Funded by
the European Union

HORIZON-CL5-2022-D4-02
EUROPEAN COMMISSION
European Climate, Infrastructure and Environment Executive Agency

Grant agreement no. 101123238

VELIXIA
BUILDINGS AS ACTIVE UTILITY NODES

Smart Grid-Efficient Interactive Buildings

Deliverable D1.5
Evaluation Framework with KPI Repository & Stakeholder Management Plan

Project acronym	EVELIXIA
Full title	Smart Grid-Efficient Interactive Buildings
Grant agreement number	101123238
Topic identifier	HORIZON-CL5-2022-D4-02-04
Call	HORIZON-CL5-2022-D4-02
Funding scheme	HORIZON Innovation Actions
Project duration	48 months (1 October 2023 – 30 September 2027)
Coordinator	ETHNIKO KENTRO EREVNAS KAI TECHNOLOGIKIS ANAPTYXIS (CERTH)
Consortium partners	CERTH, RINA-C, CEA, CIRCE, UBE, HAEE, IESRD, UNIGE, SOLVUS, R2M, EI-JKU, FHB, EEE, EG, ÖE, PINK, TUCN, DEER, TN, ENTECH, SDEF, EGC, KB, AF, Sustain, NEOGRID, MPODOSAKEIO, DHCP, HEDNO, BER, MEISA, ITG, NTTDATA, TUAS, NEOY, HES-SO
Website	https://www.evelixia-project.eu/
Cordis	https://cordis.europa.eu/project/id/101123238

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ACKNOWLEDGMENT

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Deliverable D1.5
Evaluation Framework with KPI Repository & Stakeholder Management Plan

Deliverable number	D1.5
Deliverable name	EVELIXIA Evaluation Framework with KPI Repository and Stakeholder Management Plan
Lead beneficiary	CERTH
Description	This deliverable is directly linked to the activities foreseen in Task 1.3 (both subtasks 1.3.1 and 1.3.2), considering the consolidation of the EVELIXIA evaluation and impact assessment framework as well as the stakeholder engagement strategy to feed the social engagement field (WP7). It comprises the first version of D1.6.
WP	WP1
Related task(s)	T1.3
Type	Report
Dissemination level	Public
Delivery date	30.05.2024
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Document history

Version	Date	Changes	Author
V0 - first draft	30.10.2023	Initial Table of Contents and Structure of the Deliverable	Paraskevi Giourka Ioannis-Athanasios Zornatzis
V0 - second draft	15.02.2024	Initial draft based on the work of CERTH	Paraskevi Giourka Ioannis-Athanasios Zornatzis
V1 – first draft	30.04.2024	First complete draft after integrating feedback from all relevant partners and conducting an internal review	Paraskevi Giourka Ioannis-Athanasios Zornatzis
V1 – reviews	14.06.2024	Review from ITG, HES-SO	Pablo Carrasco, Sylvain Weber
V1 – consolidated version	14.06.2024	Incorporate additions and address review comments	Paraskevi Giourka Ioannis-Athanasios Zornatzis
2nd review	17.06.2024	Review from RINA-C	Elisa Crocco
V2 – second draft	17.06.2024	Address review comments	Paraskevi Giourka Ioannis-Athanasios Zornatzis
3rd review	20.06.2024	Review from CEA	Eric Francois
Final version	21.06.2024	Address review comments	Paraskevi Giourka Ioannis-Athanasios Zornatzis
Final deliverable submission	26.06.2024	Final edit prior to submission	Paraskevi Giourka Ioannis-Athanasios Zornatzis

ABBREVIATIONS

Abbreviation	Name
CM	Congestion Management
EC	European Commission
EI	Expected Impact
EO	Expected Outcome
GA	Grant Agreement
GHG	Greenhouse Gas
KPI	Key Performance indicator
KIP	Key Impact Pathway
WP	Work Package

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EXECUTIVE SUMMARY

Deliverable *D1.5 Evaluation Framework with KPI Repository & Stakeholder Management Plan* sets the framework for the monitoring and evaluation activities during EVELIXIA project. The defined Key Performance Indicators (KPIs) will be used to evaluate the progress and performance of interventions across Pilot Sites as well as the overall success of EVELIXIA. The present document describes the work performed in Task 1.3 of WP1 till M9.

The KPIs included in this deliverable have been compiled through a methodological approach that considers a variety of transparent criteria for evaluating relevant indicators identified in the literature and combines the expertise of EVELIXIA consortium partners. This approach led to a holistic framework grouped under three (3) KPI dimensions: a) Scientific b) Societal (including Environmental); c) Economic/Technological. Two levels of temporal scale have also been defined: short-, medium-term (during the project until its completion) and long-term (after the completion of the project).

For the short-, medium-term evaluation, the initial KPI pool was formed after careful mapping of the Expected Outcomes. Complementary KPIs were identified through the assessment of other existing frameworks, tailored feedback by EVELIXIA's horizontal technology providers and other sources. This process led to the extended KPI pool that included a large group of indicators particularly under the “Technological” dimension. KPIs were also clustered into three (3) levels of Evaluation, namely a) Project, b) Pilot Site, and c) Technology, facilitating the reviewing process. The extended pool was evaluated by the Pilot Site Managers, relevant stakeholders of the Pilot Sites' ecosystems and key EVELIXIA partners based on transparent, pre-defined evaluation criteria. The process resulted in a reduced list of KPIs that has been further assessed and refined into the final KPI list (and the associated KPI cards) presented in this deliverable. KPI cards include all evaluation metrics and formulas, relevant aggregation levels and initial recommendations for data collection and measurement methodologies along with a first assessment of the KPI ownership.

For the long-term evaluation the initial pool was formed after cross-referencing the Expected Impacts. A first list of suggested pathways and estimation methods is derived. The long-term final pool of KPIs will be refined in the months to come based on knowledge gained from the implementation and progress of EVELIXIA and in collaboration with key EVELIXIA's experts.

D1.5 is the first step towards EVELIXIA's monitoring procedures. The KPI list defined will be shared with all partners responsible for relevant tasks and associated monitoring activities who will have the flexibility to refine these KPIs, if necessary, according to their specific pilot needs and targets. The updated deliverable (D1.6) will be delivered on M30 and shall feed the evaluation plan, monitoring procedures and overall evaluation of EVELIXIA.

1 INTRODUCTION

Key Performance Indicators (KPIs) serve as a universal instrument to evaluate EVELIXIA's progress supporting the monitoring of relevant solutions and activities. 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*", tied to a goal, a target, or an objective by default[1]. Transforming building entities as active utility nodes generates considerable interest in establishing novel assessment frameworks and schemes measuring, monitoring, and evaluating performance and impacts and addressing possible challenges, before, during the project's whole life-cycle, and after its implementation.

1.1 Scope and Objectives

The evaluation of numerous KPIs available across several interrelated dimensions, and the selection of the most suitable ones is a challenging task. The resulting KPI repository should be suited and capable of managing a wide set of scenarios, that will be adopted to assess the 7 EVELIXIA Pilot Sites, resolving the need for a uniform monitoring and evaluation basis. Tailored KPIs are defined according to the scope of the specific needs of each pilot and provide comparability.

D1.5 (due on M9) sets the foundation for the comprehensive assessment of EVELIXIA's multitude of solutions by providing a holistic Key Performance Indicators (KPIs) framework. This evaluation refers both to the short-medium term (end of project), as well as the long-term (after project's end). Each KPI included in the framework's repository is described in detail and accompanied by guidelines for its calculation and interpretation, in full agreement with EVELIXIA's Key Impact Pathways (KIPs).

D1.5 defines also the stakeholder engagement strategy based on the value proposition design approach. The engagement of the stakeholders early in the project will facilitate the co-design of services with socio-economic value and environmental benefits. This sub-task will provide the strategy for the work performed in the social engagement field (WP7). The engagement strategy will help partners identify important: i) incentive schemes (both financial and non-financial ones) informing the Use Cases (UCs) (T1.2), ii) refine the conceptualization of EVELIXIA tools in the iterations of WP2, WP3, and WP4; serving also as a solid basis for T5.2.2 training activities.

[1] Bosch P., Jongeneel S., Rovers V., Neumann H.M., Airaksinen M. and Huovila A., CITYkeys indicators for smart city projects and smart cities.2017, CITYkeys, H2020, Grant Agreement no: 646440

An update of this deliverable (D1.6) is scheduled to be delivered on M30 to account for updates as the project progresses.

1.2 Relation to other tasks and activities

T1.3, as it consists of two distinct, yet critical sub-tasks, the KPI framework part and the stakeholder engagement strategy, is intertwined with several other Task activities and Work Packages (***Figure 1***).

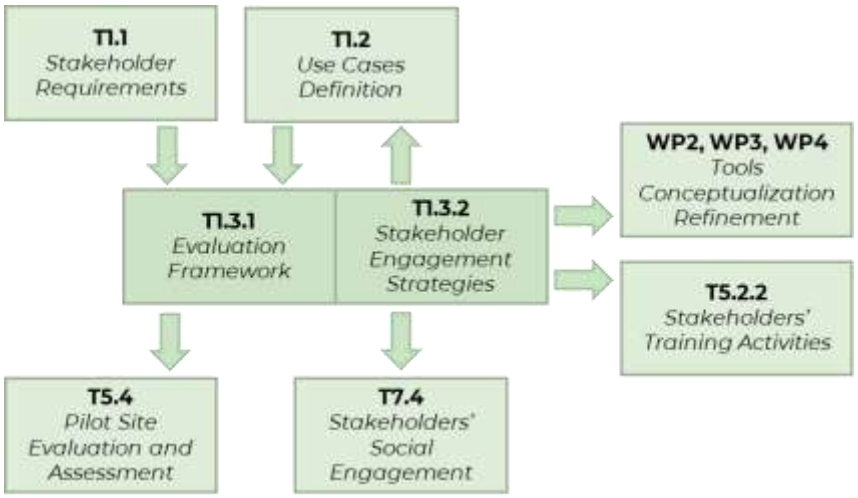

Figure 1. The flow of information between T1.3 and other tasks of EVELIXIA

The definition of the global framework for the EVELIXIA evaluation and impact assessment regarding technical, economic, environmental, and social aspects (subtask T1.3.1) will be based on the stakeholder requirements (T1.1) and the UCs (T1.2). In addition, the outcome of T1.3.1 in the form of the KPI repository will be used to assess the intervention scenarios for the 7 pilot sites (T5.4).

The stakeholder engagement strategies (sub-task T1.3.2) focuses on the engagement and empowerment of stakeholders in the framework of the work performed in the social engagement field (T7.4). Furthermore, the provision of engagement strategies will help partners identify important incentive schemes (both financial and non-financial ones) informing the UCs (T1.2). In addition, the engagement strategies will be used to refine the conceptualization of EVELIXIA tools and technologies (WP2, WP3 and WP4). Finally, the definition of these strategies will also serve as a solid basis for the pilot stakeholders training activities (T5.2.2).

1.3 Structure of the Deliverable

D5.1 is structured in **six (6)** chapters as follows:

Chapter 1 – Introduction

This chapter presents in a clear manner the aim of the deliverable, its relationship with other tasks and activities and finally the structure of information included in this deliverable.

Chapter 2 – Methodological approach

This chapter describes in a compact but inclusive manner, the methodology applied to acquire the final KPI repository. A step-by-step approach is followed to ensure that all important KPIs have been considered to support the successful monitoring of EVELIXIA's expected outcomes. The iterative approach addresses both the project needs and requirements capitalizing on input stemming from literature, standards, strategic plans, and initiatives.

Chapter 3 – Short/medium-term evaluation

This chapter provides both the extended and refined KPI repository for the short-, medium-term, the cumulative results of the evaluation process, and the respective KPI Cards.

Chapter 4 – Long-term evaluation

This chapter provides the KPI repository for the long-term evaluation and recommendations for future implementation pathway of the monitoring process.

Chapter 5 – Stakeholders' engagement strategy

This chapter describes the stakeholder engagement strategy based on the value proposition design approach that shall be the basis for the work performed in the social engagement field.

Chapter 6 – Conclusion

This chapter summarizes the main objectives and challenges addressed, points out implications of the results and concludes with emphasis on the significance of the current version of D1.5.

2 METHODOLOGY

The EVELIXIA partners will use Key Performance Indicators (KPIs) as a universal tool to assess progress, enabling the monitoring of relevant solutions and activities. Two distinct frameworks that reflect EVELIXIA's Key Impact Pathways (KIPs) will be developed and applied, one focusing on the short-, medium-term (until the end of the project) and the other on the long-term evaluation (post-project completion and during its exploitation). Both frameworks are aligned with the Key Impact Pathways (KIPs), forming a common basis for evaluation.

2.1 Short-term evaluation pathway

The methodology employed to formulate the Key Performance Indicator (KPI) pool embodies a systematic and iterative approach aimed at capturing the essence of EVELIXIA's expected outcomes while leveraging external expertise and stakeholder input. EVELIXIA's approach for identifying the KPIs of the Evaluation Framework involves four (4) consecutive steps. Step 1 initiates the process by creating an initial pool of KPIs directly aligned with the project's anticipated outcomes. This foundational step serves as the bedrock upon which subsequent iterations build. Step 2 expands the KPI pool by assimilating insights from related projects and tailored feedback obtained from horizontal Technology Providers. This collaborative endeavor enriches the pool with diverse perspectives. In Step 3, refinement of the KPI pool occurs through rigorous evaluation by stakeholders within the Pilot Site ecosystems, guided by predefined criteria. This participatory approach ensures that the selected metrics are not only comprehensive but also resonate with the needs and priorities of the project's stakeholders and verifies the feasibility of the proposed metrics. Finally, Step 4 culminates in the development of KPI cards for the final repository, providing a comprehensive overview of each metric's definition, calculation methodology, and relevance to project objectives. Through these methodological steps, the evaluation framework is meticulously created, reflecting a synthesis of project goals, external insights, stakeholder input, and predefined criteria, thereby laying a robust foundation for subsequent evaluation and analysis.

2.1.1 Key Impact Pathways

Based on the stakeholder requirements (T1.1) and the UCs (T1.2), EVELIXIA's global framework for evaluation and impact assessment (T1.3.1) reflects on **three (3)** key dimensions of impact categories for the short-, medium-term, namely 1) Scientific, 2) Societal (including Environmental), and 3) Economic/ Technological aspects. Those complementary categories address all major project objectives and challenges that reflect EVELIXIA's expected outcomes and impacts in accordance with the Grant Agreement.

