D6.3 SmartLivingEPC Evaluation Framework

This project has received funding from the European Union's Horizon Europe research and innovation programme under the grant agreement number 101069639. The European Union is not liable for any use that may be made of the information contained in this document, which is merely representing the authors' view.

Project Acronym:	SmartLivingEPC
Project Full Title:	Advanced Energy Performance Assessment towards Smart Living in Building and District Level
Grant Agreement:	101069639
Project Duration:	36 months (01/07/2022 – 30/06/2025)

Deliverable 6.3 SmartLivingEPC Evaluation Framework

Work Package:	WP6
Task:	Task 6.3
Document Status:	v0.1
File Name:	SmartLivingEPC_D6.3_SmartLivingEPC_Evaluation_Framework
Due Date:	1.07.2024
Submission Date:	12.07.2024
Lead Beneficiary:	FRC

Dissemination Level	
Public	☒
Confidential, only for members of the Consortium (including the Commission Services)	☐

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Version History

Version	Author(s)	Date	Brief Description
0.1	Christos Kythreotis, Paris Fokaides	22.03.2024	Initial draft of deliverable 6.3.
0.2	Beatriz Fraga, Sara Ruffini, Raphaelle Papa, Bishnu Babu	1.04.2024	Input on KPI 8, KPI9, KPI6, KPI1
0.3	Leandro Ferrón	5.04.2024	Input on KPI 10
0.4	Eider Iribar	28.04.2024	Input on KPI 3
0.5	Andrea Ferrantelli, Helena Kuivjõgi	25.05.2024	Input on KPI 4 and KPI 8
0.6	Christos Kythreotis, Paris Fokaides	11.07.2024	Final version of Deliverable 6.3.

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Executive Summary

This report presents the methodology for the final evaluation and comparative assessment of the SmartLivingEPC project. The primary objective of this task was to establish and implement a framework for evaluating and assessing the impact of the SmartLivingEPC project from multiple perspectives: technical, economic, environmental, and social.

To evaluate the project's technological efficiency and achievement of its initial objectives, a set of Key Performance Indicators (KPIs) was defined. These KPIs encompass the comprehensiveness and acceptance of the solution by various stakeholders. The methodology for calculating these KPIs incorporates input from EPC assessors, end-users, and project partners, ensuring their relevance and accuracy. A total of 11 KPIs were identified, based on the main expected impacts and initial objectives of the project. By providing detailed guidance, the methodology ensures a clear and consistent understanding of the indicators, enabling an effective evaluation of the SmartLivingEPC project's results. Additionally, the descriptions and calculation methodologies of the KPIs served as valuable resources for creating comprehensive questionnaires to gather feedback from stakeholders. Tailored questionnaires will be distributed to different stakeholder groups, aligning with the nature of the KPIs and the respondents' experience in the field of energy efficiency and EPC issuance procedures. These customized questionnaires ensured the relevance of the questions to each stakeholder group's expertise, thereby collecting accurate and valuable feedback. The classification of the questionnaires and the topics of the respondents' feedback are as follows:

EPC Assessors: Acceptance and understanding of the SmartLivingEPC platform and novel indicators; integration of operational rating, BIM technologies, and SRI; drawbacks of the current EPC schema and potential standards improvements; perception of the solution's impact on the energy sector.

End-users: Acceptance and understanding of the SmartLivingEPC platform and novel indicators; awareness of energy efficiency and operational rating; acceptance of EPCs; motivations for renovation and energy savings.

This evaluation framework, when applied, will allow for the measurement of 11 key performance indicators to assess the technical, economic, environmental, and social impacts of the SmartLivingEPC project. Through both numerical analysis and qualitative surveys and questionnaires, a comprehensive assessment will be conducted, including the perspectives of stakeholders. The high levels of acceptance of the SmartLivingEPC solution are expected to confirm the project's success in achieving its objectives and expected impacts.

The outlined methodology ensures a robust framework for evaluating the SmartLivingEPC project, supporting a thorough and multi-faceted assessment of its impact.

