		End of project (mid-term)	X		
				Post-project (long-term)			

ETT-reference	ETT#1		ETT#2		ETT#3	X	ETT#4	

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IS-reference	IS-1.1		IS-1.2		IS-1.3		IS-2.1		IS-2.2	
	IS-3.1		IS-3.2	X	IS-4.1		IS-4.2		IS-4.3	

4.6 KPIs in Social Dimension

4.6.1.1 S.1 People Reached (CORE)

People Reached (CORE)							
KPI Description	Percentage of people in the target group that have been reached and/or are activated by the project. 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 for each integrated solution have to be clearly defined before assessing the indicator.						
KPI Owner	**Evora: CME**; RINA-C; DECSIS **Alkmaar: GA**; SEV						
KPI Formula	(number of citizens reached/total number of citizens considered as the total target group of the project) * 100%						
Recommended Measurement Process and Data Sources	**Step 1:** The LH managers create a log file to record people reached through: a) communication campaigns (press, social media), b) events organized by POCITYF, c) participation in third party events, and d) an estimation of people reached through social media and press is recorded; **Step 2:** Calculate the number of people in the project implementation area but also expand this to other scale of evaluation i.e. city if relevant						
Recommended Evaluation Interval	Yearly		Reporting to SCIS	*YES*		*NO*	X
Unit of Measurement	%		Threshold Target Value	TBD			
Relevant Stakeholders	Energy Utilities	X	Spatial Scale of Evaluation	Building Level			X
	Consumers (end-users)	X		Building Block Level (PEB)			X
	Technology and Services Providers	X		District Level (PED)			X
	Policy-making Bodies/Governance	X		City Level			X
	Representative Citizen Groups	X					
	Citizen Ambassadors	X					
Type of Indicator	Output		Temporal Scale of Evaluation	In-project timeframe			X
	Impact	X		End of project			X
				Post-project			

ETT-reference	ETT#1	X	ETT#2	X	ETT#3	X	ETT#4	X		
IS-reference	IS-1.1	X	IS-1.2	X	IS-1.3	X	IS-2.1	X	IS-2.2	X
	IS-3.1	X	IS-3.2	X	IS-4.1	X	IS-4.2	X	IS-4.3	X

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4.6.1.2 S.2 Connection to the existing cultural heritage (CORE)

Connection to the existing cultural heritage (CORE)	
KPI Description	The extent to which making a connection to the existing cultural heritage was considered in the design of the project. An important aspect in promoting the feeling of community/home is 'place-making'; the creation of place and identity. This identity can be created by building on local and regional history, culture and character. This entails integrating urban design and heritage conservation so that it enhances or connects to the existing character of the place, e.g. preservation and/or adaptive re-use of historic buildings and cultural landscapes. Keeping these location's special identity could also bring economic as well as other benefits to the area.
KPI Owner	**Evora: CME**; DECSIS **Alkmaar: GA;**
KPI Formula	The indicator provides a qualitative measure and is rated on a five-point Likert scale: Not at all - 1 — 2 — 3 — 4 — 5 — Very much 1. Not at all: no attention has been paid to existing cultural heritage. 2. Fair: heritage places have received some attention in the project, but not as an important element. 3. Moderate: some attention has been given to the conservation of heritage places. 4. Much: heritage places are reflected in the project design 5. Very much: heritage places are included in the project as clear and recognizable landmarks.
Recommended Measurement Process and Data Sources	To be derived from interviews with the project leader and the department for urban planning of the local government, and possibly from project documentation.

Recommended Evaluation Interval	Once		Reporting to SCIS	*YES*		*NO*	X
Unit of Measurement	5-point Likert scale (No Unit)		Threshold Target Value	TBD			
Relevant Stakeholders	Energy Utilities		Spatial Scale of Evaluation	Building Level	X		
	Consumers (end-users)			Building Block Level (PEB)	X		
	Technology and Services Providers	X		District Level (PED)	X		
	Policy-making Bodies/Governance	X		City Level			
	Representative Citizen Groups						
	Citizen Ambassadors						
Type of Indicator	Output	X	Temporal Scale of Evaluation	In-project timeframe	X		
	Impact			End of project			
				Post-project			

ETT-reference	ETT#1	X	ETT#2		ETT#3		ETT#4	X		
IS-reference	IS-1.1	X	IS-1.2		IS-1.3		IS-2.1		IS-2.2	
	IS-3.1		IS-3.2		IS-4.1	X	IS-4.2		IS-4.3	

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4.6.1.3 S.3 Local community involvement in the implementation and planning phase (CORE)

Local community involvement in the implementation and planning phase (CORE)							
KPI Description	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						
KPI Owner	**Evora: CME**; DECSIS **Alkmaar: GA**; SEV; Alliander						
KPI Formula	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.						
Recommended Measurement Process and Data Sources	To be derived from project documentation and/or interviews with project leader and others involved in the project. **Step 1.** Data collection **Step 2.** KPI calculation						
Recommended Evaluation Interval	Yearly		Reporting to SCIS	*YES*		*NO*	X
Unit of Measurement	5-point Likert scale (No Unit)		Threshold Target Value	TBD			
Relevant Stakeholders	Energy Utilities		Spatial Scale of Evaluation	Building Level			X
	Consumers (end-users)	X		Building Block Level (PEB)			X
	Technology and Services Providers	X		District Level (PED)			X
	Policy-making Bodies/Governance	X		City Level			X
	Representative Citizen Groups	X					
	Citizen Ambassadors	X					
Type of Indicator	Output	X	Temporal Scale of Evaluation	In-project timeframe			X
	Impact			End of project			
				Post-project			X

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ETT-reference	ETT#1	X	ETT#2	X	ETT#3	X	ETT#4	X		
IS-reference	IS-1.1	X	IS-1.2	X	IS-1.3	X	IS-2.1	X	IS-2.2	X
	IS-3.1	X	IS-3.2	X	IS-4.1	X	IS-4.2	X	IS-4.3	X

4.6.1.4 S.4 Degree of satisfaction (CORE)

Degree of satisfaction (CORE)									
KPI Description	Level of satisfaction and acceptance of people affected by the action in the topics analysed: • Technical point of view: perceived adequateness, perceived benefit (e.g. comfort), perceived usefulness, perceived ease of use, aesthetical solution satisfaction. • Economic point of view: cost, risk, benefit.								
KPI Owner	**Evora: CME**; RINA-C; DECSIS **Alkmaar: GA**; RINA-C								
KPI Formula	The indicator provides a qualitative measure and is rated on a five-point Likert scale: (could be measured separately for economic and technical) No satisfaction - 1 — 2 — 3 — 4 — 5 — High satisfaction 1. Not at all: No satisfaction. 2. Fair: There is some satisfaction but overall the solution is poorly developed. 3. Moderate: the solution is somewhat satisfactory, with some technical / economic benefits for the users 4. Much: There are some clear technical / economic benefits that makes the related investment meaningful. 5. Very much: There is a very high degree of satisfaction. It is a solution that has created multiple versatile benefits i.e. level of adequateness, benefit (e.g. comfort), usefulness, ease of use, aesthetical solution satisfaction, cost reduction and risk reduction.								
Recommended Measurement Process and Data Sources	To be derived from project documentation and/or interviews with project leader and others involved in the project.								
Recommended Evaluation Interval	Once/Yearly		Reporting to SCIS	*YES*		*NO*	X		
Unit of Measurement	5-Point Likert Scale (No Unit)		Threshold Target Value	TBD					
Relevant Stakeholders	Energy Utilities		Spatial Scale of Evaluation	Building Level	X				
	Consumers (end-users)	X		Building Block Level (PEB)	X				
	Technology and Services Providers			District Level (PED)	X				
	Policy-making Bodies/Governance	X		City Level	X				
	Representative Citizen Groups	X							
	Citizen Ambassadors	X							
Type of Indicator	Output		Temporal Scale of Evaluation	In-project timeframe (short-term)	X				
	Impact	X		End of project (mid-term)	X				
				Post-project (long-term)					
ETT-reference	ETT#1	X	ETT#2	X	ETT#3	X	ETT#4	X	

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IS-reference	IS-1.1	X	IS-1.2	X	IS-1.3	X	IS-2.1	X	IS-1.1	X
	IS-3.1	X	IS-3.2	X	IS-4.1	X	IS-4.2	X	IS-3.1	X

4.6.1.5 S.5 Percentage of citizens' participation in online decision-making (SUPPORTING)

Percentage of citizens' participation in online decision-making (SUPPORTING)						
KPI Description	% of citizens' participation in online decision-making					
KPI Owner	**Evora: CME**; UBIWHERE; DECSIS **Alkmaar: GA**; SEV					
KPI Formula	% of citizens' participation in online decision-making = citizens participated / total citizens of the district or city					
Recommended Measurement Process and Data Sources	**Step 1:** Data collection of open processes i.e. written suggestions, complains and comments, **Step 2:** Data Calculation					
Recommended Evaluation Interval	Yearly		Reporting to SCIS	*YES*	*NO*	X
Unit of Measurement	%		Threshold Target Value	TBD		
Relevant Stakeholders	Energy Utilities		Spatial Scale of Evaluation	Building Level		
	Consumers (end-users)	X		Building Block Level (PEB)	X	
	Technology and Services Providers			District Level (PED)	X	
	Policy-making Bodies/Governance	X		City Level	X	
	Representative Citizen Groups	X				
	Citizen Ambassadors	X				
Type of Indicator	Output	X	Temporal Scale of Evaluation	In-project timeframe	X	
	Impact			End of project	X	
				Post-project	X	

ETT-reference	ETT#1		ETT#2		ETT#3		ETT#4	X		
IS-reference	IS-1.1		IS-1.2		IS-1.3		IS-2.1		IS-2.2	
	IS-3.1		IS-3.2		IS-4.1	X	IS-4.2	X	IS-4.3	X

4.7 KPIs in Governance Dimension

4.7.1.1 G.1 Online visits to the municipal open data portal per 100 000 population (CORE)

Online visits to the municipal open data portal per 100 000 population (CORE)	
KPI Description	Number of visits to the municipal open data portal a year per 100 000 population.
KPI Owner	**Evora: CME**; UBIWHERE **Alkmaar: GA**
KPI Formula	Total number of municipal open data portal visits (numerator) / 100 000 inhabitants
Recommended Measurement	Data on the number of visits to the open data portal should be obtained from websites hosting statistics related to a) Garbage and Recycling; b) Public Safety; c)

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Process and Data Sources	Fire Department; d) Roads and Traffic; e) Bylaws, f) Violations and Enforcement; g) Permits and Licences; h) Planning; i) Building; j) Policies, Projects and Initiatives; k) Rentals and Catering of City Buildings; l) Water and Sewers; and m) Property Taxes and Utilities, obtained from the municipality's website administration or provided by the domain host(s). An open data portal shall refer to a data portal operated by the city providing access to open data, which shall be defined as structured data that is machine-readable, freely shared, used and built on without restrictions. An online visit shall refer to an individual visitor who arrives at the city's open data portal online and proceeds to browse and peruse the open data portal. A visit counts all visitors, no matter how many times the same visitor may have been to the open data portal.						
Recommended Evaluation Interval	Monthly / Yearly		Reporting to SCIS	*YES*		*NO*	X
Unit of Measurement	#/100 000		Threshold Target Value	TBD			
Relevant Stakeholders	Energy Utilities		Spatial Scale of Evaluation	Building Level			
	Consumers (end-users)			Building Block Level (PEB)			
	Technology and Services Providers			District Level (PED)			
	Policy-making Bodies/Governance	X		City Level	X		
	Representative Citizen Groups						
	Citizen Ambassadors						
Type of Indicator	Output	X	Temporal Scale of Evaluation	In-project timeframe	X		
	Impact			End of project	X		
				Post-project	X		