2.1.1.1 Scientific

Scientific indicators aim to provide metrics that can track and quantify the diffusion of scientific knowledge on two key areas a) effective sector coupling, and b) strengthening the utilization of buildings as flexibility assets.

2.1.1.2 Societal (incl. Environmental)

Societal indicators address the social and environmental aspects of the envisioned buildings acting as active utility nodes measuring the overall social acceptance and awareness of solutions to be demonstrated in the seven (7) Pilot Sites.

2.1.1.3 Economic/Technological

Technological indicators are linked with fundamental aspects and specifications of the systems deployed and innovative technologies implemented as well as flexibility services demonstrated across Pilot Sites.

Economic indicators are metrics for the financial assessment of EVELIXIA's solutions that showcase the economic feasibility and monetary attractiveness of the project.

2.1.2 Step 1: Create the initial pool of KPIs

The initial pool of KPIs is extracted building upon on EVELIXIA's Call Expected Outcomes (Call EO). These outcomes are clearly defined in the Grant Agreement (GA) and are summarized in the following Table.

Table 1 EVELIXIA's Expected Outcomes

Call Expected Outcomes	EVELIXIA's Outcomes
Call EO#1: Improved interoperability and synergies between electricity and other energy carriers, and with other relevant non-energy sectors (e.g., mobility), supported by buildings, contribution to energy system integration at building's level.	Scientific
	1.1 Create and use high-quality new knowledge on issues relevant to effective sector coupling: At least 5 citations per year per publication
	Societal
	1.2 Increased awareness on available solutions that support energy system integration at building's level and their potential impact: At least 500 people engaged by the end of the project 1.3 Unlock the provision of key multi-vector ancillary services: At least 3 ancillary services demonstrated

Call Expected Outcomes	EVELIXIA's Outcomes
	1.4 Enhanced user-friendliness of EVELIXIA digital solutions – Achieve a System Usability Scale (SUS) score of >80
	Economic/Technological
	1.5 Support effective energy sector coupling: 6 novel sector coupling technologies demonstrated (IS24-29) 1.6 Improved communication, cybersecurity, and interoperability: i) (Likert Scale): 4.5/5 (Full compliance with EU telecommunication standards-protocols and GDPR) 1.7 High modularity and scalability of EVELIXIA solutions: 7 Aggregators/SOs/ESCOs platforms successfully integrated with EVELIXIA platform 1.8 Unlock the provision of novel B2G/G2B services: i) A total of 14 B2G/G2B services to be offered; ii) 14 B2G/G2B services to be included in EVELIXIA Marketplace and exploited through the BLOCKCHAIN framework within project duration
Call EO#2: Improved competitiveness of buildings as flexibility assets for grid and network management.	Scientific
	2.1 Create and use high quality new knowledge on issues strengthening the utilization of buildings as flexibility assets: At least 5 citations per year per publication
	Societal
	2.2 Reduced energy curtailment of RES and DER: Majority of installed RE can be 100% utilized 2.3 Building smartification as investing opportunity: PBT of EVELIXIA solutions to be less than 15 years on average 2.4 Reduction of carbon footprint: GHG emissions due to buildings operation to be reduced by 17% in all pilot sites
	Economic/Technological
	2.5 Enhanced flexibility: Increase electricity and thermal flexibility by at least 15% and 25% respectively in the Pilot Sites

Call Expected Outcomes	EVELIXIA's Outcomes
	2.6 Achieve higher levels of RES self-consumption: Increase RES self-consumption, reaching 80-100% in 5 out of 7 Pilot Sites 2.7 Significant cost savings: Economic benefits deriving from EVELIXIA implementation: >368 K€/y 2.8 Increased energy savings: Energy consumption to be reduced by 13.5% in all pilot sites 2.9 Increased RE penetration: On-site RE generation to be increased by 11% in all pilot sites

2.1.3 Step 2: Expand the initial pool of KPIs

The initial pool resulting from step 1, is further expanded based on sources from a wide spectrum of acknowledged, EU-wide, demonstration projects and initiatives along with feedback from key partners. The goal is to identify sets of appropriate indicators and effective metrics consistent with scientific rigor and EU research guidelines to be added in EVELIXIA's KPI pool. The process involves extracting information from each of the following sources to identify relevant Key Performance Indicators (KPIs). This entailed a thorough verification of each KPI's alignment with EVELIXIA's needs and objectives. Only those KPIs that demonstrated a clear and direct relevance are selected for further consideration and evaluation.

2.1.3.1 Related Projects

This sub-step leverages past endeavors and pertinent EU-funded projects to inform EVELIXIA's Evaluation Framework by harnessing the wealth of data and insights generated by scrutinizing their methodologies, outcomes, and evaluation frameworks. Relevant projects that contribute in contextualizing the theme of flexibility services offered to the grid by buildings acting as active utility nodes are identified through the Cordis EU platform. A filtering procedure was applied to reduce the vast number of available H2020 projects and return up to date information. The search was conducted using the keywords: "building", "grid", "energy" and "flexibility". For each of those projects the relevant objectives, actions and sets of performance subjects that reflect crucial aspects of performance and impact with significance to EVELIXIA are listed below.

Table 2 Related Projects to EVELIXIA

Acronym	Related objectives	Related actions	Related performance subjects
FLEXGRID	Innovative solutions for enhancing the flexibility of the electricity grid integrating various energy resources and demand-side management strategies to optimize grid operation and accommodate renewable energy sources.	Investigated advanced building energy management systems and demand response mechanisms towards resilience of the grid.	Building-level energy consumption patterns, responsiveness to grid signals Effectiveness of demand-side management strategies in enhancing grid stability and reliability
EUniversal	Create a seamless and efficient European electricity market, emphasizing the integration of renewable energy sources and the enhancement of grid flexibility.	Explored mechanisms for enabling buildings to actively participate in energy markets through demand response and smart grid technologies.	Degree of building-grid interaction Economic viability of demand response programs for building owners Integration of building flexibility into overall grid management strategies
OneNet	Develop an integrated framework for the European electricity market, emphasizing the integration of diverse	Examined the potential of buildings to serve as active participants in grid balancing through demand response and	Level of building-grid integration Reliability of building-based grid services Contribution of building

	energy resources and the optimization of grid operation.	energy storage technologies.	flexibility to overall grid stability
X-FLEX	Innovative solutions for enhancing the flexibility and resilience of the European electricity grid.	Explored advanced building energy management systems, demand response technologies, and energy storage solutions to enable buildings to actively participate in grid balancing.	Effectiveness of building-based flexibility services in mitigating grid imbalances Economic benefits of building participation in energy markets Scalability of building flexibility solutions across different regions
ebalance-plus	Optimizing the integration of renewable energy sources and enhancing grid flexibility through demand response and energy storage technologies.	Investigated strategies for enabling buildings to adjust their energy consumption patterns in response to grid signals and market incentives.	Responsiveness of buildings to grid signals Economic benefits of demand response programs for building owners Overall impact of building flexibility on grid stability and reliability
REDREAM	Develop solutions for enhancing the flexibility and resilience of the European electricity grid, particularly in	Investigated advanced building energy management systems, demand response technologies,	Effectiveness of building-based flexibility services in mitigating grid imbalances Economic benefits of

	the context of distributed energy resources and demand-side management.	and energy storage solutions to enable buildings to actively participate in grid balancing	building participation in energy markets
iBECOME	Develop integrated building energy management systems to enhance energy efficiency and renewable energy integration.	Optimizing energy consumption and integrating renewable energy sources within buildings & downtime planning for energy assets	Building energy consumption profiles Renewable energy integration rates Demand response capabilities Grid interaction responsiveness. Energy asset maintenance (fault detection & predicitive maintenance)
SMART2B	Develop smart building solutions to improve energy efficiency, indoor environment quality, and grid interaction.	Building flexibility through the development of smart building technologies that can dynamically adjust energy usage and interact with the grid.	Grid interaction capabilities The adoption rate of smart building technologies
SYNERGY	Develop innovative technologies for energy-efficient buildings and districts,	Explored integrated energy solutions that enable buildings to adjust energy	Energy consumption optimization rates

	focusing on integrated energy solutions.	usage in response to grid signals and market dynamics.	Adoption rates of integrated energy solutions Resilience of building energy systems.
RENAISSANCE	Develop scalable solutions for energy-efficient buildings and districts, integrating renewable energy sources and smart grid technologies.	Implemented benchmarking model for local energy grid improvement	Scalability assessments Smart grid technology adoption rates Effectiveness of building energy management systems
POCITYF	Develop innovative solutions at the building and district level that enable the increase of energy self-consumption, energy savings and the high share of locally produced renewable energy	Explored strategies for optimizing the energy consumption of buildings and integrating renewable energy sources at the community level.	Energy efficiency of buildings The contribution of building flexibility to overall energy resilience in urban environments
InCUBE	Develop innovative solutions for accelerating the transition to resource-efficient and resilient buildings by integrating renewable energy sources	Explored strategies for optimizing the energy consumption of buildings and enabling building-to-grid interaction through demand response and	Maximizing self-consumption using monitored storage systems Increase in building RE production Integration of innovative

		energy storage technologies.	renewable energy sources

2.1.3.2 EU strategic plans and initiatives

The European Union's ambitious new growth strategy places a strong emphasis on energy efficiency and renewability as central pillars of sustainable development. This commitment is evident in various initiatives, strategic documents, and financial frameworks, including the Clean Energy for all Europeans Package[2], the European Green Deal[3], and the 2021-2027 long-term EU budget & Next Generation EU[4]. These initiatives collectively aim to catalyze a Renovation Wave[5], driving transformative change across sectors. Within this context, the EVELIXIA project is strategically positioned to advance these objectives by supporting the smartification and enhancing the flexibility potential of standalone buildings. This aligns with EU tools and instruments such as Level(S) and the Smart Readiness Indicator (SRI), which provide frameworks for assessing and improving the energy performance of buildings. Drawing inspiration from the successful approach of the Horizon frameworks, EVELIXIA systematically sources, reviews, and integrates valuable Key Performance Indicators (KPIs) into its extended pool. This sub-step ensures alignment with EU priorities while fostering innovation and sustainability in the built environment.

2.1.3.3 Tailored feedback

This pivotal sub-step involves collaborating closely with the horizontal technology providers integral to EVELIXIA's solutions. This collaborative effort aims to foster a comprehensive understanding of the diverse technological landscape underpinning the objectives. Through sharing the extended pool that derived from the previous sub-step we create an inclusive platform for them to offer input, comments, and additional suggestions for KPIs, particularly those closely aligned with their respective technologies. By soliciting feedback directly from the experts the impact of each technology within the project's context and its correlation with project-level thresholds can be effectively assessed. Moreover, it promotes a sense of ownership and engagement amongst technology providers, fostering a collaborative spirit. This exchange ensures that the resulting extended evaluation framework captures the nuances and intricacies of each

[2] https://ec.europa.eu/energy/topics/energy-strategy/clean-energy-all-europeans_en
[3] https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal_en
[4] https://ec.europa.eu/commission/presscorner/detail/en/IP_20_1658
[5] https://ec.europa.eu/energy/topics/energy-efficiency/energy-efficient-buildings/renovation-wave_en

technology, yet remains robust, comprehensive, and aligned with EVELIXIA's overarching objectives.

2.1.4 Step 3: Refine the pool of KPIs

To ensure that the Evaluation Framework includes the most relevant and appropriate KPIs alone, the repository is refined through a transparent and iterative selection method that breaks down into the three following sub-steps.

2.1.4.1 Refinement prior to the Evaluation

This crucial sub-step entails a qualitative assessment aimed at fine-tuning the metrics selection. Each metric is meticulously scrutinized ensuring its alignment with project objectives and its capacity to provide meaningful insights or else it is excluded from the list. This serves as a quality assurance mechanism, enabling the identification and rectification of any discrepancies or redundancies within the extended pool. The coherence and effectiveness of the metrics framework is further optimized laying a solid foundation for the subsequent evaluation from the pilot sites ecosystems' stakeholders. The refinement process included rephrasing the definitions, searching for cross-references, providing formulas, recommendations for data sources and excluding indicators that are either specifically targeted at a particular technology alone or do not directly correlate with the project's objectives.

2.1.4.2 Evaluation using pre-defined criteria

During the first General Assembly Meeting in Austria (April 2024) a comprehensive workshop is convened to introduce the Evaluation process to all partners involved. Garnering insights and feedback from diverse stakeholders representing the Pilot Sites' ecosystems, the streamlined process applies the **five (5)** selection criteria initially proposed by the CIVITAS framework[6], as described below:

- **Criterion #1: Relevance:** The specific criterion refers to the importance of a KPI within the evaluation process. The KPIs selected for inclusion in the repository should align with the

[6] Rooijen, T.; Nesterova, N. Deliverable 4.10: Applied framework for evaluation in CIVITAS PLUS II, WP4, May 31, 2013; CivitasWiki Project; Grant Agreement No.: 296081. Available online: https://civitas.eu/sites/default/files/Results%20and%20Publications/civitas_wiki_d4_10_evaluation_framework.pdf(Accessed on 26 July 2022).

operational objectives of the project. KPIs that are directly and/or indirectly linked with EVELIXIA expected outcomes as defined in the project's Grant Agreement (GA) are of high relevance. KPIs should be selected and defined in such a way that the implementation of EVELIXIA activities provides a clear signal in the change of the indicator value. KPIs that are influenced by other factors not related with the implementation of EVELIXIA or provide an ambiguous signal (such as uncertainty in interpreting an increase in the indicator value) are not suitable for inclusion.

- **Criterion #2: Availability:** The specific criterion refers to the availability of data required to quantify a KPI. Data for measuring the indicator should be easily available (limited time and effort should be required). Including KPIs that, while being of interest, cannot be realistically estimated during the project lifetime should be avoided. KPIs should be based, if possible, on data that either: a) are available from the technology providers or other stakeholders involved in the use case that is being evaluated; b) can easily be compiled from public sources and open-data repositories, and/or c) can easily be gathered from interviews-questionnaires, maps, or digital tools. KPIs that require, for instance, extensive interviews with occupants will receive a lower score as the large amounts of data needed are too expensive to gather. Similar considerations apply to KPIs that require extensive recalculations and additional data, such as footprint indicators, and certain financial indicators.

- **Criterion #3: Measurability:** The specific criterion refers to the capability of a KPI to be measured, objectively. It is also important for a KPI to swiftly reflect changes in the measured quantities allowing for timely corrective measures to take place and ensure the project's success. The utilization of KPIs that are of a qualitative or semi-qualitative nature (e.g., are assessed with the utilization of Likert EVELIXIAs) should be avoided. However, this might not be feasible especially when, for instance, social KPIs need to be included in the repository.