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List of Acronyms and Abbreviations

Term	Description
SCC	Social Cost of Carbon
BCR	Benefit-Cost Ratio
OR	Operational Rating
EPC	Energy Performance Certificate
CBA	Cost-Benefit Analysis
KPI	Key Performance Indicator
GIS	Geographic Information System
EBPD	Energy Performance of the Buildings Directive
HC&W	Human Comfort & Wellbeing
GHG	Greenhouse Gas Emissions
NPV	Net Present Value
SRI	Smart Readiness Indicator
AI	Artificial Intelligence
IEQ	Indoor Environmental Quality
EU	European Union
UI	User Interface
BIM	Building Information Modelling
NSLE	SmartLivingEPC Neighbourhood scale rating

1 Introduction

1.1 Scope and objectives of the deliverable

This deliverable presents the methodology and actions that will be taken to assess the SmartLivingEPC project and its impacts in technical, environmental, economic, and social terms. This includes defining the list of relevant Key Performance Indicators (KPIs) for the evaluation procedure, as well as comprehensive definitions of each KPI and its calculation methodology. The document also describes and delivers comprehensive questionnaires prepared under the Task 6.3 and elaborates on the methodology of the assessment. The presented methodology includes criteria for setting the timeframe of the analysis, as well as considerations for discounting and sensitivity assessment. This comparative assessment framework, when applied, will serve as a cost-benefit analysis to compare the SmartLivingEPC with the current EPC method. By providing detailed guidance, this document ensures a clear and consistent understanding of the KPIs, enabling an effective evaluation of the SmartLivingEPC project's results. The tailored questionnaires for different stakeholder groups—EPC assessors, end-users, and project partners—ensure relevant and valuable feedback, enhancing the accuracy of the assessment.
Overall, this deliverable outlines a robust framework for evaluating the SmartLivingEPC project, supporting a thorough and multi-faceted assessment of its impact.

1.2 Structure of the deliverable

This section outlines the organization of the deliverable and provides an overview of the main sections, their interdependencies, and the flow of information within the document. The purpose is to guide the reader through the content in a logical and coherent manner.
Section 3 provides in-depth information and analysis related to specific aspects of the evaluation framework. Each subsection within the section 3 details methodologies, key performance indicators (KPIs), and their calculation methods. For instance, detailed methodologies for evaluating the project's technological efficiency and achievement of its initial objectives are presented. This includes a set of Key Performance Indicators (KPIs) defined to encompass the comprehensiveness and acceptance of the solution by various stakeholders. The methodology for calculating these KPIs incorporates input from EPC assessors, end-users, and project partners, ensuring their relevance and accuracy. A total of 11 KPIs are identified based on the main expected impacts and initial objectives of the project. The classification of the questionnaires and the topics of the respondents' feedback are as follows: EPC Assessors: Acceptance and understanding of the SmartLivingEPC platform and novel indicators; integration of operational rating, BIM technologies, and SRI; drawbacks of the current EPC schema and potential standards improvements; perception of the solution's impact on the energy sector.

1.3 Relation to Other Tasks and Deliverables

This document’s main scope is define the detailed evaluation framework to validate the performance within the pilots according to the requirements and specifications defined in Work Package 1. This work includes the definition of test case scenarios, based on the pilot demonstrations, and performing the mapping between pilots and expected concrete features which will be shown. The evaluation plan will formulate the methodology to be employed for the evaluation, the definition of expected results, and Key Performance Indicators (KPIs). The plan will indicate the data that will be needed to assess the performance and the usability of the SmartLivingEPC solution, as well as the end-users questionnaire to collect useful feedback regarding any optimizations and further customizations that have to be performed. This task will detail the evaluation and validation framework, which will be conducted in the context of the demonstration and assessment tasks Task 6.4 and Task 6.5, organized in two iterations.

2 SmartLivingEPC evaluation framework methodology based on expected impacts and project objectives

The SmartLivingEPC project targets building decarbonization by implementing a dynamic strategy to enhance energy performance certificates for building improvements. These dynamic EPCs encompass critical elements like building performance monitoring, energy management, and renovation planning, thereby significantly reducing energy consumption, minimizing environmental impacts, and improving occupants' quality of life. The project, with its ambitious goals, outlined the expected impacts and objectives during the project description phase. To ensure the achievement of these initial objectives, project evaluation and impact assessment procedures are established based on identifying key performance indicators derived from the expected impacts and project objectives.

2.1 Expected Impacts

Table 1 presents a summary of expected impacts that were identified and relevant for the project assessment, as well as the target values that have been set to be achieved by the project.