ETT-reference	ETT#1		ETT#2		ETT#3		ETT#4	X		
IS-reference	IS-1.1		IS-1.2		IS-1.3		IS-2.1		IS-2.2	
	IS-3.1		IS-3.2		IS-4.1	X	IS-4.2		IS-4.3	X

4.7.1.2 G.2 Percentage of city services accessible and that can be requested online (e-Governance) (CORE)

Percentage of city services accessible and that can be requested online (e-Governance) (CORE)	
KPI Description	The percentage of city services accessible online. City services shall refer to services provided by the city and typically cover the following areas: Garbage and Recycling; Public Safety; Fire Department; Roads and Traffic; Bylaws, Violations and Enforcement; Permits and Licences; Planning; Building; Policies, Projects and Initiatives; Rentals and Catering of City Buildings; Water and Sewers; and Property Taxes and Utilities. City services is a broad term encompassing the many "touch-points" cities have with citizens and businesses. Particularly for city services accessible online this term can include, for example, requesting and receiving permits; assessing and collecting taxes; lodging and addressing complaints; and requesting information on services within the city's jurisdiction or authority.
KPI Owner	**Evora: CME**; UBIWHERE **Alkmaar: GA**
KPI Formula	(Total number of city services offered to people and businesses through a centralized Internet interface (numerator) / total number of city services offered by the city (denominator)) * 100

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Recommended Measurement Process and Data Sources	An inventory of all city services offered must be taken to provide an accurate percentage output. Information on city services should be sourced from city departments, or institutions that provide services. Figures on services available through web or mobile should also be obtained from city departments, or institutions providing the service, or from the municipal government website administrators.						
Recommended Evaluation Interval	Yearly		Reporting to SCIS	YES		NO	X
Unit of Measurement	%		Threshold Target Value	TBD			
Relevant Stakeholders	Energy Utilities		Spatial Scale of Evaluation	Building Level			
	Consumers (end-users)			Building Block Level (PEB)			
	Technology and Services Providers			District Level (PED)			
	Policy-making Bodies/Governance	X		City Level	X		
	Representative Citizen Groups						
	Citizen Ambassadors						
Type of Indicator	Output		Temporal Scale of Evaluation	In-project timeframe	X		
	Impact	X		End of project	X		
				Post-project	X		

ETT-reference	ETT#1		ETT#2		ETT#3		ETT#4	X

IS-reference	IS-1.1		IS-1.2		IS-1.3		IS-2.1		IS-2.2	
	IS-3.1		IS-3.2		IS-4.1		IS-4.2		IS-4.3	X

4.7.1.3 G.3 Monitoring and evaluation (SUPPORTING)

Monitoring and evaluation (SUPPORTING)	
KPI Description	The extent to which the progress towards a smart city and compliance with requirements is being monitored and reported. Continued monitoring of performance and compliance with the requirements is an essential stimulating factor for success and allows the presentation of the actual progress made (Fortune and White 2006). Continued monitoring and reporting refers to the control processes by which at each stage of development, key personnel report on how the smart city program progresses with regards to the initial goals, schedule and budget. Adequate monitoring and reporting mechanisms allow for an anticipation on problems, to oversee corrective measures, and warrants that no deficits are overlooked.
KPI Owner	**Evora: CME**; VTT **Alkmaar: GA**; VTT
KPI Formula	The indicator provides a qualitative measure and is rated on a five-point Likert scale: no continued monitoring - 1 – 2 – 3 – 4 – 5 – Extensive monitoring 1. No monitoring & reporting: No monitoring and reporting at all was used to verify the progress of policies/strategies/projects. 2. Little monitoring & reporting: there is a basic monitoring scheme in place: a basic set of indicators assessed at irregular time intervals. 3. Some monitoring & reporting: there is a city-wide monitoring scheme in place with an elaborate set of indicators’ measurement intervals, backed by well-defined (SMARTY) goals of the smart city strategy. 4. Very much monitoring & reporting: there is a city-wide monitoring scheme in place with an elaborate set of indicators and measurement intervals, the findings of which are yearly reported upon.

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<table>
<tr><td></td><td colspan="12">5. Extensive monitoring & reporting: there is a city-wide monitoring scheme in place addressing all stages of the process, the findings of which are yearly reported upon and published transparently online.</td></tr>
<tr><td>Recommended Measurement Process and Data Sources</td><td colspan="12">To be derived from the Smart city strategy document, interviews with the smart city coordinator and monitoring reports. It is expected that the strategy document is easily available (online) and the smart city coordinator can be contacted easily. The availability of the monitoring reporting depends on the extent of monitoring and reporting.</td></tr>
<tr><td>Recommended Evaluation Interval</td><td colspan="4">Yearly</td><td colspan="2">Reporting to SCIS</td><td>YES</td><td colspan="2"></td><td>NO</td><td colspan="2">X</td></tr>
<tr><td>Unit of Measurement</td><td colspan="4">5-Point Likert Scale (No Unit)</td><td colspan="2">Threshold Target Value</td><td colspan="6">TBD</td></tr>
<tr><td rowspan="6">Relevant Stakeholders</td><td colspan="3">Energy Utilities</td><td>X</td><td colspan="2" rowspan="6">Spatial Scale of Evaluation</td><td colspan="5">Building Level</td><td>X</td></tr>
<tr><td colspan="3">Consumers (end-users)</td><td>X</td><td colspan="5">Building Block Level (PEB)</td><td>X</td></tr>
<tr><td colspan="3">Technology and Services Providers</td><td>X</td><td colspan="5">District Level (PED)</td><td>X</td></tr>
<tr><td colspan="3">Policy-making Bodies/Governance</td><td>X</td><td colspan="5">City Level</td><td>X</td></tr>
<tr><td colspan="3">Representative Citizen Groups</td><td></td><td colspan="5"></td><td></td></tr>
<tr><td colspan="3">Citizen Ambassadors</td><td></td><td colspan="5"></td><td></td></tr>
<tr><td rowspan="3">Type of Indicator</td><td colspan="3">Output</td><td></td><td colspan="2" rowspan="3">Temporal Scale of Evaluation</td><td colspan="5">In-project timeframe</td><td>X</td></tr>
<tr><td colspan="3">Impact</td><td>X</td><td colspan="5">End of project</td><td>X</td></tr>
<tr><td colspan="3"></td><td></td><td colspan="5">Post-project</td><td>X</td></tr>
<tr><td colspan="13"></td></tr>
<tr><td>ETT-reference</td><td>ETT#1</td><td>X</td><td>ETT#2</td><td>X</td><td>ETT#3</td><td>X</td><td>ETT#4</td><td>X</td><td colspan="4"></td></tr>
<tr><td rowspan="2">IS-reference</td><td>IS-1.1</td><td>X</td><td>IS-1.2</td><td>X</td><td>IS-1.3</td><td>X</td><td>IS-2.1</td><td>X</td><td>IS-1.1</td><td>X</td><td colspan="2"></td></tr>
<tr><td>IS-3.1</td><td>X</td><td>IS-3.2</td><td>X</td><td>IS-4.1</td><td>X</td><td>IS-4.2</td><td>X</td><td>IS-3.1</td><td>X</td><td colspan="2"></td></tr>
</table>

4.7.1.4 G.4 Legal Framework Compatibility (SUPPORTING)

Legal Framework Compatibility (SUPPORTING)	
KPI Description	The level of suitability of the legal framework for the integration of a) self-consumption RES generation solutions in buildings, b) symbiotic waste heat solutions, c) energy flexibility policies (such as incentives for peak-shaving), d) private EVs and public transport EVs in the city mobility policies, e) a city information platform for the energy management and citizen engagement (this takes into account not only whether the platform is permitted, but also what measurements are taken in order to maintain system security and privacy).
KPI Owner	**Evora: CME;** RUG **Alkmaar: GA;** RUG
KPI Formula	The indicator provides a qualitative measure and is rated on a five-point Likert scale: Not compatible - 1 – 2 – 3 – 4 – 5 – Fully compatible 1. No permission: The legal framework firmly prohibits the integration of the proposed technology solution. 2. Legal barriers: The legal framework leaves very little space for the integration of the proposed technology making it almost impossible. 3. Unclear legal platform: The legal framework has not taken into account the proposed technology solution, making it unclear whether its integration is allowed or not. 4. Legal permission: The legal framework generally approves of the integration of the proposed technology solution. Some special guidelines are out of date making possible a legal lack of support.

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	5. Full legal support: The legal framework fully approves the integration of the proposed technology solution.							
Recommended Measurement Process and Data Sources	To be derived from interviews with the LH managers, the Department for urban planning of the local government, local government authorities and possibly from project documentation. **Step 1:** Undertaking the interviews **Step 2:** Analysis of the results							
Recommended Evaluation Interval	Yearly		Reporting to SCIS	*YES*		*NO*	X	
Unit of Measurement	5-Point Likert Scale (No Unit)		Threshold Target Value	TBD				
Relevant Stakeholders	Energy Utilities		Spatial Scale of Evaluation	Building Level	X			
	Consumers (end-users)			Building Block Level (PEB)	X			
	Technology and Services Providers			District Level (PED)	X			
	Policy-making Bodies/Governance	X		City Level	X			
	Representative Citizen Groups							
	Citizen Ambassadors							
Type of Indicator	Output		Temporal Scale of Evaluation	In-project timeframe	X			
	Impact	X		End of project				
				Post-project	X			

ETT-reference	ETT#1	X	ETT#2	X	ETT#3	X	ETT#4	X		
IS-reference	IS-1.1	X	IS-1.2	X	IS-1.3	X	IS-2.1	X	IS-2.2	X
	IS-3.1	X	IS-3.2	X	IS-4.1	X	IS-4.2	X	IS-4.3	X

4.7.1.5 G.5 Open government dataset (SUPPORTING)

Open government dataset (SUPPORTING)							
KPI Description	The number of open government datasets per 100.000 inhabitants. It measures how involved is the local government in building a smart city. Open data refers those data that can be freely used, re-used and redistributed by anyone.						
KPI Owner	**Evora: CME** **Alkmaar: GA**						
KPI Formula	(number of open government datasets/total population) x 100.000						
Recommended Measurement Process and Data Sources	Planning or economic department should be able to provide an overview. Data should be gathered from the last year with available data. The value must be reported with the corresponding year.						
Recommended Evaluation Interval	Yearly		Reporting to SCIS	*YES*		*NO*	X
Unit of Measurement	#/100,000		Threshold Target Value	TBD			
Relevant Stakeholders	Energy Utilities		Spatial Scale of Evaluation	Building Level	X		
	Consumers (end-users)			Building Block Level (PEB)	X		
	Technology and Services Providers			District Level (PED)	X		