- **Criterion #4: Reliability:** The specific criterion refers to the clarity of defining a KPI and its calculation method. The definition and the calculation method of the KPIs should be clear and not subject to varying interpretations. It should also encompass data collection parameters that can impact the quality of the measurements, such as spatial and temporal levels. EVELIXIA envisions addressing this criterion with the provision of the KPI cards which will summarize essential information.

- **Criterion #5: Familiarity**: The specific criterion refers to the easiness of comprehension regarding the subject matter addressed by a KPI. KPIs should be easily understood by all stakeholders, ideally even by non-experts. EVELIXIA has drawn upon KPIs from existing indicator-based frameworks that typically meet this requirement, however in some instances the definition of the KPI was unclear especially for non-experts.

Each KPI is evaluated by its respective partners and potential owners. Societal indicators were evaluated by HES-SO, whilst Economic/Technological indicators are evaluated by Pilot Site Managers in collaboration with stakeholders and technology providers of their Pilot Site. The Evaluation is performed through the utilization of a 3-point scoring system based on the following guidelines:

- **0 points:** The KPI does not satisfy this criterion adequately
- **1 point:** The KPI satisfies this criterion sufficiently
- **2 points**: The KPI fully satisfies this criterion

The partners submit their scores asynchronously at a later stage. These individual scores are then aggregated and averaged among stakeholders closely associated with the respective metrics, ensuring a representative and inclusive assessment. As a result of this procedure each KPI has received a score from 0 (minimum score) to 10 (maximum score). A cut-off rule of a minimum score of **7 points** was set for all KPIs to be considered for selection. Final cumulative scores of the KPIs are presented in Section 3.1.5.

2.1.4.3 Refinement based on additional pre-defined criteria

To formulate a non-redundant, yet concise repository critical revision of the selection process is necessary either in case two KPIs served the same purpose, where the one with the highest score was selected, or in case of equal scores the KPI with the highest score in relevance is selected. The following qualitative criteria are considered during the KPI selection process:

- **Completeness:** The set of KPIs should consider all different aspects of EVELIXIA's scope. In that aspect, the selected KPIs cover all defined outcomes and different stakeholders' perspectives.

- **Non-redundancy:** The set of KPIs should not measure the same aspect of a subtheme. Extra care is 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.

2.1.4.4 Revision with key partners

This final sub-step is imperative so that the selected KPIs accurately reflect the key concept and the needs of the EVELIXIA and provide the framework to monitor and assess the results of the proposed site-specific solutions and systems. The above-described steps are shared and iteratively discussed both internally and with EVELIXIA's key partners, refining the repository based on input and prioritization criteria collected from parallel WP1 activities regarding EVELIXIA's architecture, components' requirements and Use-Cases definitions. Detailed results of the selection process are presented in Section 3.1.6.

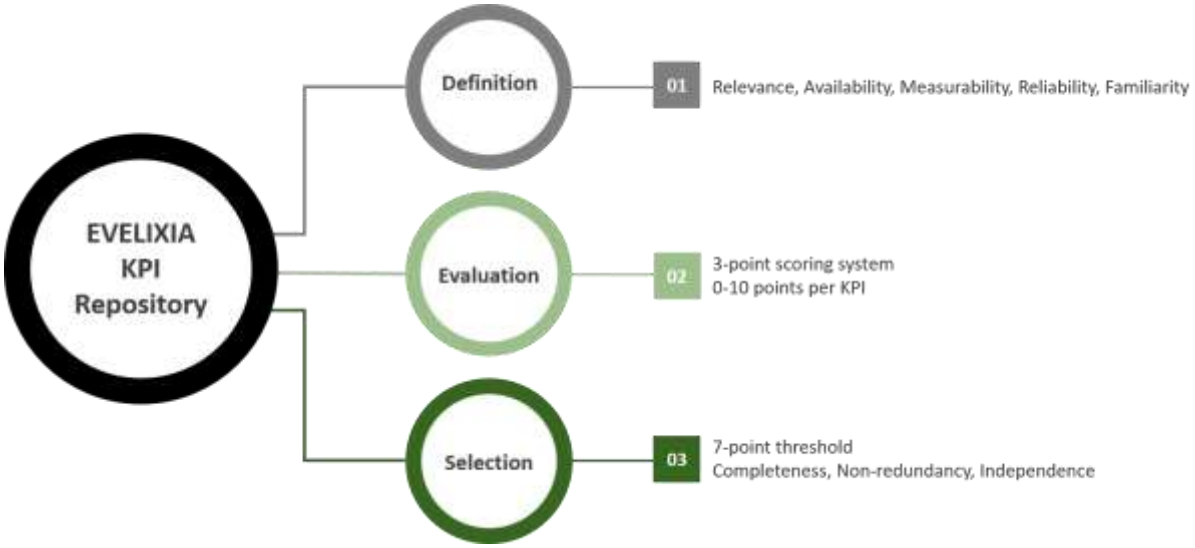

Figure 2. Streamlined process for EVELIXIA's KPI selection

2.1.5 Step 4: Develop KPI cards

The final step includes the preparation of the KPI cards for the KPIs of the final repository for M9. The KPI cards contain all the necessary information for the understanding and estimation of each KPI included in EVELIXIA's final KPI repository. KPI cards aim to provide key insights on WHAT-HOW-WHEN needs to be measured and will provide major guidance to relevant Tasks dealing with demonstration (feasibility phase), evaluation, and impact assessment. The following info will be provided per card:

- KPI Title: title of the KPI

- KPI Definition: the process to be followed for its estimation, including (if applicable) the mathematical formula; relevant details and data sources
- Recommended Estimation Process: Overview of estimation process, incl. data sources, measurement methods and mathematical formulas (if applicable)
- Recommended Data Sources: Relevant sources from which to extract input data (eg. sensors, smart meters, documentation, surveys etc.)
- Unit: the recommended unit(s) of measurement to be applied, aligned with the estimation process;
- Monitoring interval: the frequency of measurement for the KPI – as well a reference to the relevant life cycle phase i.e., design/construction/operation;
- Relevant contributors: reference to partners/stakeholders that provide input data, expertise or feedback tailored to this KPI
- Linked KIP: an indication of the KIP dimension that is linked with this KPI
- Evaluation level: the scope of assessment for this KPI.

The KPI card template is provided for all KPIs in the EVELIXIA's repository. The card contains all the information necessary to compose the relative KPI.

Table 3 EVELIXIA KPI Card Template

KPI Code - Card Overview					
KPI Title	Title of KPI				
KPI Responsible Partner	Partner responsible for measurement/calculation of this KPI				
KPI Definition	Definition and relevant details for this KPI				
Recommended Estimation Process	Overview of estimation process, incl. data sources, measurement methods and mathematical formulas (if applicable)				
Recommended Data Sources	Relevant sources from which to extract input data				
Recommended Unit	Unit of measurement		**Recommended Monitoring Interval**	(eg. annually)	
KPI Relevant Contributors	Relevant contributor(s) to this KPI				
Linked KIP	Indication of the KIP linked with this KPI				
Recommended Evaluation Level					
Technology		**Pilot**		**Project**	

Different levels of monitoring evaluation are considered. These levels are typically defined based on the scope of the evaluation and the objectives of the project. A KPI can be evaluated at more than one level. To ensure a comprehensive assessment of EVELIXIA's impact and identify areas for improvement the recommended evaluation levels are:

- **Technology Level Evaluation:** This level of evaluation focuses on assessing the impact of the specific technology being used in the project. It involves evaluating the performance and effectiveness of the technology and its ability to achieve the intended outcomes.
- **Pilot Level Evaluation:** This level of evaluation focuses on assessing the impact of the project on one or several pilot demonstrations. It involves evaluating how a technology is being used and its effectiveness in addressing the specific needs of the users.
- **Project Level Evaluation:** This level of evaluation focuses on assessing the overall impact of the project on its intended beneficiaries or stakeholders. It typically involves monitoring the project's progress and outcomes against the project's goals and objectives. The evaluations include analyzing data on project inputs, activities, outputs, and outcomes. It will also involve collecting feedback from stakeholders to identify areas of improvement.

2.2 Long-term evaluation pathway

The long-term evaluation pathway gauges progress and ensures alignment with overarching envisioned impacts. This subchapter delves into three distinct phases. Firstly, it explores the creation of the initial pool of long-term Key Performance Indicators (KPIs) derived from EVELIXIA's Expected Impacts. Subsequently, it scrutinizes the iterative process of revision and refinement, leveraging feedback from key project partners and experts to enhance the effectiveness and relevance of the identified KPIs. Finally, it offers comprehensive recommendations and suggestions for the estimation and calculation of KPIs to facilitate robust evaluation practices and informed decision-making beyond the lifecycle of the project. Through this systematic and robust approach, the long-term Evaluation Framework emphasizes on how to increase EVELIXIA's dissemination, communication and exploitation potential.

2.2.1 Step 1: Initial pool based on EVELIXIA's Expected Impacts

The expected impacts of EVELIXIA have been clearly defined in Grant Agreement. Based on these impacts, linked KPIs are extracted and summarized in Table 4.

Table 4 EVELIXIA's Expected Impacts

Call Expected Impacts (EI)	EVELIXIA Impacts
EI#1: More energy efficient building stocks supported by an accurate understanding of buildings performance in Europe and of related evolutions	Scientific
	1.1 New breakthrough scientific discoveries on how to improve energy efficiency of buildings through increased levels of smartness
	Societal/Environmental
	1.2 Contribute to Fit for 55 (also accounting REPowerEU) and Built4People goals, as well as the deployment of positive energy districts in EU
	Economic/Technological
	1.3 Long-term (after 2030) energy savings that can be triggered by EVELIXIA ≥80 GWh/y
EI#2: Building stocks that effectively combine energy efficiency, renewable energy sources and digital and smart technologies to support the transformation of the energy system towards climate neutrality	Scientific
	2.1 Scientific advancements on building digitalization and smartification of buildings
	Societal/Environmental
	2.2 Smartification of the EU-building stock: >2.8 M m^2 of floor area per year of EU building stock to improve its SRI by +47% (on average)
	Economic/Technological
	2.3 Support building digitalization: >2.8 M m^2 of floor area per year of EU building stock to acquire a BIM digital twin 2.4 Facilitate the penetration of high shares of RE without affecting energy system stability 2.5 Support a more standardized, consolidated and integrated building smartification process in EU
EI#3: Higher buildings' performance with lower environmental impacts through increased rates of holistic renovations	Societal/Environmental
	3.1 Support building stock de-carbonization - Long-term GHG reductions (during operation) triggered by EVELIXIA > 25,000 tCO_{2eq}/y

Call Expected Impacts (EI)	EVELIXIA Impacts
	3.2 More EU buildings with better IEQ
EI#4: Higher quality, more affordable built environment preserving climate, environment and cultural heritage and ensuring better living conditions	Scientific
	4.1 Creation of new knowledge on SSH issues relevant to buildings smartification (incl. user satisfaction, acceptance etc.)
	Societal/Environmental
	4.2 More sustainable living - Offer tailored-made solution packages considering individual needs and preferences
	Economic/Technological
	4.3 Unlock energy savings in old and/or cultural heritage buildings where major-energy retrofitting is not an option

2.2.2 Step 2: Refined pool of KPIs based on tailored feedback

This Step involves an iteration with EVELIXIA's key partners (e.g. key stakeholders, technology providers, Exploitation Manager) towards defining the final KPI repository, and especially partners that are highly related with the future exploitation of EVELIXIA solutions. As is the case for Short/Medium-term KPIs, these KPIs should also reflect the opinion and needs of the EVELIXIA partnership in view of maximizing the impacts of the project. Therefore, KPIs extracted from Step 1 will be shared and iteratively evaluated as the project progresses. Tailored suggestions shall be provided for KPIs that present a specific interest for EVELIXIA upon agreement between EVELIXIA's key partners. This process is planned for the spanning period between M9 and M30. It shall result in the finalized long-term KPI repository and will be presented in detail in the updated deliverable (D1.6).

2.2.3 Step 3: Provide guidance for future estimations

As a final step, generic guidance is provided, on aspects and parameters that need to be considered in the future in order to monitor the long-term performance of EVELIXIA and quantify the proposed KPIs in a successful manner. Many of the recommendations proposed will ensure the sustainability of EVELIXIA after the EC funding and support the implementation of its core concepts in a wider scale. This step is performed both for the initial and for the final long-term repository. For the former, the current suggestions are imperative to the ongoing discussion addressing

EVELIXIA's expected impacts successfully. For the latter, the updated suggestions integrated in D1.6 offering tailored and descriptive guidelines on recommended pathways.

3 SHORT-, MEDIUM-TERM EVALUATION

This section summarizes the key results derived by implementing the methodology and more specifically the methods relevant to Steps 1-4. The following sub-chapters delve into the critical task of defining EVELIXIA's Evaluation Framework for both short- and medium-term objectives by identifying the repository of Key Performance Indicators (KPIs). This chapter is divided into two main parts. The first part presents the results of the iterative process that guides the evolution of the KPI repository from its inception in the initial pool, through evaluation and refinement in the extended pool, culminating in the establishment of the final pool. The second part provides the KPI cards, offering detailed insights into the KPIs integrated into the final pool. By elucidating this comprehensive methodology, the aim is to lay a solid foundation for robust evaluation practices that will effectively measure and assess the progress and impact of the EVELIXIA project across its short- and medium-term objectives.

3.1 Short-, medium-term KPI repository

The KPI selection forms the cornerstone of the development of the Evaluation Framework. This sub-chapter delineates the journey from the initial pool of evaluation metrics to the final selection, emphasizing the dynamic nature of the process itself. It highlights the iterative cycles of evaluation, feedback incorporation, and refinement, underscoring the project's commitment to ensuring the comprehensiveness and relevance of the chosen metrics for assessing short- and medium-term impacts. Following the steps in transitioning from the initial pool to the extended pool and ultimately to the final pool, this chapter describes the rigorous methodology employed to curate a robust KPI repository.

3.1.1 Initial pool based on Call Expected Outcomes

Each KPI of this initial pool is intricately tied to a distinct Expected Outcome (EO), aligning closely with the overarching goals outlined in the GA. These KPIs are meticulously organized based on their respective Key Impact Pathways (KIP) dimensions. This structured approach clusters KPIs with similar thematic relevance and impact potential, fostering coherence. By adhering to this systematic arrangement, the evaluation framework not only enhances clarity and organization but also enables stakeholders to discern meaningful patterns and correlations across diverse sets of metrics, thereby empowering informed decision-making and strategic planning. This step produced an initial pool of **16** KPIs in total, **2** Scientific, **4** Societal, **8** Technological and **2** Economic.