Table 1: Expected Impacts

Expected Impact	Expected impact	Main objective/objectives
Expected impact 1	More energy efficient building stocks supported by an accurate understanding of buildings performance in Europe and of related evolution	Energy transformation of the EU-building stock: >0.74M m2 of floor area renovated per year to become more energy efficient; Long-term energy savings triggered by SmartLivingEPC >35.13GWh/y; Link EPCs with other instruments such as Building Renovation Passports (BRPs) and Digital Logbook
Expected impact 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 conducted in parallel, reduced gap between assessment and actual performance	Create and use high quality new knowledge on issues supporting synergy and optimal management of energy at neighbourhood/district level; Create new knowledge on digitalization and smartification of buildings; Link EPCs with other instruments such as the SRI, Level(s); Enhanced digitalisation and smartification of EU building stock; Support the formation of REC
Expected impact 3	Higher buildings' performance with lower environmental impacts through increased rates of holistic renovations	Promote new breakthroughs on building construction, operation and management; Trigger building stock decarbonisation- Reduction of 60% GHG emissions; Increase in energy efficiency through the application of advanced analytics and AI technologies >20%;

		Generate innovation-based growth of the construction/renovation sector
Expected impact 4	Higher quality, more affordable built environment preserving climate, environment and cultural heritage and ensuring better living conditions	Create new knowledge on SSH issues relevant to buildings energy performance; Build Covid-19 Infection Resilience for common indoor spaces; Enable more sustainable living and make buildings fit for the energy transition; Develop a network of advisory services towards smart living; Increase investments in sustainable energy

2.2 Project Objectives

Table 2 presents a summary of project objectives that were identified and relevant for the project assessment, as well as the target values that have been set to be achieved by the project.

Table 2: Project Objectives

Project Objectives	Expected impact	Main objective/objectives
Objective 1	The development of a more reliable, cost-effective and highly replicable energy performance calculation method, utilizing data and information from the overall building's life cycle	Develop an integrated methodology, making use of available and increasing number of building energy-related data from sensors, smart meters, connected devices and building systems with the help of its IoT visualization platform (goal of Task 5.3) and the middleware (goal of Task T4.1) to assess buildings based on their actual energy performance, counting also additional aspects such as indoor air quality, comfort, acoustics and non-energy consumption.
Objective 2	The integration of building automation and control systems intelligence into the EPC calculation procedure through the SRI scheme	Undertake all necessary actions, in order to achieve the integration of the SRI rating into the EPC procedure, and particularly to enable its inclusion in the final EPC rating.
Objective 3	The establishment of a scheme that allows for synergies with building sustainability relevant instruments and relevant parts of Level(s)	Incorporate specific sustainability indicators of the Level (s) scheme, thus enhancing the information that will be provided to the user; inspire and support a life cycle approach when discussing energy performance of buildings.
Objective 4	The development of a methodology for operational EPCs towards incorporating	Develop the necessary procedures and methodology; Enable the utilization of the findings of building

	technical systems audits and adapting the certificate ratings to the actual energy consumption of the building	systems periodic audits, in the process of calculating the energy class of the building, and their reflection in the operational EPC
Objective 5	The design and development of a certification process based on digital construction practices and Industry 4.0 building services	Integrate processes compatible with the digitally structured environment; Deliver a certificate, fully compatible with BIM literacy, which will retrieve information from smart meters and digital twins on the actual performance of the building, enabling in this manner the issuance of certificates with inputs from the actual building behaviour.
Objective 6	The development of an EPC, compatible with digital building logbooks	Entail all required elements and features, that will allow its integration into digital building logbooks (goal of Task 4.4), facilitating in this manner transparency, trust, informed decision making and information sharing within the construction sector, among building owners and occupants, financial institutions and public authorities.
Objective 7	The development of a new rating scheme for neighbourhood scale, based on the assessment of individual building units and on additional building complex parameters	Launch and introduce a new energy classification methodology at the neighbourhood level, which on the one hand will be based on the categorization of individual building units, on the other hand will consider the energy infrastructure and services on a district scale, as well as the interaction of buildings; Certificate at a complex level, which will allow energy savings at the level of neighbourhood energy infrastructure.
Objective 8	The development of AI services supporting the building performance assessment and as a consequence the next generation EPCs	Launch and introduce a new energy classification methodology at both building and neighbourhood level, following the revised EPBD provisions; Support the next generation EPCs with a number of AI services which will assist the evaluation and assessment of the actual user-centric performance of the building.