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	Policy-making Bodies/Governance	X		City Level	X
	Representative Citizen Groups				
	Citizen Ambassadors				
Type of Indicator	Output	X	Temporal Scale of Evaluation	In-project timeframe	X
	Impact			End of project	X
				Post-project	X

ETT-reference	ETT#1		ETT#2		ETT#3		ETT#4	X		
IS-reference	IS-1.1		IS-1.2		IS-1.3		IS-2.1		IS-2.2	
	IS-3.1		IS-3.2		IS-4.1		IS-4.2		IS-4.3	X

4.8 KPIs in Propagation Dimension

4.8.1.1 P.1 Social compatibility (CORE)

Social compatibility (CORE)	
KPI Description	The extent to which the project's solution fits with people's 'frame of mind' and does not negatively challenge people's values or the ways they are used to do things. The indicator 'social compatibility' aims to provide an indication of the extent to which a solution fits with people's current "frame of mind", that is influenced by values and past experiences. If an innovation requires people to significantly think differently, and challenges assumptions or the ways how we normally are accustomed to do things, its implementation in society will be more difficult. Abdalla (2012) has shown that the gains from environmental measures in sustainable residential districts that go beyond the building codes, may be offset by residents' behaviour if these measures do not match residents' beliefs and expectations. For example, an innovation has a higher compatibility when it does not require an extremely different 'frame of mind' or 'ways of doing things'. Moreover, social compatibility is affected by socio-cultural values and beliefs or past collective experiences that influence the general opinion about the innovation or similar innovations. The 'frame of mind', therefore, can differ between countries.
KPI Owner	**Evora: CME**; DECSIS; RINA-C **Alkmaar: GA**; RINA-C; SEV
KPI Formula	The indicator provides a qualitative measure and is rated on a five-point Likert scale: Not at all - 1 – 2 – 3 – 4 – 5 – Very much 1. Not at all: the solution differs to such a degree from the usual way of doing things and/or from existing norms and values, that it is almost impossible for people to accept the solution. 2. Low: the solution requires considerable changes in the current way of doing things, and/or requires a change in norms and values. 3. Moderate: the solution has certain aspects that differ from the usual way of doing things which users (or others involved) will need to get accustomed to, but requires no major changes in norms or values. 4. High: the solution is largely compatible with the current way of doing things, or with existing norms and values. Only slight adjustments are needed. 5. Very high: the solution does not differ from the usual way of doing things in operational sense and is fully consistent with existing norms and values Two examples and nuances between required changes to people's values or ways of doing things:

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	• A car sharing system with membership and a per km payments requires a completely different mindset compared to a privately owned car and a change in travel habits, and thus would score a 1. • A public transport paying card requires some changes in habits (not buying paper tickets, ensuring that you always have the card with you when travelling, etc.), but not a major change in norms and values and thus gets a score of 3.									
Recommended Measurement Process and Data Sources	To be derived from project documentation and/or interviews with the project leader and/or end-users and stakeholders.									
Recommended Evaluation Interval	Once				Reporting to SCIS	*YES*		*NO*	X	
Unit of Measurement	5-Point Likert Scale (No Unit)				Threshold Target Value	TBD				
Relevant Stakeholders	Energy Utilities			X	Spatial Scale of Evaluation	Building Level				
	Consumers (end-users)			X		Building Block Level (PEB)				
	Technology and Services Providers					District Level (PED)				X
	Policy-making Bodies/Governance			X		City Level				X
	Representative Citizen Groups			X						
	Citizen Ambassadors			X						
Type of Indicator	Output				Temporal Scale of Evaluation	In-project timeframe				X
	Impact			X		End of project				X
						Post-project				X
ETT-reference	ETT#1	X	ETT#2	X	ETT#3	X	ETT#4	X		
IS-reference	IS-1.1	X	IS-1.2	X	IS-1.3	X	IS-2.1	X	IS-1.1	X
	IS-3.1	X	IS-3.2	X	IS-4.1	X	IS-4.2	X	IS-3.1	X

4.8.1.2 P.2 Technical compatibility (CORE)

Technical compatibility (CORE)	
KPI Description	The extent to which the smart city solution fits with the current existing technological standards/infrastructures. This indicator aims to provide an indication of the technical compatibility of the smart city solution, meaning the extent to which the solution fits with current practices, administrative and existing technological standards/infrastructures. The large-scale implementation of micro-CHP in households, for example, is hampered by technical (and economic, regulatory and practical/organizational) barriers; problems “concerning voltage” profiles, power quality and voltage displacement of the star point of the utility grid” (Six, Vekemans and Dexters 2009, 244) hamper the mass introduction of micro-CHP for domestic use. The culmination of such technical barriers hampers the technical compatibility of an innovation in society.
KPI Owner	**Evora: CME**; EDPL **Alkmaar: GA**; SEV
KPI Formula	The indicator provides a qualitative measure and is rated on a five- point Likert scale: No technical compatibility - 1 — 2 — 3 — 4 — 5 — Very high

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	1. No technical compatibility: the solution needs many and major adjustments to current (infra)structures and/or practices for its implementation. 2. Low compatibility: the solution requires some major adjustments to current (infra)structures and/or practices for its implementation. 3. Moderate: some adjustments to current (infra)structures and/or practices are necessary to implement the solution. 4. High: only minor adjustments (think of a different type of plug, a specific internet connection, etc.) are needed to implement the solution. 5. Very high: no adjustments to current (infra)structures and/or practices are needed, the solution can immediately be implemented.						
Recommended Measurement Process and Data Sources	To be derived from interviews with the project leader and/or stakeholders and based on expert judgement						
Recommended Evaluation Interval	Once		Reporting to SCIS	*YES*		*NO*	X
Unit of Measurement	5-Point Likert Scale (No Unit)		Threshold Target Value	TBD			
Relevant Stakeholders	Energy Utilities	X	Spatial Scale of Evaluation	Building Level			
	Consumers (end-users)	X		Building Block Level (PEB)			X
	Technology and Services Providers	X		District Level (PED)			X
	Policy-making Bodies/Governance	X		City Level			X
	Representative Citizen Groups						
	Citizen Ambassadors						
Type of Indicator	Output		Temporal Scale of Evaluation	In-project timeframe			X
	Impact	X		End of project			X
				Post-project			X

ETT-reference	ETT#1	X	ETT#2	X	ETT#3	X	ETT#4	X	
IS-reference	IS-1.1	X	IS-1.2	X	IS-1.3	X	IS-2.1	X	IS-2.2	X
	IS-3.1	X	IS-3.2	X	IS-4.1	X	IS-4.2		IS-4.3	X

4.8.1.3 P.3 Market demand (CORE)

Market demand (CORE)	
KPI Description	The extent to which there is a general market demand for the solution. An important characteristic for the rate of adoption of smart city solutions is the extent to which the innovation meets the needs of its potential adopters. It is expected that innovation can have a distinctive connection to generic problems in European cities, but that the current demand for a solution is relatively low. The potential for diffusion is expected to be greater for solutions with a high level of market demand.
KPI Owner	**Evora: CME**; RINA-C **Alkmaar: GA**; RINA-C; SEV
KPI Formula	The indicator provides a qualitative measure and is rated on a five- point Likert scale:

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	No demand - 1 — 2 — 3 — 4 — 5 — Very high demand 1. No demand: There is no discernible market demand for the offered solution. 2. Little demand: There is little market demand for the offered solution. 3. Some demand: There is some market demand for the offered solution. 4. High demand: There is a large market demand for the offered solution. 5. Very high demand: There is a widespread market demand for the offered solution.				
Recommended Measurement Process and Data Sources	To be derived from interviews with the project leader and/or stakeholders, and based on expert judgement.				
Recommended Evaluation Interval	Yearly		**Reporting to SCIS**	*YES*	*NO* X
Unit of Measurement	5-Point Likert Scale (No unit)		**Threshold Target Value**	TBD	
Relevant Stakeholders	Energy Utilities	X	**Spatial Scale of Evaluation**	Building Level	X
	Consumers (end-users)	X		Building Block Level (PEB)	X
	Technology and Services Providers	X		District Level (PED)	X
	Policy-making Bodies/Governance	X		City Level	X
	Representative Citizen Groups	X			
	Citizen Ambassadors	X			
Type of Indicator	Output		**Temporal Scale of Evaluation**	In-project timeframe	X
	Impact	X		End of project	X
				Post-project	X

ETT-reference	ETT#1	X	ETT#2	X	ETT#3	X	ETT#4	X		
IS-reference	IS-1.1	X	IS-1.2	X	IS-1.3	X	IS-2.1	X	IS-1.1	X
	IS-3.1	X	IS-3.2	X	IS-4.1	X	IS-4.2	X	IS-3.1	X

4.8.1.4 P.4 Diffusion to other locations (CORE)

Diffusion to other locations (CORE)	
KPI Description	The extent to which the project is planned to be copied or already copied in other cities and regions. A smart city concept can attract the interest to be copied by other cities or regions. This can entail both the solutions within the project (e.g. technology, new product) as the institutional aspects of the project. The latter can for instance be the copying of procurement process, mimicking the way civil servants' support for a new development, creating a culture conducive of change, or changing regulations in another location to free the way for a new development. An example of active copying of low carbon strategies is the 'Replication Cluster' in the European SINFONIA project by 'early adopter cities'. It is presumed that smart city projects have a higher potential for diffusion, when other locations have already copied the solutions or institutional aspects.
KPI Owner	**Evora: CME;**

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<table>
<tr><td></td><td colspan="6">Alkmaar: GA;</td></tr>
<tr><td>KPI Formula</td><td colspan="6">The indicator provides a qualitative measure and is rated on a five- point Likert scale:
Not copied in other locations - 1 — 2 — 3 — 4 — 5 — Very much copied in other locations
1. The innovation is not copied in other locations and no MoC is signed
2. The innovation has attracted the interest to be copied once in another location within the same city/region and a MoC is signed.
3. The innovation has attracted the interest to be copied several times within the same city/region and more than two MoC are signed
4. The innovation has attracted the interest to be copied in projects within the same city/region with more than two MoC signed, as well as projects outside the original city/region with more than two MoC signed
5. The innovation has been copied in its country of origin, as well as internationally.
The number of MoC signed needs to be reported as well.</td></tr>
<tr><td>Recommended Measurement Process and Data Sources</td><td colspan="6">To be derived from interviews with the project leader and/or stakeholders and an online search with keywords.</td></tr>
<tr><td>Recommended Evaluation Interval</td><td colspan="2">Once</td><td>Reporting to SCIS</td><td colspan="3">YES | | NO | X</td></tr>
<tr><td>Unit of Measurement</td><td colspan="2">5-Point Likert Scale (No Unit)</td><td>Threshold Target Value</td><td colspan="3">TBD</td></tr>
<tr><td rowspan="6">Relevant Stakeholders</td><td>Energy Utilities</td><td>X</td><td rowspan="6">Spatial Scale of Evaluation</td><td colspan="2">Building Level</td><td>X</td></tr>
<tr><td>Consumers (end-users)</td><td></td><td colspan="2">Building Block Level (PEB)</td><td>X</td></tr>
<tr><td>Technology and Services Providers</td><td>X</td><td colspan="2">District Level (PED)</td><td>X</td></tr>
<tr><td>Policy-making Bodies/Governance</td><td>X</td><td colspan="2">City Level</td><td>X</td></tr>
<tr><td>Representative Citizen Groups</td><td></td><td colspan="2"></td><td></td></tr>
<tr><td>Citizen Ambassadors</td><td></td><td colspan="2"></td><td></td></tr>
<tr><td rowspan="3">Type of Indicator</td><td>Output</td><td></td><td rowspan="3">Temporal Scale of Evaluation</td><td colspan="2">In-project timeframe</td><td></td></tr>
<tr><td>Impact</td><td>X</td><td colspan="2">End of project</td><td>X</td></tr>
<tr><td></td><td></td><td colspan="2">Post-project</td><td>X</td></tr>
</table>

ETT-reference	ETT#1	X	ETT#2	X	ETT#3	X	ETT#4	X		
IS-reference	IS-1.1	X	IS-1.2	X	IS-1.3	X	IS-2.1	X	IS-1.1	X
	IS-3.1	X	IS-3.2	X	IS-4.1	X	IS-4.2	X	IS-3.1	X

4.9 POCITYF's Project Success Indicators (PSIs)

In addition to the KPIs selected and presented above, POCITYF needs to comply with broader project based objectives linked to Smart City Projects expected impact and EU core ambition for energy transition. These objectives can be evaluated with the help of Project Success Indicators (PSIs). We differentiate these indicators to the aforementioned KPIs as they provide a global view of the project success and its impact towards green, smart, resilient and autonomous cities. They have been already described in the GAF with well-defined target values. **Their evaluation and monitoring is essential and should be performed in each reporting period (when applicable).** Please note that in the GAF, these Project Success Indicators are mentioned as KPIs.