Table 5 Initial Pool of KPIs

#	Dimension	Title	Unit	Linked EO
Scientific				
1	Scientific	Citations per publication (effective sector coupling)	[number]	EO#1.1
2	Scientific	Citations per publication (buildings as flexibility assets)	[number]	EO#2.1
Societal				
3	Societal	System Usability Scale (SUS) score	[number]	EO#1.4
4	Societal	Ancillary services demonstrated	[number]	EO#1.3
5	Societal	People engaged by the end of the project	[number]	EO#1.2
6	Environmental	GHG emissions reductions	percentage	EO#2.4
Technological				
7	Technological	Improved communication, cybersecurity and interoperability	Likert scale	EO#1.6
8	Technological	B2G/G2B services to be included in EVELIXIA Marketplace	[number]	EO#1.8
9	Technological	Platforms integrated with EVELIXIA's platform	[number]	EO#1.7
10	Technological	Electricity flexibility increase (all sites)	percentage	EO#2.5
11	Technological	Thermal flexibility increase (all sites)	percentage	EO#2.5
12	Technological	Energy consumption reduction (all sites)	percentage	EO#2.4
13	Technological	RE generation increase (all sites)	percentage	EO#2.9
14	Technological	RE self-consumption increase (5/7 sites)	percentage	EO#2.3
Economic				
15	Economic	Cost savings	k€/y	EO#2.7
16	Economic	Payback Time (PBT)	Years	EO#2.3

3.1.2 1st iteration: Extended pool based on literature review

In this first iteration, the initial pool is expanded embarking on the foundational step of introducing two pivotal elements, the Classification and the Evaluation Level. Classification delineates metrics into three categories: a) Core (related to EVELIXIA Expected Outcomes EO), b) Suggested (based on other sources), and c) Supportive (KPIs necessary for the calculation of another KPI). The Evaluation Level stratifies KPIs according to their significance and level of assessment, thereby facilitating efficient resource allocation and strategic focus for all partners and contributors. Concurrently, this structured approach establishes a coherent prioritization that optimally balances comprehensiveness with practicality, laying a solid groundwork for subsequent iterations and refinements. This step produced an expanded pool of **42** KPIs in total, **2** Scientific, **7** Societal, **26** Technological and **7** Economic.

Table 6 Extended Pool of KPIs (based on literature review)

#	Proposed by	Dimension	Title	Unit	Evaluation Level
1	CERTH	Scientific	Citations per publication (effective sector coupling)	[number]	Project
2	CERTH	Scientific	Citations per publication (buildings as flexibility assets)	[number]	Project
3	CERTH	Societal	System Usability Scale (SUS) score	[number]	Pilot Site
4	CERTH	Societal	Ancillary services demonstrated	[number]	Project
5	CERTH	Societal	People engaged by the end of the project	[number]	Project
6	CERTH	Societal	Awareness of economic benefits of reduced	Likert scale	Project

#	Proposed by	Dimension	Title	Unit	Evaluation Level
			energy consumption		
7	CERTH	Societal	Increased environmental awareness	Likert scale	Project
8	CERTH	Environmental	GHG emissions reductions	percentage	Pilot Site
9	CERTH	Environmental	Air quality index (Air pollution)	μg/m3	Project
10	CERTH	Technological	Improved communication, cybersecurity and interoperability	Likert scale	Project
11	CERTH	Technological	B2G/G2B services to be included in EVELIXIA Marketplace	[number]	Project
12	CERTH	Technological	Platforms integrated with EVELIXIA's platform	[number]	Project
13	CERTH	Technological	Electricity flexibility increase (all sites)	percentage	Project
14	CERTH	Technological	Thermal flexibility increase (all sites)	percentage	Project
15	CERTH	Technological	Energy consumption reduction (all sites)	percentage	Pilot Site
16	CERTH	Technological	RE generation increase (all sites)	percentage	Pilot Site

#	Proposed by	Dimension	Title	Unit	Evaluation Level
17	CERTH	Technological	RE self-consumption increase (5/7 sites)	percentage	Pilot Site
18	CERTH	Technological	Self-consumption ratio	[number]	Pilot Site
19	CERTH	Technological	Self-sustenance ratio	[number]	Pilot Site
20	CERTH	Technological	Specific Yield	kWh/kWp	Pilot Site
21	CERTH	Technological	Accuracy of energy supply and demand prediction	kW/kW	Pilot Site
22	CERTH	Technological	Peak demand savings	€ or kWh	Pilot Site
23	CERTH	Technological	Reaction time to increase/decrease power delivery	seconds	Pilot Site
24	CERTH	Technological	Operational Congestion Management (non-contracted bids)	€/MWh/y	Pilot Site
25	CERTH	Technological	Energy system flexibility (electrical or thermal)	kW/kW	Pilot Site
26	CERTH	Technological	Total electrical production	kWh	Pilot Site
27	CERTH	Technological	Total electrical consumption	kWh	Pilot Site

#	Proposed by	Dimension	Title	Unit	Evaluation Level
28	CERTH	Technological	Peak electrical demand	kWh	Pilot Site
29	CERTH	Technological	Electricity imports from Grid	kWh	Pilot Site
30	CERTH	Technological	Electricity exports to Grid	kWh	Pilot Site
31	CERTH	Technological	Influence of energy storage on cutting peak demand	kW/kW	Pilot Site
32	CERTH	Technological	Variable renewable energy surplus	percentage	Pilot Site
33	CERTH	Technological	Self-consumption during DR action	kW/kW	Pilot Site
34	CERTH	Technological	Reserves adequacy	MWh/y of stored energy	Project
35	CERTH	Technological	Energy curtailment	percentage	Pilot Site
36	CERTH	Economic	Cost savings	k€/y	Project
37	CERTH	Economic	Payback Time (PBT)	Years	Project Level
38	CERTH	Economic	Total annual cost	€/y	Pilot Site
39	CERTH	Economic	Initial Capital Cost (for pilot sites with new infrastructure integration)	€	Pilot Site
40	CERTH	Economic	Lifetime Capital Cost (for pilot sites with new infrastructur	€	Pilot Site

#	Proposed by	Dimension	Title	Unit	Evaluation Level
			e integration)		
41	CERTH	Economic	Return on Investment (ROI)	percentage	Pilot Site
42	CERTH	Economic	Net Present Value (NPV)	€	Pilot Site

3.1.3 2nd iteration: Expanded pool based on tailored feedback

In the second iteration, the pool transitions to a culmination of refined insights gleaned from collaborative engagements with EVELIXIA's horizontal Technology Providers. The project team actively integrates comments, feedback, input, references, and suggestions from the perspective of a diverse array of experts. The evaluation framework undergoes a nuanced evolution, ensuring alignment with industry best practices and emerging trends. The tailored feedback received serves as a catalyst for augmenting the scope of the metrics pool in correlation with the planned solutions to be implemented, thereby enriching the evaluative landscape and enhancing its relevance and effectiveness. This step produced a further expanded pool of **84** KPIs in total, **2** Scientific, **7** Societal, **67** Technological and **8** Economic.

Table 7 Extended Pool of KPIs (based on feedback from horizontal Technology Providers)

#	Proposed by	Dimension	Title	Evaluation Level
1	CERTH	Scientific	Citations per publication (effective sector coupling)	Project
2	CERTH	Scientific	Citations per publication (buildings as flexibility assets)	Project
3	CERTH	Societal	System Usability Scale (SUS)	Pilot Site
4	CERTH	Societal	Ancillary services demonstrated	Project
5	CERTH	Societal	People engaged by the end of the project	Project
6	CERTH	Societal	Awareness of economic benefits of reduced energy consumption	Project

#	Proposed by	Dimension	Title	Evaluation Level
7	CERTH	Societal	Increased environmental awareness	Project
8	CERTH	Environmental	Carbon footprint	Pilot Site
9	CERTH	Environmental	Air quality index (Air pollution)	Project
10	CERTH	Technological	Improved communication, cybersecurity and interoperability	Project
11	CERTH	Technological	B2G/G2B services to be included in EVELIXIA Marketplace	Project
12	CERTH	Technological	Platforms integrated with EVELIXIA's platform	Pilot Site
13	CERTH	Technological	Electricity flexibility (all sites)	Pilot Site
14	CERTH	Technological	Thermal flexibility (all sites)	Pilot Site
15	CERTH	Technological	Primary energy consumption (all sites)	Pilot Site
16	CERTH	Technological	RE generation capacity (all sites)	Pilot Site
17	CERTH	Technological	RE self-consumption (5/7 sites)	Pilot Site
18	CERTH	Technological	RE self-consumption	Pilot Site
19	CERTH	Technological	Self-sustenance	Pilot Site
20	CERTH	Technological	Specific Yield	Technology
21	CERTH	Technological	Accuracy of energy supply and demand prediction	Pilot Site
22	CERTH	Technological	Peak demand savings	Pilot Site
23	CERTH	Technological	Reaction time to increase/decrease power delivery	Pilot Site
24	CERTH	Technological	Operational Congestion Management (non-contracted bids)	Pilot Site

#	Proposed by	Dimension	Title	Evaluation Level
25	CERTH	Technological	Energy system flexibility (electrical or thermal)	Pilot Site
26	CERTH	Technological	Electricity production (all sites)	Pilot Site
27	CERTH	Technological	Electricity consumption (all sites)	Pilot Site
28	CERTH	Technological	Peak electrical demand	Pilot Site
29	CERTH	Technological	Electricity imports from the grid	Pilot Site
30	CERTH	Technological	Electricity exports to the grid	Pilot Site
31	CERTH	Technological	Influence of energy storage on cutting peak demand	Pilot Site
32	CERTH	Technological	Variable renewable energy surplus	Pilot Site
33	CERTH	Technological	Self-consumption during DR action	Pilot Site
34	CERTH	Technological	Reserves adequacy	Project
35	CERTH	Technological	Energy curtailment	Pilot Site
36	CERTH	Technological	Filtering Effectiveness	Technology
37	CERTH	Technological	Accuracy of Imputation	Technology
38	CERTH	Technological	Computational Efficiency: Time taken for data filtering and imputation.	Technology
39	CIRCE	Technological	API Response Time	Technology
40	CIRCE	Technological	API Request Success Rate	Technology
41	CIRCE	Technological	API Usage	Technology
42	CIRCE	Technological	Number of Connected Devices or Systems	Technology
43	CIRCE	Technological	Operational Resilience	Technology
44	CIRCE	Technological	Data Integrity	Technology
45	CIRCE	Technological	Energy Efficiency	Technology
46	CIRCE	Technological	Semantic Accuracy	Technology

#	Proposed by	Dimension	Title	Evaluation Level
47	CIRCE	Technological	Ontology Utilization	Technology
48	CIRCE	Technological	Data Compatibility	Technology
49	CIRCE	Technological	Knowledge Graph Complexity	Technology
50	CIRCE	Technological	Interoperability	Technology
51	CIRCE	Technological	Server Configuration Efficiency	Technology
52	CIRCE	Technological	Data Management Efficiency	Technology
53	CIRCE	Technological	Semantic Query Efficiency	Technology
54	CIRCE	Technological	AES Performance Enhancement	Technology
55	CIRCE	Technological	Intermediary Development Efficiency	Technology
56	CIRCE	Technological	Verification Test Success Rate	Technology
57	CIRCE	Technological	Blockchain Security Efficiency	Technology
58	R2M	Technological	Number of interventions listed to achieve a higher SRI score (Completeness of input data)	Technology
59	R2M	Technological	Cost effective strategies accuracy/efficiency	Technology
60	IESRD	Technological	Confidence Level of simulation engine inputs	Technology
61	IESRD	Technological	Calibration metrics of simulation model	Technology
62	IESRD	Technological	Predictability and measurability of forecasting toolboxes inputs	Technology
63	IESRD	Technological	Energy Savings triggered (or expected)	Technology
64	IESRD	Technological	Thermal comfort improvements	Technology

#	Proposed by	Dimension	Title	Evaluation Level
65	IESRD	Technological	Electricity savings (MWh)	Technology
66	IESRD	Technological	Heating savings (MWh)	Technology
67	CEA	Technological	Cumulative exposures to CO2 greater than a threshold value	Technology
68	CEA	Technological	Number of hours in a year with CO2 overexposure compared with threshold value	Technology
69	CEA	Technological	Availability rate of: - electric resistor heater for AHU's anti-freeze protection - fans, pumps for ventilation or heating systems	Technology
70	CEA	Technological	Discomfort degree-hour (for cold or hot season)	Pilot Site
71	CEA	Technological	Number of hours in a year when operative temperature exceeds threshold value	Pilot Site
72	CEA	Technological	State of Health (SOH) evolution of Battery Energy Storage System (BESS)	Technology
73	CEA	Technological	Thermal Energy Consumption (all sites)	Pilot Site
74	CEA	Technological	RE primary Energy Savings (all sites)	Pilot Site
75	RINA-C	Technological	Covered total surface	Pilot Site
76	RINA-C	Technological	Sensors displayed	Pilot Site
77	CERTH	Economic	Cost savings	Project
78	CERTH	Economic	Payback Period	Project
79	CERTH	Economic	Total annual cost	Pilot Site
80	CERTH	Economic	Initial Capital Cost (for pilot sites with	Pilot Site

#	Proposed by	Dimension	Title	Evaluation Level
			new infrastructure integration)	
81	CERTH	Economic	Lifetime Capital Cost (for pilot sites with new infrastructure integration)	Pilot Site
82	CERTH	Economic	Return on Investment (ROI)	Project
83	CERTH	Economic	Net Present Value (NPV)	Pilot Site
84	R2M	Economic	Accuracy of input data	Pilot Site

3.1.4 3rd iteration: Internal refinement prior to the Evaluation

In the third iteration the extended pool of metrics undergoes a phase of internal refinement based on qualitative criteria before reaching the Pilot Site Managers for Evaluation as described in 2.1.4.1. This step reduced the pool to **38** KPIs in total, **1** Scientific, **5** Societal, **27** Technological and **4** Economic.