3 Key performance indicators and Calculation methodology

3.1 KPI 1: Primary energy savings triggered by the project.

3.1.1 Indicator Description

The " Primary energy savings triggered by the project " Key Performance Indicators (KPI) in the SmartLivingEPC project aims to provide a quantifiable measurement of the amount of primary energy saved through energy efficiency measures compared to a baseline scenario. By integrating such KPI, SmartLivingEPC aspires to monitor the achieved progress towards the set sustainability and energy-saving goals and, ultimately, ensure that the proposed recommendations for energy upgrades are maximizing impact.
The proposed KPI evaluates the effectiveness of the proposed recommendations for energy efficiency practices, energy upgrades, optimal operation, maintenance, etc. The KPI shall provide a comprehensive and quantifiable evaluation of the SmartLivingEPC recommendation potential taking into account the tangible building performance.

Table 3: KPI 1 information

Name	Primary energy savings triggered by the project
ID	KPI 1
Expected Impact	More energy efficient building stocks supported by an accurate understanding of buildings performance in Europe and of related evolution. The development of AI services supporting the building performance assessment and as a consequence the next generation EPCs.
Description	When referring to primary energy, the direct use at the source is implied. To this end, KPI 1 refers to the achieved savings of crude energy and as so energy that has not been subjected to any conversion or transformation process. KPI 1 provides an evaluation of the recommendations provided to the EPC assessor concerning retrofitting actions, optimal operation patterns, and maintenance procedures that aim to upgrade the asset's energy efficiency.
Assessment Methodology	The methodology for assessing KPI 1 includes collection of the all the related dynamic and static information. To this end, a baseline and a "current-state" scenario total primary energy consumption assessment is needed.
Unit of Measurement	kWh/m^2/year
Evaluation period	Annually

3.1.2 Calculation Methodology

The total energy consumption at the baseline and "current-state" scenario should be collected based on a clear definition of the various sources of energy used in the building, including electricity, natural gas, district heating, etc. The definition, within the framework of SmartLivingEPC, is based on the collection of data with respect to the energy consumption over a specific period (here: over a year), from the installed energy meters (and/or other sources like utility bills). To effectively disaggregate the energy consumption, one has to consider the various Primary Energy Factors (PEFs)[1] as these are described in Ref[2] in order to estimate the energy consumption per energy source. Figure 1 shows the various PEFs for the source categories that are most commonly used.

[1] PEF is a factor that represents the amount of primary energy required to produce one unit of delivered energy.
[2] Hitchin R, Thomsen KE, Wittchen KB. Primary Energy Factors and Members States Energy Regulations: Primary factors and the EPBD. In Concerted Action: Energy Performance of Buildings. 2018. Available at: (link)

Table 4: PEFs for the source categories that are most commonly used

Countries	Mains gas	LPG	Oil - general	Diesel or heating oil	Fuel oil	Coal - general	Biomass - general	Wood - general	Wood pellets	Grid Electricity	District heating - general
EU countries in average	1.00 - 1.26	1.00 - 1.20	1.00-1.23	1.00-1.14	1.00 - 1.20	1.00-1.46	0.01-1.10	0.01-1.20	0.01-1.26	1.5-3.45	0.15-1.50
CEN (non-renewable) defaults	1.1	1.1	1.1	1.1	1.1	1.1	0.2	0.2	0.2	2.3	1.3

(source: Hitchin et al., 2018)

Once all the individual energy consumptions per source are evaluated, these can then be aggregated to estimate the baseline and "current-state" total primary energy consumption, allowing thus for the calculation of the annual energy saving at the premises. To allow for generalization of the results, the total consumptions can be expressed per m^2 of building area.

The below expression can be used for estimating the primary energy savings triggered by the SmartLivingEPC project. The energy savings can be derived based on comparing the primary energy consumption of the baseline with the "current-state" scenario i.e., after implementing the energy-saving measures as follows:

$$Primary\ energy\ savings_{SLE} = Primary\ energy\ consumption_{baseline} - Primary\ energy\ consumption_{current-state}$$

where Primary energy consumption$_{baseline}$ is the primary energy consumed by the building before implementing energy-saving measures and the Primary energy c onsumption$_{current\text{-}state}$ is the primary energy consumed by the building after implementing energy-saving measures.