A large set of these PSIs can be easily evaluated with the help of the selected KPIs; Nevertheless, a substantial set of PSIs cannot be evaluated similarly and thus we choose to define them separately with simplified cards. Aggregations do not make sense (especially on ETT/IS/Spatial levels) for these PSIs and their calculation formula/method is straight-forward. Their calculation will in one sense naturally occur during the project and they will be reported in several POCITYF reports and/or deliverables. For example, all dissemination activities are reported into the Project/Technical Management deliverables as well as Technical Reports so the KPI: Number of peer-reviewed publications due to POCITYF activities will be available by the end of the project. In contrast to other impact related KPIs, this set of indicators does not fit into the chosen dimensions or/and are too simplified and case specific so that are excluded from the KPI selection methodology and process. **Please note that KPI ownership has been assigned to LH management partners and it is subject to change.**

In the following subsections both sets of PSIs are presented: Firstly, in section 4.9.1 the separately defined PSI list is presented (along with details in the form of PSI cards) while in section 4.9.2 we present the correspondence of the set of PSI that can be directly linked to the KPIs defined. We note that in the separately defined PSI list, PSIs 7.1-7.5 have not been numbered in the GAF.

4.9.1 Separately defined PSI list

4.9.1.1 PSI 1.1-1.2: PEBs and PEDs deployed

<table>
<tr><th colspan="8">PEBs and PEDs deployed</th></tr>
<tr><td>KPI Description</td><td colspan="7">The total number of PEBs and PEDs deployed. To be assessed in two temporal levels: At the end of POCITYF and until 2030 due to POCITYF</td></tr>
<tr><td>KPI Owner</td><td colspan="7">Evora: EDPL; Alkmaar: GA</td></tr>
<tr><td>Recommended Measurement Process and Data Sources</td><td colspan="7">N/A</td></tr>
<tr><td>Recommended Evaluation Interval</td><td colspan="2">Each reporting period</td><td>Reporting to SCIS</td><td>YES</td><td></td><td>NO</td><td>X</td></tr>
<tr><td>Unit of Measurement</td><td colspan="2">#</td><td>Threshold Target Value</td><td colspan="4">End of project: 4
Post-project (2030): 4 PEDs and 12 PEBs</td></tr>
<tr><td rowspan="3">Type of Indicator</td><td>Output</td><td></td><td rowspan="3">Temporal Scale of Evaluation</td><td colspan="3">In-project timeframe</td><td></td></tr>
<tr><td>Impact</td><td>X</td><td colspan="3">End of project</td><td>X</td></tr>
<tr><td></td><td></td><td colspan="3">Post-project</td><td>X</td></tr>
</table>

4.9.1.2 PSI 1.3 POCITYF cities with approved and implemented SECAP

<table>
<tr><th colspan="2">POCITYF cities with approved and implemented SECAP</th></tr>
<tr><td>KPI Description</td><td>The total number of POCITYF cities with an approved and implemented Sustainable Energy and Climate Action Plan (SECAP) by the end of the project</td></tr>
<tr><td>KPI Owner</td><td>Evora: EDPL; Alkmaar: GA</td></tr>
<tr><td>Recommended Measurement</td><td>N/A</td></tr>
</table>

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Process and Data Sources							
Recommended Evaluation Interval	Each reporting period		Reporting to SCIS	*YES*		*NO*	X
Unit of Measurement	#		Threshold Target Value	8			
Type of Indicator	Output		Temporal Scale of Evaluation	In-project timeframe			
	Impact	X		End of project			X
				Post-project			

4.9.1.3 PSI 3.1: Cities committed as new POCITYF FCs

Cities committed as new POCITYF FCs							
KPI Description	The number of cities committed to replicate solutions as new POCITYF FCs until the end of the project						
KPI Owner	Evora: **EDPL;** Alkmaar**: GA**						
Recommended Measurement Process and Data Sources	N/A						
Recommended Evaluation Interval	Each reporting period		Reporting to SCIS	*YES*		*NO*	X
Unit of Measurement	#		Threshold Target Value	20			
Type of Indicator	Output		Temporal Scale of Evaluation	In-project timeframe			
	Impact	X		End of project			X
				Post-project			

4.9.1.4 PSI 3.2: Floor area for demonstrating (LH) and replicating (FC) POCITYF solutions

Floor area for demonstrating (LH) and replicating (FC) POCITYF solutions	
KPI Description	Floor area for demonstrating (LH) and replicating (FC) POCITYF solutions. For demonstrating, the floor area should be evaluated in the end of the project while for replicating in the 2030 timeframe.
KPI Owner	Evora: **EDPL;** Alkmaar**: GA**
Recommended Measurement Process and Data Sources	N/A

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Recommended Evaluation Interval	Each reporting period		Reporting to SCIS	*YES*		*NO*	X
Unit of Measurement	#		Threshold Target Value	Demonstrating: 87,480 m2 Replicating: >140.265 m2			
Type of Indicator	Output		Temporal Scale of Evaluation	In-project timeframe			
	Impact	X		End of project	X		
				Post-project	X		

4.9.1.5 PSI 3.4 Number of residents living within the PEDs of POCITYF's LHs and FCs

Number of residents living within the PEDs of POTICYF's LHs and FCs							
KPI Description	The number of residents living (or expected to be living) inside the PEDs created by POCITYF in the LHs and FCs						
KPI Owner	Evora: **EDPL;** Alkmaar**: GA**						
Recommended Measurement Process and Data Sources	N/A						
Recommended Evaluation Interval	Each reporting period		Reporting to SCIS	*YES*		*NO*	X
Unit of Measurement	#		Threshold Target Value	169,247			
Type of Indicator	Output		Temporal Scale of Evaluation	In-project timeframe			
	Impact	X		End of project	X		
				Post-project			

4.9.1.6 PSI 7.1: Number of patents per 100 000 population per year

Number of patents due to POCITYF							
KPI Description	The total number of patents identified during and due to the project implementation.						
KPI Owner	Evora: **EDPL;** Alkmaar**: GA**						
Recommended Measurement Process and Data Sources	Data could be sourced from the municipalities and the LH managers. Data could be obtained from Government Patent Offices, who maintain records of all patents registered to persons and corporations across jurisdiction.						
Recommended Monitoring Interval	Each reporting period		Reporting to SCIS	*YES*		*NO*	X

Unit of Measurement	#		Threshold Target Value	>3	
Type of Indicator	Output		Temporal Scale of Evaluation	In-project timeframe	
	Impact	X		End of project	X
				Post-project	

4.9.1.7 PSI 7.2: Number of peer-reviewed publications due to POCITYF activities

Peer-reviewed publications due to POCITYF activities							
KPI Description	The total number of peer-reviewed publications by the end of the project due to POCITYF activities						
KPI Owner	Evora: **EDPL;** Alkmaar**: GA**						
Recommended Measurement Process and Data Sources	The number of the publicly accessible publications will be reported on the SYGMA platform. N						
Recommended Evaluation Interval	Each reporting period		Reporting to SCIS	*YES*		*NO*	X
Unit of Measurement	#		Threshold Target Value	>10			
Type of Indicator	Output		Temporal Scale of Evaluation	In-project timeframe			
	Impact	X		End of project			X
				Post-project			

4.9.1.8 PSI 7.3: Similar projects where cooperation with POCITYF is established

Similar projects where cooperation with POCITYF is established							
KPI Description	The total number of similar projects where cooperation has been established by the end of the project						
KPI Owner	Evora: **EDPL;** Alkmaar**: GA**						
Recommended Measurement Process and Data Sources	POCITYF will collaborate with several other project. Workshops will be organized and noted down.N						
Recommended Evaluation Interval	Each reporting period		Reporting to SCIS	*YES*		*NO*	X
Unit of Measurement	#		Threshold Target Value	>5			

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Type of Indicator	Output		Temporal Scale of Evaluation	In-project timeframe	
	Impact	X		End of project	X
				Post-project	

4.9.1.9 PSI 7.4: Additional European cities included into POCITYF dissemination and exploitation networks

Additional European cities included into POCITYF dissemination and exploitation networks							
KPI Description	The number of additional European cities included into POCITYF dissemination and exploitation networks						
KPI Owner	Evora: **EDPL;** Alkmaar: **GA**						
Recommended Measurement Process and Data Sources	N/A						
Recommended Evaluation Interval	Each reporting period		Reporting to SCIS	*YES*		*NO*	X
Unit of Measurement	#		Threshold Target Value	100			
Type of Indicator	Output		Temporal Scale of Evaluation	In-project timeframe			
	Impact	X		End of project			X
				Post-project			

4.9.1.10 PSI 7.5: Parties interested in using POCITYF solutions

Parties interested in using POCITYF solutions							
KPI Description	The number and geographical spread of parties potentially interested in using POCITYF solutions						
KPI Owner	Evora: **EDPL;** Alkmaar: **GA**						
Recommended Measurement Process and Data Sources	N/A						
Recommended Evaluation Interval	Each reporting period		Reporting to SCIS	*YES*		*NO*	X
Unit of Measurement	#		Threshold Target Value	>50 entities from > 10 countries			
Type of Indicator	Output			In-project timeframe			

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	Impact	X	Temporal Scale of Evaluation	End of project	X
				Post-project	

4.9.2 PSIs with direct correspondence with defined KPIs

In this section the connection of the selected KPIs with POCITYF Objectives and related success indicators is established. The POCITYF Success Indicators have been extracted from the BEST tables (see GA and amendment) and form a collection of indicators which need to be evaluated in order to assess the global success and performance of the project at its end. We hereby call them Project Success Indicators (PSI) in order to differentiate them with the KPIs identification. As explained in section 4.9 (and before) the selected KPIs need to provide the means for monitoring and evaluating these PSIs and thus a direct link between each of these indicators should be easily made. Moreover, these indicators have very clearly defined target values which can be used as such, for the relevant KPIs too. Table 10 summarizes this correspondence. Note that for specific PSIs more than one KPI needs to be used in order to evaluate its specific performance. The KPI-linked required variables for the PSI calculation are provided as well as the calculation formula (when applicable and it is not directly derived from the KPI value).