Table 8 Refined Pool of KPIs (prior to the Evaluation)

#	Proposed by	Dimension	Title	Unit	Evaluation Level
Scientific					
1	CERTH	Scientific	Citations per publication	[number] /publ./y	Project
Societal					
2	CERTH	Societal	System Usability Scale (SUS) score	[number]	Pilot Site
3	CERTH	Societal	People engaged by the end of the project	[number]	Project
4	CERTH	Environmental	Carbon footprint	teqCO2/ m2/y	Pilot Site
5	CERTH	Environmental	Primary energy demand	kWh/m2/ y	Pilot Site
6	CEA	Environmental	Exposure to CO2	ppm.hours /y	Pilot Site
Technological					
7	CERTH	Technological	Improved communication,	Likert scale	Project

#	Proposed by	Dimension	Title	Unit	Evaluation Level
			cybersecurity and interoperability		
8	CERTH	Technological	B2G/G2B services to be included in EVELIXIA Marketplace	[number]	Project
9	CERTH	Technological	Ancillary services demonstrated	[number]	Project
10	CERTH	Technological	Sector coupling technologies demonstrated	[number]	Project
11	CERTH	Technological	Platforms integrated with EVELIXIA's platform	[number]	Project
12	CERTH	Technological	Potential Offered Flexibility	kW/y or kWh/y	Pilot Site
13	CERTH	Technological	Voltage Variation	percentage	Pilot Site
14	CERTH	Technological	Final energy consumption	kWh/m2/y	Project
15	CERTH	Technological	RE generation	kWh/y	Project
16	CERTH	Technological	Self-consumption	percentage	Pilot Site
17	CERTH	Technological	Self-sustenance	percentage	Pilot Site
18	CERTH	Technological	Specific Yield	kWh/kWp	Technology
19	CERTH	Technological	Congestion Management Income	€/MWh/y	Pilot Site
20	CERTH	Technological	Peak electrical demand	kW	Pilot Site
21	CERTH	Technological	Energy curtailment	percentage	Project
22	CERTH	Technological	Filtering Effectiveness	percentage	Technology
23	CERTH	Technological	Accuracy of Imputation	same as the	Technology

#	Proposed by	Dimension	Title	Unit	Evaluation Level
				original data being measured	
24	CIRCE	Technological	API Response Time	-	Technology
25	CIRCE	Technological	API Request Success Rate	-	Technology
26	R2M	Technological	Cost effective strategies accuracy/efficiency	€/% of SRI score	Technology
27	IESRD	Technological	Calibration metrics of simulation model	-	Technology
28	CERTH	Technological	Accuracy of RES production forecast calculated 24 hours in advance	percentage	Pilot Site
29	CERTH	Technological	Electricity imports from the grid	kWh	Pilot Site
30	CERTH	Technological	Electricity exports to the grid	kWh	Pilot Site
31	CIRCE	Technological	Ontology Utilization	-	Technology
32	IESRD	Technological	Electricity savings	MWh	Pilot Site
33	IESRD	Technological	Thermal energy savings	MWh	Pilot Site
34	CERTH	Technological	Increase in the amount of load capacity participating in DR	percentage	Pilot Site
Economic					
35	CERTH	Economic	Cost Savings	k€/y	Project

#	Proposed by	Dimension	Title	Unit	Evaluation Level
36	CERTH	Economic	Payback Period	Years	Pilot Site
37	CERTH	Economic	Return on Investment (ROI)	percentage	Pilot Site
38	ENTECH	Economic	Levelized Cost of Energy	€/kWh/y	Pilot Site

3.1.5 Evaluation Scores

The results of the Evaluation process (described in 2.1.4.2), which encapsulate the collective perspectives offer valuable insights into the performance and impact of the project within the context of the Pilot Sites' demonstration. Presented below in a tabular format: a) the average score for each of the pre-defined criteria given the integer values from the relevant evaluators per KPI and b) the aggregated final score per KPI as the cumulative sum of those values. Both numbers are rounded up to the first decimal place.

Table 9 Evaluation Scores for the Refined Pool of KPIs

#	Title	Relevance	Availability	Measurability	Reliability	Familiarity	Final Score
Scientific							
1	Citations per publication	2,0	1,0	2,0	1,0	1,0	**7,0**
Societal							
2	System Usability Scale (SUS)	2,0	1,0	1,5	1,5	2,0	**8,0**
3	People engaged by the end of the project	2,0	1,5	1,5	1,0	1,5	**7,5**
4	Carbon footprint	1,9	1,3	1,3	1,4	1,6	**7,4**
5	Primary energy demand	2,0	1,7	2,0	1,6	1,9	**9,1**
6	Exposure to CO2	1,1	1,0	1,0	1,0	1,0	**5,1**
Technological							
7	Improved communication,	1,5	0,9	0,9	0,9	0,9	**5,0**

#	Title	Relevance	Availability	Measurability	Reliability	Familiarity	Final Score
	cybersecurity and interoperability						
8	B2G/G2B services to be included in EVELIXIA Marketplace	1,7	1,4	1,7	1,4	1,0	**7,3**
9	Ancillary services demonstrated	2,0	1,7	1,7	1,3	1,0	**7,7**
10	Sector coupling technologies demonstrated	2,0	1,7	1,7	1,0	1,0	**7,3**
11	Platforms integrated with EVELIXIA's platform	1,7	1,7	1,8	1,7	1,3	**8,2**
12	Potential Offered Flexibility	2,0	1,7	1,6	1,4	1,1	**7,9**
13	Voltage Variation	1,4	1,3	1,6	1,1	1,0	**6,4**
14	Final energy consumption	2,0	1,7	2,0	1,6	1,9	**9,1**
15	RE generation	1,9	1,9	1,9	1,6	1,9	**9,0**
16	Self-consumption	1,7	1,4	1,7	1,3	1,4	**7,6**
17	Self-sustenance	1,4	1,6	1,7	1,3	1,4	**7,4**
18	Specific Yield	1,3	1,6	1,4	1,3	1,4	**7,0**
19	Congestion Management Income	0,6	0,2	0,4	0,6	0,2	**2,0**
20	Peak electrical demand	1,4	1,6	1,4	1,3	1,4	**7,1**

#	Title	Relevance	Availability	Measurability	Reliability	Familiarity	Final Score
22	Energy curtailment	1,8	1,6	1,6	1,8	1,8	**8,6**
22	Filtering Effectiveness	0,3	0,8	0,8	0,7	0,5	**3,2**
23	Accuracy of Imputation	0,9	1,0	0,9	0,7	0,6	**4,0**
24	API Response Time	1,2	0,7	0,8	0,8	0,7	**4,2**
25	API Request Success Rate	1,0	0,7	0,8	0,7	0,7	**3,8**
26	Cost effective strategies accuracy/efficiency	1,3	1,2	1,2	1,0	1,0	**5,7**
27	Calibration metrics of simulation model	1,5	0,8	0,3	0,7	0,5	**3,8**
28	Accuracy of RES production forecast calculated 24 hours in advance	1,5	0,8	0,8	1,0	1,2	**5,3**
29	Electricity imports from the grid	1,4	1,3	1,4	1,3	1,0	**6,4**
30	Electricity exports to the grid	1,7	1,6	1,7	1,4	1,1	**7,6**
31	Ontology Utilization	0,7	0,5	0,3	0,7	0,5	**2,7**
32	Electricity savings	1,8	1,3	1,5	1,3	1,7	**7,7**
33	Thermal energy savings	1,2	0,8	0,7	0,5	1,3	**4,5**
34	Increase in the amount of load capacity	1,2	1,0	0,8	0,7	0,5	**4,2**

#	Title	Relevance	Availability	Measurability	Reliability	Familiarity	Final Score
	participating in DR						
Economic							
35	Cost Savings	2,0	1,0	2,0	1,0	2,0	**8,0**
36	Payback Period	2,0	1,0	2,0	1,0	1,0	**7,0**
37	Return on Investment (ROI)	1,0	1,0	1,0	1,0	2,0	**6,0**
38	Levelized Cost of Energy	2,0	1,0	1,0	1,0	2,0	**7,0**

3.1.6 4th iteration: Final version for M9

In the fourth and final iteration, the pool undergoes further refinement, both internally (Section 2.1.4.3) and in collaboration with key partners and strategic stakeholders (Section 2.1.4.4), culminating in the finalized version for M9. The project team harnesses collective expertise and insights to enhance the framework's precision and relevance. Through iterative cycles of review and adjustment, the framework evolves into its definitive form, aligning seamlessly with project objectives and stakeholder expectations. As a result, from this process, the number of KPIs to be included into the EVELIXIA'S KPI repository was reduced to **19** KPIs in total, **1** Scientific, **4** Societal, **11** Technological and **3** Economic.

Table 10 Final Pool of KPIs for M9

#	Dimension	Title	Unit	Evaluation Level	Linked EO#
Scientific					
1	Scientific	Citations per publication	[number]/ publ./y	Project	EO#1.1, #2.1
Societal					
2	Societal	System Usability Scale (SUS)	[number]	Project	EO#1.4
3	Societal	People engaged	[number]	Project	EO#1.3
4	Environmental	GHG emissions	teqCO2/m2 /year	Project	EO#2.4
5	Environmental	Primary energy demand	kWh/y	Pilot Site	EO#2.4

#	Dimension	Title	Unit	Evaluation Level	Linked EO#
Economic/Technological					
6	Technological	Ancillary services demonstrated	[number]	Project	EO#1.3
7	Technological	Potential Offered Flexibility	kW/y or kWh/y	Project	EO#2.5
8	Technological	Final energy consumption	kWh/y	Project	EO#2.4
9	Technological	RE generation	kWh/y	Project	EO#2.9
10	Technological	Self-consumption	percentage	Project	EO#2.6
11	Technological	Self-sustenance	percentage	Pilot Site	EO#2.2
12	Technological	Energy curtailment	percentage	Pilot Site	EO#2.2
13	Economic	Cost savings	k€/y	Pilot Site	EO#2.7
14	Economic	Payback period	Years	Project	EO#2.3
15	Economic	Levelized Cost of Energy	€/kWh	Pilot Site	EO#2.7
16	Technological	Improved communication, cybersecurity and interoperability	Likert scale	Pilot Site	EO#1.6
17	Technological	B2G/G2B services to be included in EVELIXIA Marketplace	[number]	Project	EO#1.8

#	Dimension	Title	Unit	Evaluation Level	Linked EO#
18	Technological	Sector coupling technologies demonstrated	[number]	Technology	EO#1.5
19	Technological	Platforms integrated with EVELIXIA's platform	[number]	Technology	EO#1.7

3.2 KPI Cards

In this sub-chapter, the attention is directed towards the tangible outcome of the iterative evaluation process: the cards for the Key Performance Indicator (KPI) repository comprising the final pool metrics for M9 that utilize each KPI as a quantifiable measure essential for gauging the effectiveness and progress of the EVELIXIA project across short- and medium-term timelines. The KPI cards presented in the following section encapsulate important information pertaining to each metric, including definition, calculation methodology and the respective formulas, and relevance to project objectives.

3.2.1 Scientific Key Impact Pathway

3.2.1.1 Citations per publication

KPI 1.1 - Card Overview	
KPI Title	Citations per publication
KPI Responsible Partner	RINA-C
KPI Definition	EVELIXIA aspires to create and use high-quality new knowledge in the areas of: a) Effective sector coupling b) Strengthening the utilization of buildings as flexibility assets Peer-reviewed publications in open-access scientific journals or/and repositories, can serve as the means to validate the credibility of EVELIXIA's high-quality new knowledge generated.
Recommended Estimation Process	The number of citations (a reference to the source of information used in a research) is a common way to indicate the appeal and quality of new knowledge generated by EVELIXIA.

Recommended Data Sources	Google Scholar, Research Gate, Web of Science, Scopus, JSTOR etc.		
Recommended Unit	[number]/publ./y	**Recommended Monitoring Interval**	annually
KPI Relevant Contributors	CERTH, HES-SO, CEA, CIRCE, UNIGE, FHB, TUCN, ITG, TUAS		
Linked KIP	Scientific		

Recommended Evaluation Level					
Technology		**Pilot**		**Project**	

3.2.2 Societal Key Impact Pathway

3.2.2.1 System Usability Scale (SUS) score

KPI 2.1 - Card Overview	
KPI Title	System Usability Scale (SUS) score
KPI Responsible Partner	HES-SO
KPI Definition	The System Usability Scale (SUS) is a widely used standardized questionnaire for the assessment of perceived usability[7]. The SUS consists of a 10-item questionnaire with five response options for respondents; from "Strongly agree" to "Strongly disagree". It allows to build a score ranging from 0 to 100 that will be interpreted as a quantifiable measure of the satisfaction and usability of EVELIXIA solutions. A higher score indicates improved usability, whereas a lower score indicates potential usability issues.
Recommended Estimation Process	The standard version of the SUS contains the following questions: 1. I think that I would like to use this system frequently. 2. I found the system unnecessarily complex. 3. I thought the system was easy to use. 4. I think that I would need the support of a technical person to be able to use this system. 5. I found the various functions in this system were well integrated. 6. I thought there was too much inconsistency in this system.