Certainly, the above evaluation can be expressed as a percentage as follows:

$$Primary\ energy\ savings_{SLE}\ (\%) = \frac{(\ Primary\ energy\ consumption_{baseline} - Primary\ energy\ consumption_{current-state})}{Primary\ energy\ consumption_{baseline}} \times 100\%$$

3.2 KPI2: Energy savings related investments triggered by the project

3.2.1 Indicator Description

The Key Performance Indicator (KPI) "Energy savings related investments triggered by the project" in the SmartLivingEPC project aims to identify energy-saving investments prompted by the project. This KPI evaluates whether any actions or renovations with the purpose of energy saving have been or will be undertaken at each pilot site and whether these were triggered by the project. It quantifies the level of energy-saving actions and associated investments through a questionnaire administered to building owners or maintainers.

Table 5: KPI 2 basic information

Name	Energy savings related investments triggered by the project
ID	KPI 2
Expected impact	Higher quality, more affordable built environment preserving climate, environment and cultural heritage and ensuring better living conditions.
Description	A survey will be conducted among building owners and maintainers to gather feedback on the energy-saving measures implemented and the investments made in renovations.
Assessment Methodology	The methodology for assessing KPI 2 includes surveys of building owners and maintainers. These surveys will capture details on the energy-saving measures implemented and the investments made in renovations.
Unit of Measurement	The unit of measurement for this KPI will be a description of the energy-saving measures and the associated investments.
Evaluation period	Tbd

3.2.2 Calculation Methodology

The calculation methodology for KPI 2, "Energy savings related investments triggered by the project," involves conducting a survey to gather both quantitative and qualitative data from end-users. The survey questions are designed to assess the clarity, depth, and usefulness of the information provided by the Level(s) sustainability indicators.

The objective is to identify the energy-saving investments prompted by the project. Therefore, respondents will be asked to report the renovation costs of the energy-saving measures triggered by the project (e.g., the building owner replaced the HVAC equipment due to the results of SmartLivingEPC calculations).

3.2.3 Energy saving renovation cost report

This assessment is crucial for identifying energy-saving renovation measures and their associated costs. By obtaining the report (Table 6) from building supervisors (owners or maintainers), this approach aims to measure the impact of the SmartLivingEPC outcomes and the investment needs for each pilot building.

Table 6: Report format of energy saving related measures

No	Energy saving measure	Description of the measure	Investment cost of the measure
1	Upgraded HVAC system	Replaced old HVAC with a high-efficiency system	5000€
2	Improved insulation	Added insulation to walls and roof to reduce heat loss	3000€
3	Installed solar panels	Installed solar panels to generate renewable energy	8000€

3.3 KPI3: Building Stock Enhancement

3.3.1 Indicator Description

The "Building Stock Enhancement" Key Performance Indicator (KPI) in the SmartLivingEPC project aims to trigger new renovation opportunities based on use of the data available in the Energy Performance Certificates, alongside other data. This KPI evaluates the reliability and effectiveness of the recommendations for building renovation/ upgrade/ maintenance in the decision-making process, both at the level of the individual building and at the level of the building stock renovation strategy and policies. It is important to note that the proposed recommendations for energy upgrades maximize impact by considering embodied energy and environmental footprint through the integration of LCA aspects into the performance benchmarking and evaluation tool.
Furthermore, the SmartLivingEPC certificate enables interaction and compatibility with digital logbooks and BRPs, supporting the harmonization of EPC data collection, enhancement, and information sharing. It is expected that this aids in informed decision-making for building renovation. Additionally, this compatibility allows for automatic upload to a central registry, enhancing data transparency, simplifying statistical analysis, and facilitating decision-making for long-term renovation strategies.

Table 7: KPI 3 basic information

Name	Building Stock Enhancement
ID	KPI 3
Expected Impact	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 conducted in parallel, reduced gap between assessment and actual performance
Description	The "Building Stock Enhancement" KPI evaluates the effectiveness and understanding of the SmartLivingEPC certificate in facilitating decision-making for building improvements. The SmartLivingEPC certificate provides personalized building improvement recommendations through a benchmarking and evaluation tool developed in the project. It is based on the analysis of real-time data using a fully configured and documented API, along with AI-added value tools.
Assessment Methodology	The methodology for assessing KPI 3 includes surveys of pilot end-users and EPC assessors.
Unit of Measurement	The unit of measurement for this KPI will be a Likert scale converted to a percentage of acceptance, reflecting the degree to which respondents accept and understand the effectiveness of the SmartLivingEPC elements to trigger the building improvement measures.
Evaluation period	Tbd