Table 10. Key Performance Indicators and Project Success Indicators correspondence

KPI - PSI Correspondence			
POCITYF KPI	**E.1 Energy Demand and Consumption** Required variables: TE_d = Final Thermal energy demand EE_d = Final Electrical energy demand **E.3 Self sufficiency ratio** Required variables: C = RES power that is utilized directly within the system (building etc)	POCITYF PSI	**4.2: Reduction of total incoming energy through PEBS** Calculation/Formula: $[(TE_d + EE_d) - C]_{baseline} - [(TE_d + EE_d) - C]_{monitored}$ *Refer to BEST Tables if estimated otherwise*
Target value	10,492.6 MWh/y		
POCITYF KPI	**E.2 Degree of energetic self supply** Required variables: LPE_T = Locally produced thermal energy LPE_E = Locally produced electrical energy	POCITYF PSI	**2.1: Total local RES produced within the PEBs** Calculation/Formula: $LPE_T + LPE_E$
Target value	16,913 MWh/year		

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POCITYF KPI	**E.2 Degree of energetic self supply** Required variables: LPE_T = Locally produced thermal energy LPE_E = Locally produced electrical energy **E.3 Self sufficiency ratio** Required variables: C = RES power that is utilized directly within the system (building etc)	POCITYF PSI	**4.3: Increase of total out coming energy through PEBs** Calculation/Formula: $[(LPE_T + LPE_E) - C]_{monitored} - [(LPE_T + LPE_E) - C]_{baseline}$ *Refer to BEST Tables if estimated otherwise*
Target value	7,803.7 MWh/y		
POCITYF KPI	**E.4 Energy Savings** Required variables: ES_{total}	POCITYF PSI	**4.1: Total net energy savings due to POCITYF within PEBs**
Target value	2,311 MWh/y		
POCITYF KPI	**E.7 Smart Storage Capacity** Required variables: $SCI_{R\&I}$ = storage capacity installed due to R&I activities during the project in the area (thermal, batteries, V2G)	POCITYF PSI	**2.4: Thermal storage within PEBs** **2.5: Batteries storage within PEBs** **2.6: V2G storage within PEBs**
Target value	2.4: 2,052 MWh 2.5: 1.885 MWh 2.6: 1.916 MWh		
POCITYF KPI	**E.8 Heat Recovery Ratio** Required variables: $TE_{recovered}$ = Thermal energy (waste heat) recovered from the system	POCITYF PSI	**2.3: Waste heat recovery within PEBs**
Target value	5,880 MWh		

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POCITYF KPI	**E.3 Self Sufficiency Ratio** Required variables: C = RES power that is utilized directly within the system (building etc) A = Net energy demand	POCITYF PSI	**2.2: Percentage of total net energy needs covered by local RES within the PEBs** Calculation/Formula: $C/A \times 100$ **4.4: Percentage of total energy needs covered by resources coming from outside PEBs** Calculation/Formula: $\min(1{,}1 - \frac{C}{A}) \times 100$ *Refer to BEST Tables if estimated otherwise*
Target value	**2.2:** 114% (PEB1-Evora), 125% (PEB2-Evora), 124% (PEB3-Evora) and 178% (194%) (PEB1-Alkmaar) **4.4:** 19% (PEB1-Evora), 18% (PEB2-Evora), 0% (PEB3-Evora) and 37% (PEB1-Alkmaar)		
POCITYF KPI	**EN.2 Carbon Dioxide Emission Reduction** Required variables : m_{CO_2}	POCITYF PSI	**6.1: Total carbon dioxide emission reduction** Calculation/Formula: $m_{CO_2\,baseline} - m_{CO_2}$
Target value	9,743 tons CO2eq/year		
POCITYF KPI	**EN.1 Greenhouse Gas Emissions** Required variables: GGE	POCITYF PSI	**2.7: Reduction of building energy consumption related GHG emissions emitted within PEBs** Calculation/Formula: $GGE_{baseline} - GGE$
Target value	3,574 tons CO2eq/y		
POCITYF KPI	**EN.3 Air Quality Index**	POCITYF PSI	**6.2: Nitrogen oxides reduction due to increased e-mobility** **6.3: Sulfur dioxide reduction due to increased e-mobility** *Refer to GA for detailed estimations and assumptions applied*
Target value	6.2: 47.5 tons NOX/year 6.3: 271.5 tons SO2/year		
POCITYF KPI	**EC.3 Payback Period** Required variables: EPP	POCITYF PSI	**3.5: Pay-back period of POCITYF solutions**
Target value	<10 years		
POCITYF KPI	**M.1 Electric Vehicles & Low-Carbon Emission Vehicles deployed in the area**	POCITYF PSI	**5.1: Expected number of new e-vehicles rolled-out by the end of POCITYF on a city level**
Target value	2,050 e-cars, 37 e-buses, 8,500 e-bikes		

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POCITYF KPI	**M.2 Number of EV charging stations**/points **and solar powered V2G charging stations**/points **deployed in the area**	POCITYF PSI	**5.3: Expected number of new EV charging points rolled-out by the end of POCITYF**
Target value	1,099 (on a city level), 101 (within PEDs) - target value is subject to modifications on DC lampposts solution in Alkmaar LH		
POCITYF KPI	**M.5 Shared Electric Vehicles Penetration Rate**	POCITYF PSI	**5.2: Number of EVs participating in car-sharing schemes by the end of POCITYF**
Target value	110		
POCITYF KPI	**EC.10 New Business Ideas Generated**	POCITYF PSI	**7.6: Number of new and feasible product ideas generated within the project duration**
Target value	>30		
POCITYF KPI	**P.4 Diffusion to other locations**	POCITYF PSI	**7.7: Memorandum of cooperation with cities aiming at replication activities**
Target value	20		

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5 Conclusions

The definition of POCITYF Key Performance Indicators (KPIs) has been realized through a detailed methodological process which strongly relates to the needs of LH cities and their citizens towards their energetic transition. These needs include concerns on energy, environmental, social, ICT, mobility, economic, governance and diffusion/propagation dimensions which also relate to the various stakeholders participating or being interested in POCITYF's interventions. By proper clustering of the indicators to evaluation levels (spatial, temporal, ETT), the performance of these interventions as well as the overall success of POCITYF in terms of a SCC project can be monitored and evaluated in a transparent and holistic way. The defined KPI cards including all metrics and formulas along with the Project Success Indicators defined also in this deliverable, formulate an complete framework for the necessary monitoring activities in POCITYF and will serve greatly towards achieving the project objectives as well as properly and timely mitigating any associated risks during the demonstration activities.

ANNEX A

KPI pool and evaluation according to pre-defined criteria

		Evaluation Criteria					Score
KPI Dimension	KPIs (Green: Core / Blue: Supporting)	Relevance	Availability	Measurability	Reliability	Familiarity	
Energy							
Energy	Energy demand and consumption	2	1	2	2	2	9
Energy	Energy savings	2	1	2	2	2	9
Energy	Reduction in annual final energy consumption	2	2	2	2	2	10
Energy	Electricity System Outage Frequency	2	2	2	2	1	9
Energy	Electricity System Outage Time	2	2	2	2	1	9
Energy	Degree of energetic self-supply by RES	2	1	2	2	1	8
Energy	Increase in local renewable energy production	2	2	2	2	2	10
Energy	Renewable energy generated within the city	2	1	2	2	2	9
Energy	Reduced energy curtailment of RES and DER	2	1	2	1	1	7
Energy	Energy intensity (consumption / GDP)	2	1	1	1	1	6
Energy	Individual building energy balance	2	2	1	1	1	7
Energy	Specific Yield	2	1	2	1	1	7
Energy	Solar gain coefficient	2	2	2	1	1	8
Energy	kWp photovoltaic installed per 100 inhabitants	2	2	2	2	2	10
Energy	System performance	2	1	1	1	1	6
Energy	Generation system efficiency	2	1	1	1	1	6
Energy	Distribution system efficiency	2	1	1	1	1	6
Energy	Consumption system efficiency	2	1	1	1	1	6
Energy	Equipment energy efficiency	2	1	1	1	1	6
Energy	Smart Storage Capacity	2	1	2	1	1	7
Energy	Battery Degradation Rate	2	1	1	1	1	6
Energy	Storage Energy Losses	2	1	2	1	1	7
Energy	Maximum Hourly Deficit (MHDx)	2	1	1	1	0	5
Energy	Capacity factor	2	1	2	1	1	7
Energy	Influence of energy storage on cutting peak demand	2	1	2	1	1	7
Energy	Storage capacity of the city's energy grid per total city energy consumption	2	1	1	1	1	6
Energy	Storage system efficiency	2	1	1	1	1	6

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Energy	Buildings served by the district heating	2	1	1	1	1	6
Energy	Thermal load reduction	2	1	2	1	1	7
Energy	Heat recovery ratio	2	1	2	1	1	7
Energy	Peak demand reduction	2	1	2	1	1	7
Energy	Accuracy of energy supply and demand prediction	2	1	1	1	1	6
Energy	Integrated Building Management Systems in Buildings	2	2	2	1	1	8
Energy	Peak load and load profile of electricity demand	2	1	2	1	1	7
Energy	Peak load and load profile of thermal energy demand	2	1	2	1	1	7
Energy	Percentage of street lighting managed by a light performance management system	2	1	2	2	2	9
Energy	Energy used for lighting	1	2	2	2	2	9
Energy	Lighting energy efficiency	1	1	2	1	1	6
Energy	Percentage of buildings in the city with smart energy meters	2	1	2	2	2	9
Energy	Smart electricity meters	2	2	2	1	1	8
Energy	Percentage of waste drop-off centres (containers) equipped with telemetering	1	1	2	2	1	7
Energy	Percentage of the city population that has a door-to-door garbage collection with an individual monitoring of household waste quantities	1	1	2	2	1	7
Energy	Percentage of total amount of waste in the city that is used to generate energy	1	1	1	2	2	7
Energy	Percentage of public garbage bins that are sensor-enabled public garbage bins	1	1	1	2	2	7
Energy	Cultural Heritage building preservation	2	1	2	1	1	7
Energy	Refurbished buildings improving energy performance	2	1	1	1	1	6
Environmental							
Environmental	Greenhouse Gas Emissions	2	2	2	2	2	10
Environmental	Primary Energy Demand and Consumption	2	1	1	2	1	7
Environmental	Carbon dioxide Emission Reduction	2	2	2	2	2	10
Environmental	Reduction in lifecycle CO2 emissions	2	0	1	1	1	5
Environmental	Climate resilience measures	1	2	1	1	2	7
Environmental	Climate resilience strategy	2	2	1	1	2	8
Environmental	Decreased emissions of Nitrogen oxides (NOx)	1	1	1	2	1	6
Environmental	Nitrogen oxide emissions (Nox)	1	1	2	2	1	7
Environmental	Decreased emissions of Particulate matter (PM2,5)	2	1	1	2	1	7
Environmental	Fine particulate matter emissions (or concentration) (PM2.5)	2	1	2	2	1	8
Environmental	Number of days particulate matter PM10 concentrations exceed 50 µg/m³	2	1	2	2	1	8
Environmental	Annual average concentration of PM10	2	1	2	2	1	8
Environmental	Sulphur dioxide levels	1	1	2	2	1	7
Environmental	O3 emissions (or concentration)	1	1	2	2	1	7
Environmental	Indoor air quality	1	0	2	1	2	6
Environmental	Air quality index (Air pollution)	2	1	2	2	1	8