7 Lewis, J. R. (2018). The System Usability Scale: Past, Present, and Future. *International Journal of Human–Computer Interaction*, *34*(7), 577–590. https://doi.org/10.1080/10447318.2018.1455307

	7. I would imagine that most people would learn to use this system very quickly. 8. I found the system very cumbersome to use. 9. I felt very confident using the system. 10. I needed to learn a lot of things before I could get going with this system. Each of these 10 items are answered on a 1 (= strongly disagree) to 5 (= strongly agree) Likert scale. As can be observed, the items alternate between positive tone (odd-numbered items) and negative tone (even-numbered items). Therefore, to construct the score, one must first manipulate the raw scores obtained as follows: - For the odd-numbered items (positive tone) subtract 1 from the raw score, so that adjusted score ranges from 0 (poorest rating) to 4 (best rating). - For the even-numbered items (negative tone), subtract the raw score from 5, so that the adjusted score also ranges from 0 to 4. These adjusted scores are then summed up and multiplied by 2.5 so that the final overall SUS score ranges from 0 to 100, with zero being the least and 100 being the maximum. It is calculated as follows: More concisely, one may also express the SUS score using the following equation: SUS = 2.5 x (20 + SUM[SUS01, SUS03, SUS05, SUS07, SUS09] - SUM[SUS02, SUS04, SUS06, SUS08, SUS10]) Where: SUS## is the original (non-adjusted) score provided by the respondents for item ##.				
Recommended Data Sources	The SUS score will be calculated through surveys.				
Recommended Unit	[number]	**Recommended Monitoring Interval**	once at the end of the project		
KPI Relevant Contributors	RINA-C, CEA, Pilot Site Managers				
Linked KIP	Societal				
Recommended Evaluation Level					
Technology		**Pilot**		**Project**	

3.2.2.2 People engaged

KPI 2.2 - Card Overview					
KPI Title	People engaged				
KPI Responsible Partner	RINA-C				
KPI Definition	Number of people engaged during the lifetime of the project based on a) increased awareness on available solutions that support the transformation of buildings into active utility nodes and their potential impact to the energy system, and b) participation in EVELIXIA activities (i.e., workshops, events, conferences, etc.)				
Recommended Estimation Process	Questionnaires with targeted and open-ended questions on both topics.				
Recommended Data Sources	Large-scale surveys, communication campaigns, dissemination activities, workshops and seminars, conferences and events, webinars, social media interactions, collaborations and partnerships, synergies.				
Recommended Unit	[number]	**Recommended Monitoring Interval**	once at the end of the project		
KPI Relevant Contributors	HES-SO, CEA, Pilot Site Managers				
Linked KIP	Societal				
Recommended Evaluation Level					
Technology		**Pilot**		**Project**	

3.2.2.3 Greenhouse Gas Emissions

KPI 3.1 - Card Overview	
KPI Title	Greenhouse Gas Emissions
KPI Responsible Partner	EEE, TUCN, ENTECH, ECG, CERTH, ITG, NTTDATA, TUAS, NEOY
KPI Definition	GHGs are gases in the atmosphere that absorb infrared radiation that would otherwise escape to space; thereby contributing to global warming. There are six major GHGs: carbon dioxide (CO2), methane (CH4), nitrous oxide (N2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and Sulphur hexafluoride (SF6). 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). This KPI quantifies the GHG emissions that derive from the operation of the building, as well as the generation and distribution of electricity and thermal energy with a view to evaluate the reduction achieved across Pilot Sites. This KPI should be aligned with the foreseen final energy consumption (KPI 4.3) and RE generation (KPI 4.4).
Recommended Estimation Process	The following indicative formula can be applied to estimate this KPI: $$GGE = \frac{\sum_i TE_{C,i}.GEF_{T,i} + \sum_i EE_{c,i}.GEF_{E,i}}{A_b}$$ where: GGE = Greenhouse gas emissions per building unit $\mathrm{TE_{C,i}}$ = Thermal energy consumption (monitored) of the demonstration site per energy carrier [kWh/(month); kWh/ (year)] $\mathrm{EE_{C,i}}$ = Electrical energy consumption (monitored) of the demonstration site per energy carrier [kWh/(month); kWh/ (year)] $\mathrm{GEF_T}, i$ = Greenhouse gas emission factor for thermal energy per energy carrier(weighted average based on thermal energy production source/fuel mix) (kg CO2eq/kWh consumed) $\mathrm{GEF_{E,i}}$ = Greenhouse gas emission factor for electrical energy per energy carrier (weighted average based on electricity production source/fuel mix) (kg CO2eq/kWh consumed) $\mathrm{A_b}$ = Floor area of the building [m2] A baseline estimation should be performed, prior to the installation of EVELIXIA solutions in order to calculate the KPI before and after EVELIXIA solutions.
Recommended Data Sources	Preliminary estimations performed during the proposal phase and are reported in GA, Section 2.1, Call EO#2. For the cases of AT, RO, DK, GR and ES Pilot Sites, emissions should be extracted based on the foreseen energy mix of DH networks. The updated LCA 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, as well local emission factors (if available).

Recommended Unit	tonsCO_{2eq}/m^2/year	**Recommended Monitoring Interval**	once at the beginning of the project and then annually
KPI Relevant Contributors	CEA, CERTH		
Linked KIP	Environmental		
Recommended Evaluation Level			
Technology		**Pilot**		**Project**	

3.2.2.4 Primary energy demand

KPI 3.2 - Card Overview	
KPI Title	Primary energy demand
KPI Responsible Partner	EEE, TUCN, ENTECH, ECG, CERTH, ITG, NTTDATA, TUAS, NEOY
KPI Definition	The primary energy demand of a system encompasses all the naturally available energy consumed in the supply chain of the energy carriers. To enable the comparability between systems, the total primary energy demand can be related to the size of the system (e.g., conditioned area) and the considered time interval (e.g., month, year).
Recommended Estimation Process	The primary energy use is based on primary energy factors per energy carrier, which may be based on national or regional annual weighted averages or a specific value for on-site production. All calculations should be aligned with the national or regional calculation method for energy performance laid down in the Member State where the buildings are located. If other calculation methods are used, they must be compliant with the EN ISO 52000-1 series. The calculation method and assessment type (as defined by the EN ISO series) shall be reported in all cases. The following indicative formula can be applied to estimate this KPI: $$PE_d = \frac{\sum_i TE_{d,i}.PEF_{T,i} + \sum_i EE_{d,i}.PEF_{E,i}}{A_b}$$ Where: PEd = Primary energy demand TEd,i = Thermal energy demand [kWh/(month); kWh/(year)] EEd,i = Electrical energy demand [kWh/(month); kWh/(year)]

	PEFT,i = Primary energy factor for thermal energy (weighted average based on source/fuel mix in production) PEFE,i = Primary energy factor for electrical energy (weighted average based on source/fuel mix in production) Ab = Floor area of the building [m2] i = rank of each energy carrier considered A baseline estimation should be performed, prior to the installation of EVELIXIA solutions in order to calculate the KPI before and after EVELIXIA solutions.		
Recommended Data Sources	Data collection through simulation process. The calculation of respective primary energy demand 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 local primary energy factors if deemed necessary.		
Recommended Unit	kWh/m²/y	**Recommended Monitoring Interval**	once at the beginning of the project and then annually
KPI Relevant Contributors	CEA, CERTH		
Linked KIP	Environmental		

Recommended Evaluation Level					
Technology		**Pilot**		**Project**	

3.2.3 Economic/Technological Key Impact Pathway

3.2.3.1 Ancillary services demonstrated

KPI 4.1 - Card Overview	
KPI Title	Ancillary services demonstrated
KPI Responsible Partner	CEA, ECG
KPI Definition	This KPI represents the number of key multi-vector ancillary services. Set of support functions and capabilities tendered by TSO essential for maintaining reliable, stable, and efficient power supply and operation of the grid. Indicative examples for both existing and emerging applications such as Frequency Containment Reserve (FCR), Automatic Frequency Restoration Reserve (aFRR), Manual Frequency

	Restoration Reserve (mFRR), Voltage Support, Replacement Reserve (RR), Synchronous Inertial Response (SIR), Load Following, Black Start, Fast Frequency Response (FFR), Enhanced Frequency Response (EFR).			
Recommended Estimation Process	Cumulative number of demonstrated TSO level services across Pilot Sites.			
Recommended Data Sources	Pilot Site demonstrations cross-referenced with Use Case descriptions and stakeholders' requirements.			
Recommended Unit	[number]	**Recommended Monitoring Interval**	once at the end of the project	
KPI Relevant Contributors	ITG, CERTH			
Linked KIP	Technological			
Recommended Evaluation Level				
Technology		**Pilot**		**Project**

3.2.3.2 Potential Offered Flexibility

KPI 4.2 - Card Overview	
KPI Title	Potential Offered Flexibility
KPI Responsible Partner	EEE, TUCN, ENTECH, ECG, CERTH, ITG, NTTDATA, TUAS, NEOY
KPI Definition	This KPI measures the potential amount of flexibility that all flexible resources of the portfolio are able to offer in terms of either electricity or thermal energy sent from a flexible resource during an examined period. It represents the enhancement of the ability 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 interventions.
Recommended Estimation Process	The following indicative formula can be applied to estimate this KPI: For electricity: FlexPO,e= P_flexPOi,t For thermal: FlexPO,t= E_flexPOi,t where:

	P_flexPOi,t : The amount of power send from the ith flexible resource at time t to offer flexibility for sale. It contains the potential flexibility that is available (kW). E_flexPOi,t : The amount of energy send from the i flexible resource at time t to market platform to offer flexibility for sale. It contains the potential flexibility that is available (kWh). i: set of flexible resources t: examined period A baseline estimation should be performed, prior to the installation of EVELIXIA solutions in order to calculate the percentage of increase after EVELIXIA solutions.		
Recommended Data Sources	Data extracted from monitoring sensors.		
Recommended Unit	kW/y or kWh/y	**Recommended Monitoring Interval**	once at the beginning of the project and then annually
KPI Relevant Contributors	CEA, CERTH		
Linked KIP	Technological		

Recommended Evaluation Level					
Technology		**Pilot**		**Project**	

3.2.3.3 Final energy consumption

KPI 4.3 - Card Overview	
KPI Title	Final energy consumption
KPI Responsible Partner	EEE, TUCN, ENTECH, ECG, CERTH, ITG, NTTDATA, TUAS, NEOY
KPI Definition	This KPI represents the amount of energy consumed by end-users, excluding energy losses during extraction, conversion, and distribution processes. This KPI represents the final energy 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 consumption based on monitored data. To enable the comparability between systems, the total final energy consumption related to the size of the system (when applicable) and the time interval. This indicator is used to assess the energy efficiency of a system. All forms of energy need to be considered, 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

	must be calculated or converted to kWh of energy to be able to sum up the separately calculated energy consumptions and achieve the total energy consumption.
Recommended Estimation Process	The following indicative formula can be applied to estimate this KPI: $$E_C = \frac{TE_C + EE_C}{A_b}$$ where: 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 [m2] 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) A baseline estimation should be performed, prior to the installation of EVELIXIA solutions in order to calculate the percentage of reduction after EVELIXIA solutions.
Recommended Data Sources	Data extracted from monitoring sensors and smart meters installed at EVELIXIA Pilot Sites
Recommended Unit	kWh/m²/y
Recommended Monitoring Interval	once at the beginning of the project and then monthly/ annually
KPI Relevant Contributors	CEA, CERTH
Linked KIP	Technological

Recommended Evaluation Level					
Technology		**Pilot**		**Project**	

3.2.3.4 RE generation

KPI 4.4 - Card Overview	
KPI Title	RE generation
KPI Responsible Partner	EEE, TUCN, ENTECH, ECG, CERTH, ITG, NTTDATA, TUAS, NEOY
KPI Definition	This KPI calculates the on-site energy production from renewable energy sources.

Recommended Estimation Process	The sum of the annual RE (electricity and thermal) generated per RE component per Pilot Site. It is suggested that electricity and thermal energy generated by RES are recorded separately in order to facilitate calculations and make the results more transparent. Results can be further provided broken down per RES type. This KPI should consider only RE generated on-site and within the boundaries of the Pilot Site.		
Recommended Data Sources	Data extracted from monitoring sensors and smart meters.		
Recommended Unit	kWh/y	**Recommended Monitoring Interval**	once at the beginning of the project and then monthly/ annually
KPI Relevant Contributors	CEA, CERTH		
Linked KIP	Technological		

Recommended Evaluation Level					
Technology		**Pilot**		**Project**	

3.2.3.5 Self-consumption

KPI 4.5 - Card Overview	
KPI Title	Self-consumption
KPI Responsible Partner	EEE, TUCN, ENTECH, ECG, CERTH, ITG, NTTDATA, TUAS, NEOY
KPI Definition	This KPI represents the average utilization of RE. It shows the efficiency of the renewable energy sources usage. It indicates the average ratio of the energy consumed from renewable resources over the total energy generated by RE. The consumed energy is the amount of energy from the renewable source used solely for the needs of the building's components. The value of the KPI is the average utilization ratio per year.
Recommended Estimation Process	The following indicative formula can be applied to estimate this KPI: $$SC = \frac{RE_{self-consumed}}{RE_{generated}} \cdot 100$$ where: SC: self-consumption ratio RE self-consumed: The energy consumed on-site that is generated from renewable resources.

	RE generated: The amount of energy generated on-site from renewable sources. A baseline estimation should be performed, prior to the installation of EVELIXIA solutions in order to calculate the percentage before and after EVELIXIA solutions.		
Recommended Data Sources	Input data linked with KPI 4.3 and KPI 4.4.		
Recommended Unit	percentage	**Recommended Monitoring Interval**	once at the beginning of the project and then annually
KPI Relevant Contributors	CEA, CERTH		
Linked KIP	Technological		

Recommended Evaluation Level					
Technology		**Pilot**		**Project**	

3.2.3.6 Self-sustenance

KPI 4.6 - Card Overview	
KPI Title	Self-sustenance
KPI Responsible Partner	EEE, TUCN, ENTECH, ECG, CERTH, ITG, NTTDATA, TUAS, NEOY
KPI Definition	This KPI represents the average reliance on RE. It indicates the average ratio of the energy consumed from renewable resources over the final energy consumption. The value of the KPI is the average reliance ratio per year.
Recommended Estimation Process	*The following indicative formula can be applied to estimate this KPI:* $$SSu = \frac{RE_{self-consumed}}{Final\ energy\ _{consumed}} \cdot 100$$ where: SS: self-sustenance ratio RE self-consumed: The energy consumed on-site that is generated from renewable resources. Final energy consumed: The amount of energy consumed for all operational activities. A baseline estimation should be performed, prior to the installation of EVELIXIA solutions in order to calculate the percentage before and after EVELIXIA solutions.