3.3.2 Calculation Methodology

Obtaining explicit numbers for future impact is complex due to insufficient data availability, which would require separate collection through statistical surveys or analysis of other data sources in the future. Thus, the methodology relies on evaluating the perception of end-users and EPC assessors on several aspects:

Renovation motivation rate:

The expected impact mentioned in the table above was estimated based on the following considerations: an average current consumption of 158.76 kWh/m2 (observed consumption of EU28 residential stock in 2014 – this value is much higher in inefficient old buildings), a minimum 30% energy savings potential from renovation, a 70% renovation rate triggered by EPCs, and a 0.2% penetration rate of the SmartLivingEPC in the EU certification market.

Therefore, the aim is to assess whether the SmartLivingEPC solution can have an impact on the renovation rate exceeding 70% through the assessment of motivation to carry out measurements by analyzing respondents' feedback.

EPC recommendations and building performance understandability:
Assesses the SmartLivingEPC solution understandability with respect to the building performance and to the tailored recommendations for building upgrades.

Utility and user friendliness of the SmartLivingEPC tools for upgrade recommendations:
Assesses the utility and user friendliness of the SmartLivingEPC tools developed in the project to provide and calculate the tailor- made recommendations.

Facilitating decision-making in building stock renovation policies:
Analyzing how compatibility with other digital tools and registries, such as digital logbooks or BRPs, improves transparency, exchange and quality of data and consequently facilitates decision making in building stock renovation policies and strategies.

The answers will be collected by means of questionnaires adapted to each type of audience.

3.3.3 EPC assessor's assessment

By soliciting feedback from EPC assessors through carefully designed questions, this approach aims to measure the effectiveness of the SmartLivingEPC solutions to increase the renovation motivation rate, to provide and calculate the tailor-made upgrade recommendations and to facilitate the decision-making in building stock renovation policies.

1. **Question:** How effective do you find the SmartLivingEPC certificate in encouraging building owners to undertake energy upgrade measures?

   Answers:

   a. Not Effective at All
   b. Slightly Effective
   c. Moderately Effective
   d. Effective
   e. Highly Effective

2. **Question:** I find the tools developed in the SmartLivingEPC project useful, user friendly and adapted to my needs to calculate and provide tailor-made upgrade recommendations.

   Answers:

   a. Strongly Disagree
   b. Disagree
   c. Neutral
   d. Agree
   e. Strongly Agree

3. **Question:** Interoperation with other digital tools and registries, such as digital logbooks or BRPs, improves transparency, exchange and quality of data and consequently facilitates decision making in building stock renovation policies and strategies.

   Answers:

a. Strongly Disagree
b. Disagree
c. Neutral
d. Agree
e. Strongly Agree

3.3.4 Pilot end users assessment

By soliciting feedback from pilot end-user through carefully designed questions, this approach aims to measure the effectiveness of the SmartLivingEPC solutions to increase the renovation motivation rate and the understandability of the information given by the certificate about the upgrade recommendations and building performance.

4. **Questions:** To what extent would the recommendations offered in the SmartLivingEPC certificate motivate you to undertake energy retrofitting measures?

   Answers:

   a. Not Effective at All
   b. Slightly Effective
   c. Moderately Effective
   d. Effective
   e. Highly Effective

5. **Questions:** I believe that the information provided by the SmartLivingEPC solution regarding the building performance and possible interventions for improvement is clear and understandable and I believe that it facilitates decision making when considering an intervention in the building.

   Answers:

   a. Strongly Disagree
   b. Disagree
   c. Neutral
   d. Agree
   e. Strongly Agree

3.4 KPI4: Human comfort integration into EPC assessment

3.4.1 Indicator Description

The Key Performance Indicator (KPI) "Human comfort integration into EPC assessment" in the SmartLivingEPC project aims to evaluate the application of SmartLivingEPC IEQ (Indoor Environmental Quality) assessment in the pilot projects.