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Environmental	Reduced exposure to noise pollution	2	1	1	1	2	7
Environmental	Noise pollution	2	1	2	2	2	9
Environmental	EMF Exposure	1	0	2	1	0	4
Environmental	Urban Heat Island	1	1	2	2	1	7
Environmental	Reduction in the amount of solid waste collected	1	1	2	1	2	7
Environmental	Municipal solid waste	2	1	2	2	2	9
Environmental	Recycling Rate	2	1	2	2	2	9
Environmental	Percentage of city population with regular solid waste collection (residential)	1	1	2	1	1	6
Environmental	Percentage of the city's solid waste that is treated in energy-from-waste plants	2	1	2	1	1	7
Environmental	Percentage of the city's solid waste that is biologically treated and used as compost or biogas	1	1	2	1	1	6
Environmental	Percentage of electrical and thermal energy produced from wastewater treatment, solid waste and other liquid waste treatment and other waste heat resources, as a share of the city's total energy mix	2	1	1	1	1	6
Environmental	Electrical and thermal energy (GJ) produced from solid waste or other liquid waste treatment per year	2	1	2	1	1	7
Environmental	Solid Waste Treatment	1	1	2	1	1	6
Economic							
Economic	Grants	1	2	2	1	2	8
Economic	Total Investments	2	2	2	2	2	10
Economic	Total Annual costs	2	1	2	2	2	9
Economic	€M reduction compared to planned investment	2	1	1	1	2	7
Economic	Total annual revenues	1	1	2	1	2	7
Economic	Payback period	2	1	2	2	2	9
Economic	Return on Investment (ROI)	2	1	2	2	1	8
Economic	Net Present Value (NPV)	1	1	2	2	1	7
Economic	Internal rate of return (IRR)	1	1	2	2	1	7
Economic	Gross Domestic Product	1	2	1	2	1	7
Economic	Percentage of the ICT sector on GDP	1	1	1	1	1	5
Economic	Improved competitiveness of electricity market	1	1	1	1	1	5
Economic	Average electricity price for companies and consumers	2	2	2	1	2	9
Economic	Increased use of local workforce	1	2	2	1	2	8
Economic	Percentage of the total Distributed Energy Resources capacity traded	2	1	2	2	2	9
Economic	Local job creation	2	2	1	2	2	9
Economic	Green jobs	1	2	1	1	1	6
Economic	City's unemployment rate (CI: core indicator)	0	2	1	2	2	7
Economic	Energy poverty	2	1	1	1	2	7
Economic	Percentage of population living below the international poverty line (CI)	0	1	1	1	2	5
Economic	Certified companies involved in the project	1	2	1	2	1	7
Economic	Share of certified companies	1	1	1	2	1	6

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Economic	Green public procurement	1	1	1	1	1	5
Economic	Share of Green Public Procurement	1	1	1	1	1	5
Economic	CO2 reduction cost efficiency	2	1	1	1	2	7
Economic	Financial benefit for the end- user	2	1	2	1	1	7
Economic	Involvement of extraordinary professionals	1	1	1	1	1	5
Economic	Innovation hubs in the city	1	2	1	2	1	7
Economic	R&D expenditure	1	2	2	1	1	7
Economic	New business creation	2	2	1	2	2	9
Economic	New startups	1	2	2	2	2	9
Economic	Stimulating an innovative environment	2	1	1	1	1	6
Economic	Awareness of economic benefits of reduced energy consumption	2	1	1	1	2	7
Economic	Incentives for final users for low carbon measures	2	1	2	1	1	7
Economic	Energy consumption reduction cost	2	1	2	1	1	7
Economic	Expenditure in local economy (ELE)	1	1	2	1	1	6
Economic	Impact in business unit (IBU)	1	1	1	1	1	5
Economic	Number of patents per 100 000 population per year (SI)	2	2	2	2	2	10
Economic	Expenditures by the municipality for a transition towards a smart city	2	2	2	1	2	9
Economic	Annual amount of revenues collected from the sharing economy as a percentage of own-source revenue	1	1	1	1	1	5
ICT							
ICT	Increased reliability	2	1	1	1	1	6
ICT	Increased Power Quality and Quality of Supply (DSO+TSO)	1	1	2	1	1	6
ICT	Increased system flexibility for energy players	2	1	2	1	1	7
ICT	Reduction of energy price by ICT related technologies	2	1	2	1	1	7
ICT	Peak load reduction	2	1	2	1	1	7
ICT	Increased hosting capacity for RES, electric vehicles and other new loads	2	1	2	2	1	8
ICT	Consumers engagement	2	1	1	1	1	6
ICT	Developer engagement	2	1	1	1	1	6
ICT	Cybersecurity & Level of Improvement (145ocalize Cybersecurity)	2	2	1	1	1	7
ICT	Data privacy - Data Safety & Level of Improvement (Improved Data Privacy)	2	2	1	2	2	9
ICT	No. of operational apps that promote citizen engagements (adjusted the "Number of APIs connected to the Decision Support Tool (DST)")	2	1	1	1	1	6
ICT	Flexibility in delivery services & Level of Improvement (Improved Flexibility)	2	2	1	1	1	7
ICT	Monitoring use of EV/FC charging stations	2	1	2	1	1	7
ICT	Number of sensors integrated/devices connected	2	1	2	1	1	7
ICT	Number of available Open Data sets/sources	2	1	2	1	1	7
ICT	ICT Response time	2	2	2	1	1	8
ICT	ICT Availability	2	1	2	1	1	7

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ICT	ICT Storage Capacity	2	1	2	1	1	7
ICT	Improved Interoperability	2	2	1	1	1	7
ICT	Cloud Solutions/Services	2	1	1	1	1	6
ICT	Data Center Capacity	1	1	1	2	1	6
ICT	Use of Open Data platform	2	1	1	1	1	6
ICT	Quality of Open Data	2	2	1	2	1	8
ICT	Open data based solutions	2	1	1	1	1	6
ICT	Electricity Supply ICT Monitoring	1	2	1	2	1	7
ICT	Demand Response Penetration	1	1	1	1	1	5
ICT	Platform downtime	2	1	2	2	1	8
Mobility							
Mobility	Energy consumption data aggregated by sector fuel	2	1	1	1	1	6
Mobility	Kilometres of high capacity public transport system per 100 000 population	1	1	2	2	2	8
Mobility	Passenger-kilometres public transport and private vehicle	1	2	1	2	2	8
Mobility	Electric Vehicles & Low-Carbon Emission Vehicles deployed in the area	2	1	2	2	2	9
Mobility	Number of Evs charging stations/points and solar powered V2G charging stations/points deployed in the area	2	2	2	2	2	10
Mobility	Impact of ICT apps into mobility	2	1	1	1	1	6
Mobility	Car pooling locations	2	2	2	1	1	8
Mobility	Clean mobility utilization	2	1	2	1	1	7
Mobility	Modal split (passengers, vehicles, trips)	2	1	2	2	1	8
Mobility	Access to vehicle sharing solutions for city travel & Level of Improvement	2	2	1	1	1	7
Mobility	Annual number of public transport per capita	1	2	2	1	2	8
Mobility	Length of bike route network: Kilometres of bicycle paths and lanes per 100 000 population	1	2	2	2	2	9
Mobility	Number of personal automobiles per capita	1	2	2	2	2	9
Mobility	Number of bikes (from bike sharing service) every 100 inhab	1	1	2	2	2	8
Mobility	Public Transport Network	1	2	2	2	1	8
Mobility	Public Transport Network Convenience OR Access to public transport	1	1	2	2	1	7
Mobility	Percentage of commuters using a travel mode to work other than a personal vehicle (SI)	1	1	2	1	2	7
Mobility	Average commute time (SI)	0	1	2	1	2	6
Mobility	Number of users of sharing economy transportation per 100,000 population	1	1	2	1	1	6
Mobility	Availability of real-time traffic information	1	1	1	1	2	6
Mobility	Yearly **km** of Shared Vehicles	2	2	2	2	2	10
Mobility	Percentage of vehicles registered in the city that are autonomous vehicles	0	2	2	2	1	7
Mobility	Percentage of roads conforming with autonomous driving systems	0	1	2	2	1	6

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Mobility	Total number of transport vehicles for passengers	1	2	2	2	2	9
Mobility	Public charging points per eVehicle (EV)	2	2	2	2	2	10
Mobility	Annual Energy delivered by charging points -	2	1	2	2	2	9
Mobility	Total Number of recharges per year (public EV charging stations	2	1	2	1	1	7
Mobility	Total operating time for EV charging operations	2	1	2	2	1	8
Mobility	Average duration of EV charging operations	2	1	2	2	1	8
Mobility	Total Occupancy time of EV charging points	2	1	2	2	1	8
Mobility	Average Occupancy time of EV charging points	2	1	2	2	1	8
Mobility	Charging points powered by renewable energy sources (number and rate)	2	2	2	2	2	10
Mobility	Availability rate of the Solar Road	2	1	2	1	1	7
Mobility	Annual energy produced by **each** charging point or solar road	2	1	2	2	2	9
Mobility	Annual number of passengers (or users) of new infrastructure	2	1	2	2	1	8
Mobility	Use of e-buses	2	2	2	1	1	8
Mobility	Availability rate of e-buses	2	1	2	2	1	8
Mobility	Shared Electric Vehicles Penetration Rate	2	2	2	1	1	8
Social							
Social	People reached	2	1	2	2	2	9
Social	Increased consciousness of citizenship	2	1	1	1	1	6
Social	Increased participation of vulnerable groups	1	2	1	1	2	7
Social	Connection to the existing cultural heritage	2	2	1	1	2	8
Social	Ease of use for end users of the solution	2	1	1	1	2	7
Social	Thermal comfort	2	1	1	1	1	6
Social	Comfort conditions	2	1	1	0	1	5
Social	Increased environmental awareness	2	1	1	1	2	7
Social	Local community involvement in the implementation and planning phase	2	1	1	1	2	7
Social	Increased citizen awareness of the potential of smart city projects	2	1	1	1	1	6
Social	Number of city officials and urban experts trained to conduct the meaningful and ethical engagement of citizens	2	1	1	1	1	6
Social	Provision of a 147ocalized multi stakeholder co-creation and co-production Field Guide for Citizen Engagement	2	1	1	1	1	6
Social	Participation of citizens, citizen representative groups and citizen ambassadors in the co-creation of local/micro KPIs for Citizen Engagement	2	1	1	1	1	6
Social	Number of municipal educational activities on the themes of Smart City every 1000 inhabitants	1	1	2	1	2	7
Social	Number of municipal websites for citizens	0	2	2	1	2	7
Social	Number of interactive social media initiatives	0	2	2	1	1	6
Social	% of citizens' participation in online decision making	2	1	2	1	1	7
Social	Residents project satisfaction	2	1	1	0	1	5