Recommended Data Sources	Input data linked with KPI 4.3 and KPI 4.4.		
Recommended Unit	percentage	**Recommended Monitoring Interval**	once at the beginning of the project and then annually
KPI Relevant Contributors	CEA, CERTH		
Linked KIP	Technological		
Recommended Evaluation Level			
Technology		**Pilot**	**Project**

3.2.3.7 Energy curtailment

KPI 4.7- Card Overview	
KPI Title	Energy curtailment
KPI Responsible Partner	EEE, TUCN, ENTECH, ECG, CERTH, ITG, NTTDATA, TUAS, NEOY
KPI Definition	This KPI measures the reduction in the amount of energy from RES and DER that is not injected to the grid (even though it is available) due to curtailment measures against operational limits, such as voltage violations, supply-demand imbalances or congestions. The integration of EVELIXIA solutions 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.
Recommended Estimation Process	The following indicative formula can be applied to estimate this KPI: $$EnI = \frac{EnI_{baseline} - EnI_{measured}}{EnI_{baseline}} \cdot 100$$ where: EnI is the percentage reduction in energy not injected in network due to technical and operational problems conditions [% in MWh]. $\mathrm{EnI}_{\mathrm{baseline}}$ is the total energy not injected in network due to technical and operational problems under baseline condition [MWh]. $\mathrm{EnI}_{\mathrm{measured}}$ is the total energy not injected in network due to technical and operational problems under new measured condition [MWh]

	A baseline estimation should be performed, prior to the installation of EVELIXIA solutions in order to calculate the percentage before and after EVELIXIA solutions.		
Recommended Data Sources	Data extracted from monitoring sensors and smart meters.		
Recommended Unit	percentage	**Recommended Monitoring Interval**	once at the beginning of the project and then annually
KPI Relevant Contributors	CEA, CERTH		
Linked KIP	Technological		
Recommended Evaluation Level			
Technology		**Pilot**		**Project**	

3.2.3.8 Cost savings

KPI 5.1 - Card Overview			
KPI Title	Cost savings		
KPI Responsible Partner	EEE, TUCN, ENTECH, ECG, CERTH, ITG, NTTDATA, TUAS, NEOY		
KPI Definition	This KPI represents the monetary benefits deriving from savings in total energy cost (electricity and heating) prior and after the implementation EVELIXIA's solutions, including gains from DR schemes and energy exports (if relevant).		
Recommended Estimation Process	The following indicative formula can be applied to estimate this KPI: $$Cost\ Savings = Initial\ Cost - Final\ Cost$$ where: Initial Cost: the total energy cost incurred before the implementation of EVELIXIA's solutions Final Cost: the total energy cost incurred after the implementation of EVELIXIA's solutions		
Recommended Data Sources	Economic documents from building operators, owners or energy providers (contracts, bills, etc.) and real-time data from sensors if applicable.		
Recommended Unit	k€/y	**Recommended Monitoring Interval**	once at the beginning of the project and then annually
KPI Relevant Contributors	CEA, CERTH		
Linked KIP	Economic		

Recommended Evaluation Level					
Technology		**Pilot**		**Project**	

3.2.3.9 Payback period

KPI 5.2 - Card Overview			
KPI Title	Payback period		
KPI Responsible Partner	EEE, TUCN, ENTECH, ECG, CERTH, ITG, NTTDATA, TUAS, NEOY		
KPI Definition	The time it takes to cover investment costs for EVELIXIA's solutions. It is considered as an additional criterion to assess building smartification as an investing opportunity.		
Recommended Estimation Process	The number of years elapsed between the initial investment and the time at which cumulative savings offset the investment for solutions funded both with own funds and through EVELIXIA per Pilot Site. The following indicative formula can be applied to estimate this KPI: $$PBT = \frac{Total\ initial\ investment\ cost}{Cash\ inflows}$$ *where:* PBT*: the payback time period per Pilot Site* $Total\ initial\ investment\ cost$ *: The sum of the initial investment cost for all individual energy-related technologies implemented per Pilot Site (€)* Cash inflows: The energy cost savings (KPI 5.1) and any other cash flows both positive (e.g., by selling excess energy) or negative (e.g., due to maintenance) per Pilot Site (€/y). For EU investments the costs (PMs) for developing the products and/or costs for dissemination activities, etc., were not considered		
Recommended Data Sources	Economic documents from building operators, owners or energy providers (contracts, bills, etc.) and real-time data extracted from sensors if applicable.		
Recommended Unit	years	**Recommended Monitoring Interval**	once at the end of the project
KPI Relevant Contributors	CEA, CERTH		
Linked KIP	Economic		

Recommended Evaluation Level					
Technology		**Pilot**		**Project**	

3.2.3.10 Levelized Cost of Energy

KPI 5.3 - Card Overview					
KPI Title	Levelized Cost of Energy				
KPI Responsible Partner	EEE, TUCN, ENTECH, ECG, CERTH, ITG, NTTDATA, TUAS, NEOY				
KPI Definition	This KPI shows the average revenue per unit of electricity generated that is required to recover the costs of building and operating the electric generators during the lifetime of the project. EVELIXIA's solutions are also expected to optimize the operation of the existing RES systems, increasing also their share, whilst reducing both their overproduction costs (through DR and DSM schemes) and their maintenance costs.				
Recommended Estimation Process	To calculate the value of this KPI the capital costs of RE generators as well the annual energy production are taken into consideration. The energy production values that come from the monitoring sensors for the first year of the analysis are multiplied with a degradation factor depending on the year of the analysis. Then the total energy production is derived from the sum of the energy production values of all years. Finally, the value of the KPI is the result of the division between the capital costs of RE generators and the lifecycle energy production per Pilot Site. The following indicative formula can be applied to estimate this KPI: $$LCOE = \frac{LCC}{LCE}$$ *where:* $LCOE$*: levelized cost of energy per Pilot Site (€/kWh/y)* LCC*: capital cost of RE generators per Pilot Site(€)* LCE*: The sum of annual RE generation per Pilot Site (kWh/y)*				
Recommended Data Sources	Economic documents from building operators, owners or energy providers (contracts, bills, etc.) and data extracted from sensors and smart meters.				
Recommended Unit	€/kWh/y		**Recommended Monitoring Interval**		annually
KPI Relevant Contributors	CEA, CERTH				
Linked KIP	Economic				
Recommended Evaluation Level					
Technology		**Pilot**		**Project**	

3.2.3.11 Improved communication, cybersecurity and interoperability

KPI 6.1 - Card Overview	
KPI Title	Improved communication, cybersecurity and interoperability
KPI Responsible Partner	EEE, TUCN, ENTECH, ECG, CERTH, ITG, NTTDATA, TUAS, NEOY
KPI Definition	This KPI refers to data privacy, or information privacy and interoperability evaluation. It analyses the extent to which regulations on data protection are followed and to which proper procedures to protect personal or private data are implemented.
Recommended Estimation Process	Survey staple based on the following questions: For each of the following statements, please indicate your level of agreement or disagreement. 1. Strongly Disagree 2. Disagree 3. Neutral 4. Agree 5. Strongly Agree **COMMUNICATION** The EVELIXIA platform uses industry-standard communication protocols (e.g., HTTP/HTTPS, FTP, SMTP). 1 2 3 4 5 The communication protocols implemented by the platform ensure secure data transmission. 1 2 3 4 5 The EVELIXIA platform supports encrypted communication protocols (e.g., TLS, SSL). 1 2 3 4 5 The EVELIXIA platform adheres to established standards for data interoperability (e.g., RESTful APIs, SOAP).

	1 2 3 4 5 The communication protocols used by the platform are compliant with relevant regulations (e.g., GDPR, HIPAA). 1 2 3 4 5 **CYBERSECURITY** The EVELIXIA platform provides robust encryption for data at rest and in transit. 1 2 3 4 5 The EVELIXIA platform includes multi-factor authentication options. 1 2 3 4 5 The EVELIXIA platform employs secure coding practices to prevent common vulnerabilities (e.g., SQL injection, XSS). 1 2 3 4 5 The EVELIXIA platform uses intrusion detection and prevention systems. 1 2 3 4 5 The EVELIXIA platform has a clear incident response plan for security breaches. 1 2 3 4 5 The EVELIXIA platform ensures user data privacy is maintained. 1 2 3 4 5 The EVELIXIA platform provides clear information about data collection and usage policies. 1 2 3 4 5 The EVELIXIA platform allows users to control their data and privacy settings.

	1 2 3 4 5 The EVELIXIA platform ensures secure data backups and recovery. 1 2 3 4 5 The EVELIXIA platform has measures in place to prevent unauthorized data access. 1 2 3 4 5 **INTEROPERABILITY** The EVELIXIA platform supports standard data exchange formats (e.g., XML, JSON, CSV). 1 2 3 4 5 The EVELIXIA platform supports integration with a wide range of databases (e.g., SQL, NoSQL). 1 2 3 4 5 The EVELIXIA platform offers comprehensive and well-documented APIs for integration. 1 2 3 4 5 The EVELIXIA platform supports RESTful and/or SOAP APIs for web services. 1 2 3 4 5 The EVELIXIA platform can connect to various third-party services and applications. 1 2 3 4 5 The EVELIXIA platform provides reliable and secure data transfer between systems. 1 2 3 4 5 The EVELIXIA platform ensures data consistency and accuracy when exchanging data with other systems. 1 2 3 4 5

	The EVELIXIA platform supports data import and export features for easy data migration. 1 2 3 4 5 The EVELIXIA platform can handle various data formats without significant issues. 1 2 3 4 5 The EVELIXIA platform adheres to industry standards for interoperability (e.g., HL7, DICOM, IEEE). 1 2 3 4 5 The EVELIXIA platform is compliant with relevant regulatory requirements for data exchange. 1 2 3 4 5		
Recommended Data Sources	Interviews and questionnaires based on the Likert-scale with the Pilot Site managers and relevant stakeholders. The number of interviewees might differ for each survey.		
Recommended Unit	Likert scale	**Recommended Monitoring Interval**	once at the end of the project
KPI Relevant Contributors	CEA, CERTH		
Linked KIP	Technological		

Recommended Evaluation Level					
Technology		**Pilot**		**Project**	

3.2.3.12 B2G/G2B services to be included in EVELIXIA Marketplace

KPI 6.2 - Card Overview	
KPI Title	B2G/G2B services to be included in EVELIXIA Marketplace
KPI Responsible Partner	EEE, TUCN, ENTECH, ECG, CERTH, ITG, NTTDATA, TUAS, NEOY
KPI Definition	This KPI shows the number of B2G/G2B services included in EVELIXIA's Marketplace.
Recommended Estimation Process	# of B2G and G2B services included in the EVELIXIA marketplace
Recommended Data Sources	EVELIXIA Progress Report

Recommended Unit	[number]	**Recommended Monitoring Interval**	once at the end of the project
KPI Relevant Contributors	CEA, CERTH		
Linked KIP	Technological		
Recommended Evaluation Level			
Technology		**Pilot**		**Project**	

3.2.3.13 Sector coupling technologies demonstrated

KPI 6.3 - Card Overview			
KPI Title	Sector coupling technologies demonstrated		
KPI Responsible Partner	EEE, TUCN, ENTECH, ECG, CERTH, ITG, NTTDATA, TUAS, NEOY		
KPI Definition	This KPI shows the number of sector coupling technologies demonstrated across Pilot Sites.		
Recommended Estimation Process	# of Sector coupling technologies demonstrated		
Recommended Data Sources	EVELIXIA Progress Report		
Recommended Unit	[number]	**Recommended Monitoring Interval**	once at the end of the project
KPI Relevant Contributors	CEA, CERTH		
Linked KIP	Technological		
Recommended Evaluation Level			
Technology		**Pilot**		**Project**	

3.2.3.14 Platforms integrated with EVELIXIA's platform

KPI 6.4 - Card Overview	
KPI Title	Platforms integrated with EVELIXIA's platform
KPI Responsible Partner	EEE, TUCN, ENTECH, ECG, CERTH, ITG, NTTDATA, TUAS, NEOY
KPI Definition	This KPI shows the number of platforms integrated with EVELIXIA's platform.
Recommended Estimation Process	# of Platforms integrated with EVELIXIA platform
Recommended Data Sources	EVELIXIA Progress Report

Recommended Unit	[number]		**Recommended Monitoring Interval**	once at the end of the project	
KPI Relevant Contributors	CEA, CERTH				
Linked KIP	Technological				
Recommended Evaluation Level					
Technology		**Pilot**		**Project**	

4 LONG-TERM EVALUATION

4.1 Long-term KPI repository

As described in Section 2.2.1, the listing of the initial long-term KPIs is based on the expected impacts of EVELIXIA and is presented In the Table that follows. In total, **ten (10)** KPIs were identified that can measure the expected long-term impacts EVELIXIA is aiming for, out of which **one (1)** addresses the project's scientific KIP, **three (3)** addresses the societal and environmental KIP and **six (6)** address the economic and technological KIP. The defined KPIs can be assessed on a Project-, an EU-level, or both. The majority of presented KPIs (6/10) are proposed to be assessed on both levels, while out of the rest, one (1) is evaluated on a project-level and three (3) on a wider EU-level.

4.1.1 Initial pool based on Expected Impacts

Table 11 Initial pool of long-term KPIs for EVELIXIA

S/N	Name of the KPI	Unit	Linked Expected Impact	Evaluation level
Scientific				
1	Scientific advancements and new breakthrough scientific discoveries on issues relevant to EVELIXIA	Likert Scale – 4.5/5.0 (Very High)	EI#1 (1.1); EI#2 (2.1); EI#4 (4.1)	Project
Societal/Environmental				
2	Gross floor area of EU building stock (smartification) to improve its SRI by +47%	m^2/y	EI#2 (2.2)	Project/ EU-level
3	Long-term (>2030) annual GHG emissions reduction triggered by EVELIXIA	tCO_{2eq}/y	EI#3 (3.1)	Project/ EU-level
4	Number of EVELIXIA platform users	#	EI#3 (3.2); EI#4 (4.2)	EU-level
Economic/Technological				
5	Number of positive energy districts deployed	#	EI#1 (1.2)	EU-level

S/N	Name of the KPI	Unit	Linked Expected Impact	Evaluation level
6	Number of very old and/or cultural heritage buildings where energy savings were unlocked	#	EI#4 (4.3)	Project/ EU-level
7	Long-term (>2030) annual energy savings triggered by EVELIXIA	GWh/y	EI#1 (1.3)	Project/ EU-level
8	Gross floor area of EU building stock to acquire a BIM-digital twin	m^2/y	EI#2 (2.3)	Project/ EU-level
9	Share of RE sources in the energy mix of EVELIXIA adopters	%	EI#2 (2.4)	Project/ EU-level
10	Level of standardization, consolidation and integration of smartification process in EU	Likert Scale – 4.5/5.0 (Very High)	EI#2 (2.5)	EU-level

4.2 Initial suggestions for long-term evaluation

In order to clarify the long term KPIs and provide a guideline for their possible future implementation, a brief description is presented for each KPI, including monitoring suggestions and relevant comments in the Table below. This list shall be shared at a later stage with key experts of the EVELIXIA consortium for further feedback and refinement. The revised list will be integrated in the updated version of the deliverable (D1.6).