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Social	Degree of satisfaction	2	1	1	1	2	7
Social	Residents involvement degree	2	1	1	1	1	6
Social	Residents energy awareness	2	1	1	1	1	6
Social	Stakeholder willingness to retrofit	2	1	1	0	2	6
Social	Active/proactive citizens's behaviour	2	1	1	1	1	6
Social	Citizens' perception in the social factors	1	1	1	1	1	5
Social	Range of people from diverse social backgrouds reached	1	1	1	1	2	6
Social	Annual number of citizens engaged in the planning process per 100 000 population	2	1	2	1	1	7
Governance							
Governance	Leadership	1	2	1	1	0	5
Governance	Balanced project team	1	2	1	1	2	7
Governance	Involvement of the city administration	2	2	1	1	1	7
Governance	Clear division of responsibility	1	2	1	1	1	6
Governance	Market orientation	1	2	1	1	1	6
Governance	Cross-departmental integration	1	2	1	1	1	6
Governance	Establishment within the administration	1	2	1	1	1	6
Governance	Monitoring and evaluation	2	2	1	1	2	8
Governance	Bottom-up or top-down initiative	0	1	1	1	1	4
Governance	Participatory governance	1	1	2	1	1	6
Governance	Citizen participation	1	1	2	1	2	7
Governance	Open public participation	0	1	2	2	1	6
Governance	Smart city policy	2	2	1	1	1	7
Governance	Municipal involvement Financial support	1	2	1	1	2	7
Governance	Smart city policy	2	2	1	1	1	7
Governance	Legal Framework compatibility	2	2	1	1	1	7
Governance	Natural disaster prevention policy	1	2	0	1	2	6
Governance	Open goverment dataset	2	1	1	2	1	7
Governance	Policy makers response to e-Mobility demonstrators	2	1	1	1	1	6
Governance	Perception of satisfaction with urban planning methodology	1	1	1	1	1	5
Governance	Targeted people reached in urban planning methodology	0	1	1	2	1	5
Governance	Perception of satisfaction with coaching / mentoring activity	1	1	1	1	1	5
Governance	People reached in urban coaching/mentoring activities	1	1	1	2	1	6
Governance	New rules / regulations due to the project	2	1	1	1	1	6
Governance	Signature and compliance with the Covenant of Mayors	2	2	1	1	1	7
Governance	Existence of plans/programs to promote energy efficient buildings	2	2	1	2	2	9
Governance	Existence of regulations for development of energy efficient districts	2	1	1	2	1	7

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Governance	Existence of plans/programs to promote sustainable mobility	1	2	1	2	2	8
Governance	Existence of regulations for development of sustainable mobility	1	1	1	2	1	6
Governance	Annual number of online visits to the municipal open data portal per 100 000 population	2	2	2	2	2	10
Governance	Percentage of city services accessible and that can be requested online (e-Governance)	2	2	2	2	1	9
Governance	Average response time to inquiries made through the city's non-emergency inquiry system (days)	0	1	2	2	1	6
Governance	Average time for building permit approval (days)	1	1	2	1	2	7
Governance	Percentage of service contracts providing city services which contain an open data policy	1	1	2	1	1	6
Governance	Public Sector e-Procurement	1	1	2	1	1	6
Governance	Smart city integrated services	2	1	2	1	1	7
Propagation							
Propagation	Social compatibility	2	1	1	1	2	7
Propagation	Technical compatibility	2	2	1	2	1	8
Propagation	Ease of use for end users of the solution	2	1	1	1	2	7
Propagation	Ease of use for professional stakeholders	1	1	1	1	1	5
Propagation	Trialability	1	1	1	1	1	5
Propagation	Advantages for end users	2	1	1	1	2	7
Propagation	Advantages for stakeholders	2	1	1	1	2	7
Propagation	Visibility of Results	2	1	1	1	2	7
Propagation	Solution(s) to development issues	2	2	1	1	1	7
Propagation	Market demand	2	2	1	2	2	9
Propagation	Changing professional norms	2	2	1	1	1	7
Propagation	Changing societal norms	1	1	1	1	1	5
Propagation	Diffusion to other locations	2	1	1	2	2	8
Propagation	Diffusion to other actors	1	1	1	1	1	5
Propagation	New forms of financing	2	1	1	1	2	7
Propagation	Smart city project visitors	2	1	1	1	2	7

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ANNEX B

Overview of KPI distribution per ETT

Dimensions	ETT#1: Innovative Solutions for Positive Energy (CH) Buildings and Districts		
	IS-1.1: Positive Energy (stand-alone) Buildings	IS-1.2: Positive Energy Districts Retrofitting	IS-1.3: Feeding PEDs with Waste Streams Promoting Symbiosis and Circular Economy
Energy	E.1 Energy Demand and Consumption (C)	E.1 Energy Demand and Consumption (C)	E.1 Energy Demand and Consumption (C)
	E.2 Degree of energetic self-supply by RES (C)	E.2 Degree of energetic self-supply by RES (C)	E.2 Degree of energetic self-supply by RES (C)
	E.3 Self Sufficiency ratio (C)	E.3 Self Sufficiency ratio (C)	E.3 Self Sufficiency ratio (C)
	E.4 Energy Savings (C)	E.4 Energy Savings (C)	E.4 Energy Savings (C)
	E.5 Reduced energy curtailment (C)	E.5 Reduced energy curtailment (C)	E.5 Reduced energy curtailment (C)
	E.6 kWp photovoltaic installed per 100 inhabitants (C)	E.6 kWp photovoltaic installed per 100 inhabitants (C)	
	E.7 Smart Storage Capacity (C)		
		E.8 Heat Recovery Ratio (C)	E.8 Heat Recovery Ratio (C)
	E.9 Integrated Building Management Systems in Buildings (C)		
	E.10 Percentage of buildings in the city with smart energy meters (C)	E.10 Percentage of buildings in the city with smart energy meters (C)	
	E.11 Specific Yield (S)	E.11 Specific Yield (S)	
	E.12 Storage Energy Losses (S)		
	E.13 Thermal Load Reduction (S)		
	E.14 Peak load reduction (S)	E.14 Peak demand reduction (S)	
		E.15 Percentage of street lighting managed by a light performance management system (S)	
Environmental	EN.1 Greenhouse Gas Emissions (C)	EN.1 Greenhouse Gas Emissions (C)	EN.1 Greenhouse Gas Emissions (C)
	EN.2 Carbon Dioxide Emission Reduction (C)	EN.2 Carbon Dioxide Emission Reduction (C)	
	EN.3 Air Quality Index (C)	EN.3 Air Quality Index (C)	EN.3 Air Quality Index (C)
	EN.4 Primary Energy Demand and Consumption (S)	EN.4 Primary Energy Demand and Consumption (S)	
			EN.7 Municipal Solid Waste (S)
			EN.8 Recycling Rate of Solid Waste (S)
Economic	EC.1 Total Investments (C)	EC.1 Total Investments (C)	EC.1 Total Investments (C)
	EC.2 Total Annual Costs (C)	EC.2 Total Annual Costs (C)	EC.2 Total Annual Costs (C)
	EC.3 Payback Period (C)	EC.3 Payback Period (C)	EC.3 Payback Period (C)
	EC.4 Return on Investment (ROI) (C)	EC.4 Return on Investment (ROI) (C)	EC.4 Return on Investment (ROI) (C)
	EC.5 Average Electricity Price for Companies and Consumers (S)	EC.5 Average Electricity Price for Companies and Consumers (S)	
	EC.6 Percentage of the Total Distributed Energy Resources Capacity Traded (S)	EC.6 Percentage of the Total Distributed Energy Resources Capacity Traded (S)	
	EC.7 Local Job Creation (S)	EC.7 Local Job Creation (S)	EC.7 Local Job Creation (S)
	EC.8 Energy Poverty (S)	EC.8 Energy Poverty (S)	
	EC.9 Carbon Dioxide Reduction Cost Efficiency (S)	EC.9 Carbon Dioxide Reduction Cost Efficiency (S)	
	EC.10 New Business Ideas Generated (S)	EC.10 New Business Ideas Generated (S)	EC.10 New Business Ideas Generated (S)
	EC.11 Expenditures by the municipality for a transition towards a smart city (S)	EC.11 Expenditures by the municipality for a transition towards a smart city (S)	EC.11 Expenditures by the municipality for a transition towards a smart city (S)

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ICT	ICT.1 Increased System Flexibility for Energy Players (C)	ICT.1 Increased System Flexibility for Energy Players (C)	
	ICT.2 Increased hosting capacity for RES, electric vehicles and other new loads (C)	ICT.2 Increased hosting capacity for RES, electric vehicles and other new loads (C)	ICT.2 Increased hosting capacity for RES, electric vehicles and other new loads (C)
	ICT.3 Improved Data Privacy (C)	ICT.3 Improved Data Privacy (C)	ICT.3 Improved Data Privacy (C)
	ICT.5 ICT Response Time (S)	ICT.5 ICT Response Time (S)	ICT.5 ICT Response Time (S)
	ICT.7 Platform Downtime (S)	ICT.7 Platform Downtime (S)	ICT.7 Platform Downtime (S)
Mobility		M.2 Number of EV charging stations (C)	
Social	S.1 People Reached (C)	S.1 People Reached (C)	S.1 People Reached (C)
	S.2 Connection to the existing cultural heritage (C)		
	S.3 Local community involvement in the implementation and planning phase (C)	S.3 Local community involvement in the implementation and planning phase (C)	S.3 Local community involvement in the implementation and planning phase (C)
	S.4 Degree of satisfaction (C)	S.4 Degree of satisfaction (C)	S.4 Degree of satisfaction (C)
Governance	G.3 Monitoring and evaluation (S)	G.3 Monitoring and evaluation (S)	G.3 Monitoring and evaluation (S)
	G.4 Legal Framework Compatibility (S)	G.4 Legal Framework Compatibility (S)	G.4 Legal Framework Compatibility (S)
Propagation	P.1 Social compatibility (C)	P.1 Social compatibility (C)	P.1 Social compatibility (C)
	P.2 Technical compatibility (C)	P.2 Technical compatibility (C)	P.2 Technical compatibility (C)
	P.3 Market demand (C)	P.3 Market demand (C)	P.3 Market demand (C)
	P.4 Diffusion to other locations (C)	P.4 Diffusion to other locations (C)	P.4 Diffusion to other locations (C)

Dimensions	ETT#2: P2P Energy Management and Storage Solutions for Grid Flexibility	
	IS-2.1: Flexible and Sustainable Electricity Grid Networks with Innovative Storage Solutions	IS-2.2: Flexible and Sustainable District Heating/Cooling with Innovative Heat Storage Solutions
Energy	E.1 Energy Demand and Consumption (C)	E.1 Energy Demand and Consumption (C)
	E.2 Degree of energetic self-supply by RES (C)	E.2 Degree of energetic self-supply by RES (C)
	E.3 Self sufficiency ratio (C)	E.3 Self sufficiency ratio (C)
	E.4 Energy Savings (C)	E.4 Energy Savings (C)
	E.5 Reduced energy curtailment (C)	E.5 Reduced energy curtailment (C)
	E.6 kWp photovoltaic installed per 100 inhabitants (C)	
	E.7 Smart Storage Capacity (C)	E.7 Smart Storage Capacity (C)
		E.8 Heat Recovery Ratio (C)
	E.9 Integrated Building Management Systems in Buildings (C)	E.9 Integrated Building Management Systems in Buildings (C)
	E.11 Specific Yield (S)	E.11 Specific Yield (S)
	E.12 Storage Energy Losses (S)	E.12 Storage Energy Losses (S)
	E.14 Peak load reduction (S)	
Environmental	EN.1 Greenhouse Gas Emissions (C)	EN.1 Greenhouse Gas Emissions (C)
	EN.2 Carbon Dioxide Emission Reduction (C)	EN.2 Carbon Dioxide Emission Reduction (C)
	EN.3 Air Quality Index (C)	EN.3 Air Quality Index (C)
	EN.4 Primary Energy Demand and Consumption (S)	EN.4 Primary Energy Demand and Consumption (S)
Economic	EC.1 Total Investments (C)	EC.1 Total Investments (C)
	EC.2 Total Annual Costs (C)	EC.2 Total Annual Costs (C)
	EC.3 Payback Period (C)	EC.3 Payback Period (C)
	EC.4 Return on Investment (ROI) (C)	EC.4 Return on Investment (ROI) (C)
	EC.5 Average Electricity Price for Companies and Consumers (S)	
	EC.6 Percentage of the Total Distributed Energy Resources Capacity Traded (S)	EC.6 Percentage of the Total Distributed Energy Resources Capacity Traded (S)
	EC.7 Local Job Creation (S)	EC.7 Local Job Creation (S)

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	EC.8 Energy Poverty (S)	EC.8 Energy Poverty (S)
	EC.9 Carbon Dioxide Reduction Cost Efficiency (S)	EC.9 Carbon Dioxide Reduction Cost Efficiency (S)
	EC.10 New Business Ideas Generated (S)	EC.10 New Business Ideas Generated (S)
	EC.11 Expenditures by the municipality for a transition towards a smart city (S)	EC.11 Expenditures by the municipality for a transition towards a smart city (S)
ICT	ICT.1 Increased System Flexibility for Energy Players (C)	
	ICT.2 Increased hosting capacity for RES, electric vehicles and other new loads (C)	ICT.2 Increased hosting capacity for RES, electric vehicles and other new loads (C)
	ICT.3 Improved Data Privacy (C)	ICT.3 Improved Data Privacy (C)
	ICT.5 ICT Response Time (S)	ICT.5 ICT Response Time (S)
	ICT.7 Platform Downtime (S)	ICT.7 Platform Downtime (S)
	M.3 Annual Energy delivered by charging points (C)	
Social	S.1 People Reached (C)	S.1 People Reached (C)
	S.3 Local community involvement in the implementation and planning phase (C)	S.3 Local community involvement in the implementation and planning phase (C)
	S.4 Degree of satisfaction (C)	S.4 Degree of satisfaction (C)
	G.3 Monitoring and evaluation (S)	G.3 Monitoring and evaluation (S)
	G.4 Legal Framework Compatibility (S)	G.4 Legal Framework Compatibility (S)
Propagation	P.1 Social compatibility (C)	P.1 Social compatibility (C)
	P.2 Technical compatibility (C)	P.2 Technical compatibility (C)
	P.3 Market demand (C)	P.3 Market demand (C)
	P.4 Diffusion to other locations (C)	P.4 Diffusion to other locations (C)

Dimensions	ETT#3: e-Mobility Integration into Smart Grid and City Planning	
	IS-3.1: Smart V2G EVs Charging	IS-3.2: e-Mobility Services for Citizens and Auxiliary EV Technologies
Energy	E.1 Energy Demand and Consumption (C)	E.1 Energy Demand and Consumption (C)
	E.2 Degree of energetic self-supply by RES (C)	
	E.3 Self sufficiency ratio (C)	E.3 Self sufficiency ratio (C)
	E.4 Energy Savings (C)	
	E.5 Reduced energy curtailment	
	E.6 kWp photovoltaic installed per 100 inhabitants (C)	
	E.7 Smart Storage Capacity (C)	
	E.11 Specific Yield (S)	E.11 Specific Yield (S)
	E.12 Storage Energy Losses (S)	
	E.14 Peak load reduction (S)	
	E.15 Percentage of street lighting managed by a light performance management system (S)	
Environmental	EN.2 Carbon Dioxide Emission Reduction (C)	EN.2 Carbon Dioxide Emission Reduction (C)
	EN.3 Air Quality Index (C)	EN.3 Air Quality Index (C)
Economic	EC.1 Total Investments (C)	EC.1 Total Investments (C)
	EC.2 Total Annual Costs (C)	EC.2 Total Annual Costs (C)
	EC.3 Payback Period (C)	EC.3 Payback Period (C)
	EC.4 Return on Investment (ROI) (C)	EC.4 Return on Investment (ROI) (C)
	EC.5 Average Electricity Price for Companies and Consumers (S)	
	EC.6 Percentage of the Total Distributed Energy Resources Capacity Traded (S)	
	EC.7 Local Job Creation (S)	EC.7 Local Job Creation (S)
		EC.8 Energy Poverty (S)
	EC.9 Carbon Dioxide Reduction Cost Efficiency (S)	EC.9 Carbon Dioxide Reduction Cost Efficiency (S)
	EC.10 New Business Ideas Generated (S)	EC.10 New Business Ideas Generated (S)
	EC.11 Expenditures by the municipality for a transition towards a smart city (S)	EC.11 Expenditures by the municipality for a transition towards a smart city (S)
ICT	ICT.1 Increased System Flexibility for Energy Players (C)	
	ICT.2 Increased hosting capacity for RES, electric vehicles and other new loads (C)	
	ICT.3 Improved Data Privacy (C)	ICT.3 Improved Data Privacy (C)

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	ICT.5 ICT Response Time (S)	
	ICT.7 Platform Downtime (S)	ICT.7 Platform Downtime (S)
Mobility	M.1 Electric Vehicles & Low-Carbon Emission Vehicles deployed in the area (C)	M.1 Electric Vehicles & Low-Carbon Emission Vehicles deployed in the area (C)
	M.2 Number of EV charging stations and solar powered V2G charging stations deployed in the area (C)	
	M.3 Annual Energy delivered by charging points (C)	
	M.4 Annual number of passengers using the new vehicles and/or infrastructure (C)	M.4 Annual number of passengers using the new vehicles and/or infrastructure (C)
		M.5 Shared Electric Vehicles and Bicycles Penetration Rate (C)
	M.6 Clean mobility utilization (S)	M.6 Clean mobility utilization (S)
	M.7 Modal Split (Passengers/Vehicles/Trips) (S)	M.7 Modal Split (Passengers/Vehicles/Trips) (S)
		M.8 Yearly km of Shared Vehicles and Bicycles (S)
Social	S.1 People Reached (C)	S.1 People Reached (C)
	S.3 Local community involvement in the implementation and planning phase (C)	S.3 Local community involvement in the implementation and planning phase (C)
	S.4 Degree of satisfaction (C)	S.4 Degree of satisfaction (C)
Governance	G.3 Monitoring and evaluation (S)	G.3 Monitoring and evaluation (S)
	G.4 Legal Framework Compatibility (S)	G.4 Legal Framework Compatibility (S)
Propagation	P.1 Social compatibility (C)	P.1 Social compatibility (C)
	P.2 Technical compatibility (C)	P.2 Technical compatibility (C)
	P.3 Market demand (C)	P.3 Market demand (C)
	P.4 Diffusion to other locations (C)	P.4 Diffusion to other locations (C)

Dimensions	ETT#4: Citizen-Driven Innovation in Co-creating Smart City Solutions		
	IS-4.1: Social Innovation Mechanisms towards Citizen Engagement	IS-4.2: Open Innovation for Policy Makers and Managers	IS-4.3: Interoperable, Modular and Interconnected City Ecosystem
Environmental		EN.5 Climate Resilience Strategy (S)	
Economic	EC.1 Total Investments (C)	EC.1 Total Investments (C)	EC.1 Total Investments (C)
	EC.2 Total Annual Costs (C)	EC.2 Total Annual Costs (C)	EC.2 Total Annual Costs (C)
	EC.3 Payback Period (C)	EC.3 Payback Period (C)	EC.3 Payback Period (C)
	EC.4 Return on Investment (ROI) (C)	EC.4 Return on Investment (ROI) (C)	EC.4 Return on Investment (ROI) (C)
	EC.7 Local Job Creation (S)	EC.7 Local Job Creation (S)	EC.7 Local Job Creation (S)
	EC.10 New Business Ideas Generated (S)	EC.10 New Business Ideas Generated (S)	EC.10 New Business Ideas Generated (S)
	EC.11 Expenditures by the municipality for a transition towards a smart city (S)	EC.11 Expenditures by the municipality for a transition towards a smart city (S)	EC.11 Expenditures by the municipality for a transition towards a smart city (S)
ICT	ICT.3 Improved Data Privacy (C)	ICT.3 Improved Data Privacy (C)	ICT.3 Improved Data Privacy (C)
	ICT.4 Quality of Open Data (C)	ICT.4 Quality of Open Data (C)	ICT.4 Quality of Open Data (C)
	ICT.5 ICT Response Time (S)		ICT.5 ICT Response Time (S)
			ICT.6 Improved Cybersecurity (S)
	ICT.7 Platform Downtime (S)	ICT.7 Platform Downtime (S)	ICT.7 Platform Downtime (S)
Social	S.1 People Reached (C)	S.1 People Reached (C)	S.1 People Reached (C)
	S.2 Connection to the existing cultural heritage (C)		
	S.3 Local community involvement in the implementation and planning phase (C)	S.3 Local community involvement in the implementation and planning phase (C)	S.3 Local community involvement in the implementation and planning phase (C)
	S.4 Degree of satisfaction (C)	S.4 Degree of satisfaction (C)	S.4 Degree of satisfaction (C)
		S.5 Percentage of citizens' participation in online decision-making (S)	S.5 Percentage of citizens' participation in online decision-making (S)
Governance			G.1 Online visits to the municipal open data portal per 100 000 population (C)

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			G.2 Percentage of city services accessible and that can be requested online (e-Governance) (C)
	G.3 Monitoring and evaluation (S)	G.3 Monitoring and evaluation (S)	G.3 Monitoring and evaluation (S)
	G.4 Legal Framework Compatibility (S)	G.4 Legal Framework Compatibility (S)	G.4 Legal Framework Compatibility (S)
			G.5 Open government dataset (S)
Propagation	P.1 Social compatibility (C)	P.1 Social compatibility (C)	P.1 Social compatibility (C)
	P.2 Technical compatibility (C)		P.2 Technical compatibility (C)
	P.3 Market demand (C)	P.3 Market demand (C)	P.3 Market demand (C)
	P.4 Diffusion to other locations (C)	P.4 Diffusion to other locations (C)	P.4 Diffusion to other locations (C)

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