Table 12 EVELIXIA's long-term KPI clarifications and evaluation suggestions

S/N	Name of the KPI	Recommended Estimation Process
Scientific		
1	Scientific advancements and new breakthrough scientific discoveries on issues relevant to EVELIXIA	The scientific advancements could be beneficial not only for the scientific community but also for the technology providers, including both large industries and smaller entities (e.g., start-ups). Scientific breakthroughs and discoveries enable the flexibility- and smartification-community to develop new technologies, services and applications, solve problems and make informed decisions. The monitoring of this KPI could use either a semi-qualitative approach (e.g. Likert-scale) or more measurable parameters e.g., number of patents, citation increase in the field etc.
Societal/Environmental		
2	Gross floor area of EU building stock (smartification) to improve its SRI by +47%	The introduction of smart devices in more and more homes around the EU is leading to higher quality of life and comfort level for the occupants, as well as a reduction in the energy consumption of the building stock. These improvements can be monitored through a building's SRI score and the provided benefits can lead to an increase in the EU's building renovation rate. EVELIXIA tools and innovative solutions for smartification (SRI advisor) are designed to increase the SRI score of buildings and facilitate the transition to a more sustainable EU building stock.
3	Long-term (>2030) annual GHG emissions reduction triggered by EVELIXIA	It is well established that GHG emissions reduction are closely tied with climate change and can help improve the air quality for EU citizens. The annual GHG emissions reduction could be measured by considering the use of RES and the GHG emissions on building (before and after AI-driven efficient operation and optimized energy consumption) and on building component level. A future target value has been set for EVELIXIA considering the assumed long-

S/N	Name of the KPI	Recommended Estimation Process
		term target energy savings of EVELIXIA, utilizing the LCA emission factors available in the Covenant of Mayors Initiative and by further assuming that the energy that will be saved originates from 35% natural gas, 35% heating oil and 30% electricity-on grid (percentages selected to reflect a representative for various cases scenario). This value can be re-estimated to also take into account RES penetration.
4	Number of EVELIXIA platform users	The total number of EVELIXIA platform users will help the consortium understand if the developed platform is useful and beneficial not only for possible clients but also for future synergies/collaborations. The number of users can be monitored together with the exploitation strategy to be adopted (i.e., though license sales, by setting up individual user accounts etc.).
Economic/Technological		
5	Number of positive energy districts (PED) deployed	This KPI aims to reinforce the 100-PED deployment (EU 2025 goal), utilizing EVELIXIA solutions, such as the formation of RECs etc. The number of PEDs deployed is being tracked by the EC and EVELIXIA's impact can be monitored through the utilization of its innovative solutions.
6	Number of very old and/or cultural heritage buildings where energy savings were unlocked	In most cultural heritage buildings, energy renovation is not an option, in order to preserve their cultural value. Taking into account EVELIXIA's target for increased efficiency through new creative design and novel technological packages would increase the number of the historical and heritage buildings that will achieve energy savings. To monitor this KPI, European statistic databases can be utilized and relevant surveys can be carried out after the end of the project, where the EVELIXIA partners would state if their technologies were implemented in historical/ heritage buildings.
7	Long-term (>2030) annual energy	Energy savings lead to reduced energy bills, improved standards of living and benefits for the environment. When assessing this KPI,

S/N	Name of the KPI	Recommended Estimation Process
	savings triggered by EVELIXIA	the target for a minimum of 13.5% energy savings after the implementation of the EVELIXIA project needs to be considered alongside the United Nations goals for a «greener» and more sustainable environment by 2030. The monitoring of this KPI can be defined accordingly by potential future beneficiaries.
8	Gross floor area of EU building stock to acquire a BIM-digital twin	EVELIXIA adopters will acquire a Digital Twin of buildings since building digitalization is an essential tool stepwise to apply more efficient operational lines and faster time-to-decarbonization. A future target value has been set for EVELIXIA considering the screening SRI results, the targeted floor area and the market penetration rate of EVELIXIA solutions. Re-estimation could be based either on external sources and databases (e.g., EU building stock observatory) or real data to be gathered by EVELIXIA exploitation team (i.e., floor area adopted EVELIXIA solution). Information about whether the renovated buildings have a digital twin can be accessed through the construction companies/partners records. The floor area should be estimated similarly with KPI#2.
9	Share of RE sources in the energy mix of EVELIXIA adopters	In the process of mitigating climate change, reducing the GHG emissions and improving energy security, the EU calls for an increase of the renewable energy sources contribution to the utilized energy mix to 32%[8][9]. EVELIXIA is aligned with this goal by including solutions such as PDP and CEPM that will facilitate the penetration of high shares of RE without affecting energy system stability. The percentage of RE in the energy mix can be

[8] EU, 2009, Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC, OJ L 140, 5.6.2009, p. 16-62.
[9] EU, 2018, Directive (EU) 2018/2001 of the European Parliament and of the Council of 11 December 2018 on the promotion of the use of energy from renewable sources, OJ L 328, 21.12.2018, p. 82-209.

S/N	Name of the KPI	Recommended Estimation Process
		provided by either the construction companies or the management responsible of each building or REC.
10	Level of standardization, consolidation and integration of smartification process in EU	In alignment with EVELIXIA's EO#1, the project is expected to deliver tools (like the PDP and CEPM) that will facilitate a more standardized and integrated energy optimization and smartification process while aiming for a sustainable transformation of the EU building stock. For the assessment of this long-term KPI, information from the construction value chain involved with EVELIXIA (or EVELIXIA influenced renovations), would be required regarding their perception of the level of standardization, consolidation and integration achieved through the implemented EVELIXIA solutions. The monitoring of this KPI could be based on a semi-qualitative approach (e.g. Likert-scale)

5 STAKEHOLDERS' ENGAGEMENT STRATEGY

The main stakeholders are presented in detail in D1.1. These stakeholders, along with brief descriptions of their characteristics and responsibilities, are as follows:

- **Building owners/developers:** They are the initial investors and decision-makers in the development and management of smart buildings. They are responsible for ensuring the implementation of smart technologies.

- **Building managers/operators:** They oversee the day-to-day operations and management of smart buildings by monitoring and controlling the building's systems.

- **Service providers:** These are mainly companies that supply and maintain various smart technologies, such as energy management systems, security systems, and IoT devices.

- **Government agencies/regulatory bodies:** They are responsible for establishing policies, guidelines, and standards related to smart buildings and smart cities to facilitate the adoption of smart technologies, promote sustainability, and ensure the safety and well-being of residents.

- **Research institutions/academia:** They contribute to the development of new technologies, methodologies, and best practices for smart buildings by conducting research, providing expertise, and collaborating with other stakeholders to improve the efficiency and performance of smart buildings.

- **Tenants/occupants:** They are the end-users of the smart building, living, or working within the premises. They need to provide feedback for improvements and contribute to energy conservation and sustainable practices.

- **DSOs/TSOs:** DSOs play a vital role in ensuring the efficient management and distribution of resources in smart buildings acting as utility nodes. TSOs do not have a direct role in smart buildings acting as utility nodes, but they are responsible for maintaining grid stability, ensuring grid integration, and managing emergencies and can therefore indirectly affect the energy management strategies of smart buildings.

- **Aggregators:** The role of aggregators in such systems is to optimize energy consumption and distribution, facilitate demand response programs, promote renewable energy integration, offer financial incentives, enable energy trading, and contribute to grid stability.

The strategy to engage the various EVELIXIA's stakeholders pivots around the online survey (Task 7.4) that will be used to assess social acceptability of the new technologies and the marketplace platform that will be designed during the project. First, during the preparation of the survey, we will be working with various stakeholders, in particular suppliers of new technologies to develop the survey and its central part; the discrete choice experiment. We will also involve other stakeholders (electricity suppliers, pilot sites, potential users, etc.) to ensure that the survey is both realistic from a technical perspective and comprehensible for non-specialist respondents. This co-creation of the survey is therefore the first step in engaging various stakeholders, who will be requested to participate in the development and exchange with each other. The survey will target pilot site users and potential users located in the region. The primary objective is to investigate social acceptability of the technologies developed in EVELIXIA to enable the technology developers to better align their product with users' preferences. Moreover, a secondary objective of the survey is to inform respondents about the new technologies and make them better aware of their benefits, thereby participating in the user engagement strategy.

Once the survey is fielded and data collected, our results will be communicated to the stakeholders who participated in the co-creation stage. This knowledge diffusion also pertains to the stakeholder engagement in a broader sense. Pilot site managers and technology developers should at this stage obtain valuable feedback regarding what users like about their services and products and what they don't. Our results will give them opportunities for better designing their products to match (potential) user preferences and appeal to a broader population.

Figure 3. Stakeholders main relationships and contributions to the surveyFigure 3 summarizes and illustrates how the various stakeholders will contribute directly or indirectly to the survey and how they are connected through this task and will therefore be requested to engage in the project. The target respondents for this survey are the end-users of the technologies (tenants and occupants). However, developing a survey that will allow us to collect meaningful information to assess social acceptability implies that respondents are able to understand and respond based on their preferences. Considering that end-users are not energy specialists, it implies that presenting to such an audience the complex technologies developed in EVELIXIA will require an effort of simplification and vulgarization. A necessary step towards this goal is to organize horizontal activities such as bilateral exchanges with technology providers and co-creation workshops

in which representatives of various stakeholders will be invited to provide information, exchange with each other, and criticize preliminary versions of the survey. Two co-creation workshops are planned at the 3rd and 4th general meetings (respectively in September/October 2024 and March/April 2025) of the EVELIXIA project.

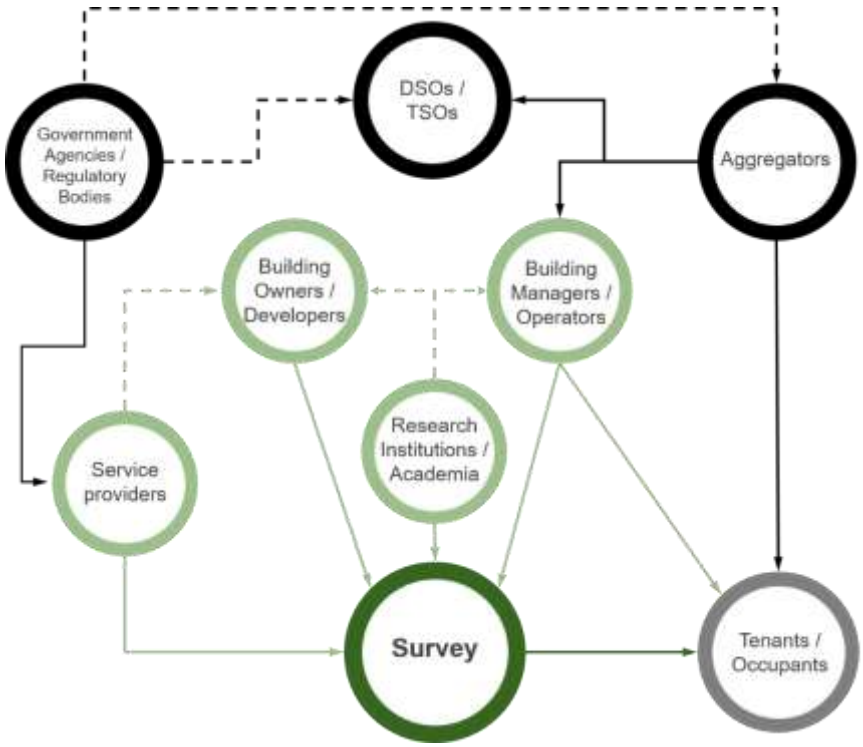

Figure 3. Stakeholders main relationships and contributions to the survey

Service providers are key players in the design of the survey. They will be requested to provide information on the technology they develop, what it is used for, and what is needed for it to function properly. Building owners and building managers are also crucial, considering they are respectively the ones to make decisions on the installation in their buildings and to communicate with the tenants/occupants of the buildings. Researchers from EVELIXIA partners will be involved and central players in that network. They will organize discussions among the various stakeholders to prepare the survey and provide feedback to interested stakeholders after the data is collected and analyzed. Other stakeholders (government, DSOs/TSOs, aggregators) are not necessarily involved directly in the preparation of the survey, but of course, they provide a framework in which the survey will be developed and must therefore be considered and optionally consulted before the survey is launched.

Another crucial aspect revealed by Figure 3 is the extent to which the relationships between the stakeholders are complex, multi-layered, and multi-directional (even though all arrows are drawn as unidirectional, it could be easily argued that some should be bi-directional and further arrows

could be drawn). Each stakeholder possesses specific skills in his context and from his point of view. Yet, all stakeholders must be involved in the creation of the survey, so that all dimensions of the situation are carefully considered and respected. This is how the survey will be the central tool to engage all stakeholders. While exchanging and discussing the co-creation of the survey, every stakeholder will be exposed to the vision of the others and therefore gain knowledge about the benefits of the novel technologies and solutions that are developed in EVELIXIA. The objective, through the co-creation workshops, is therefore to make various stakeholders discuss and exchange, so that they understand each other and feel that they have a mutual interest in collaborating, thereby effectively engaging in the project.

Besides co-creation workshops, pilot sites are to be considered as “living labs” for us to experiment with each specific ecosystem and understand better how to tackle challenges regarding the engagement of different stakeholders. Cooperation with pilot site coordinators enables us to remain as close as possible to the field to fuel the dynamic of stakeholder cooperation in addition to remain close and attentive to end-users’ feedback and sensibilities. This process will also make it possible to think about how the new technologies could be presented to end-users, who certainly do not possess technical skills or possibly lack interest. To be able to evaluate the social acceptability of new technologies from the point of view of such end-users, we must therefore present the situation very intuitively and highlight clearly what are the related gains, costs, and constraints. Most importantly, the survey can also serve as a vessel to enhance end-users’ knowledge. During the survey, respondents will be given a variety of information, which will help creating connections and goodwill with the dwelling occupants, who should thereafter be more inclined to make use of the new technologies offered to them.

On a final note, HESSO will participate in “dissemination workshops” to present the results and give feedback about social acceptability to interested stakeholders.

6 CONCLUSION

The definition of EVELIXIA's Evaluation Framework and Stakeholders' Engagement Strategy stands as a testament to the project's commitment to transparency, accountability, and impact assessment. Rooted in the detailed methodological process presented, this framework encapsulates the multifaceted dimensions of building flexibility, aligning seamlessly with the project's overarching objectives and European reference documents. Through critical analysis, it becomes evident that the framework not only provides a robust mechanism for monitoring and evaluating the performance of EVELIXIA interventions but also fosters a holistic understanding of their environmental, societal, economic, and technological implications.

The strategic engagement of stakeholders lies at the heart of EVELIXIA's success trajectory. The comprehensive Stakeholders' Engagement Strategy ensures active participation, ownership, and alignment with diverse stakeholders' interests and concerns. This inclusive approach not only fosters collaboration and knowledge exchange but also enhances the relevance and applicability of project outcomes within local contexts. As we reflect on the journey traversed thus far, it is imperative to acknowledge the invaluable contributions of stakeholders at each pilot sites, whose insights and feedback have been instrumental in shaping the project's direction and outcomes.

Looking ahead, the conclusion of this deliverable (D1.5) paves the way for prospective analysis and delineation of next steps within the EVELIXIA project. Future endeavors of Task 1.3 will focus on rigorous implementation, iterative refinement, and continuous learning. As we navigate through the demonstration activities, it is essential to remain adaptive and responsive to potential refinements in the KPI framework in case they arise. Thus, the Evaluation Framework shall adapt accordingly during the project and potential refinements will be integrated in the updated version (D1.6).