Table 8: KPI4 basic information

Name	Human comfort integration into EPC assessment
ID	KPI 4
Objective	The development of a more reliable, cost-effective and highly replicable energy performance calculation method, utilizing data and information from the overall building's life cycle. The objective of this KPI is to assess the application of SmartLivingEPC IEQ assessment in the pilots.
Description	The capability to calculate the IEQ indicators within the SmartLivingEPC framework will be quantified through surveys and evaluations.
Assessment Methodology	Surveys will be conducted to gather data on the availability of building sensors and additional information necessary for IEQ indicator assessment. The results of these surveys will be analysed to evaluate the applicability of the IEQ assessment
Unit of Measurement	Survey
Evaluation period	(To be determined)

3.4.2 Calculation methodology

The calculation methodology for KPI 4, "Human comfort integration into EPC assessment," involves conducting a survey on the availability of sensors and information necessary for calculating the sub-indicators required in the SmartLivingEPC IEQ assessment. Additionally, it includes evaluating the application of the IEQ indicators within the SmartLivingEPC framework. The indicators to be assessed are thermal comfort, indoor air quality, virus risk, and occupancy feedback. The sensors and information required for this assessment are detailed in Table 9.

3.4.3 Survey on the sensor's and information availability for sub-indicators calculation

Table 9: Sensors list required for IEQ assessment

Value Name	Unit	IEQ indicator sensor is related to	Sensor or information available/not available	Number of rooms where available
Room air temperature sensor	°C	Thermal comfort	Y/N	1 - 10
Room CO_2 volumetric concentration	ppm	Indoor air quality	Y/N	1 - 10
Room PM2.5 volumetric concentration	$\mu g/m^3$	Indoor air quality	Y/N	1 - 10
Outdoor air ventilation flow rate to the room (measured/design value)	L/s	Virus risk	Y/N	1 - 10

or in case of natural ventilation, detected from CO_2 readings				
Room occupancy	no of occupants	Virus risk	Y/N	1 - 10
Outdoor air temperature	°C	Thermal comfort	Y/N	1 - 10
Volume of the room	m^3	Virus risk	Y/N	1 - 10
Room occupancy time	hh:mm-hh:mm and names of the days of week	Thermal comfort, Indoor air quality	Y/N	1 - 10
Ventilation type	DCV/CAV/natural ventilation	Indoor air quality, virus risk	Y/N	1 - 10

3.5 KPI5: Upgrade of operational EPC rating process

3.5.1 Indicator Description

The "Upgrade of Operational EPC Rating Process" Key Performance Indicator (KPI) in the SmartLivingEPC project aims to improve Energy Performance Certificates (EPCs) by integrating digital construction practices and advanced building services. This KPI evaluates the integration and effectiveness of digital technologies, and the feedback mechanisms from users and assessors, focusing on their impact on the SmartLivingEPC's accuracy, comprehensibility, and energy efficiency improvements. It quantifies digital tool adoption, feedback utilization, user satisfaction, engagement levels, and tangible improvements in building energy performance, providing a comprehensive view of the advancements in the SmartLivingEPC process through specific questions and feedback evaluation from building users and assessors.

Table 10: KPI 5 basic information

Name	Upgrade of operational EPC rating process
ID	KPI 5
Expected Impact	The design and development of a certification process based on digital construction practices and Industry 4.0 building services.
Description	Integrate processes compatible with the digitally structured environment; Deliver a certificate, fully compatible with BIM literacy, which will retrieve information from smart meters and digital twins on the actual performance of the building, enabling in this manner the issuance of certificates with inputs from the actual building behaviour
Assessment Methodology	The methodology for assessing KPI 5 includes surveys of building tenants and EPC assessors. These surveys will capture their perceptions of the enhanced EPC process and the integration of digital tools.
Unit of Measurement	The unit of measurement for this KPI will be a Likert scale converted to a percentage of acceptance, reflecting the degree to which respondents accept and understand the new EPC process.
Evaluation period	Tbd

3.5.2 Calculation Methodology

The calculation methodology involves analysing respondents' feedback on several aspects:

Facilitating Communication and Responsibility: Analyzing how the newly introduced indicators aid in enhancing dialogue and responsibility among different parties involved.
Stakeholder Reception: This involves measuring the degree of acceptance and adaptability among stakeholders towards the updated EPC framework. Special attention is given to their readiness to integrate IoT devices and perform detailed building characterization, which are essential components of the SmartLivingEPC framework.
Digital Tool Adoption Rate: Measures the percentage of EPC assessments utilizing advanced digital technologies and methodologies.
EPC Accuracy and Comprehensibility Impact: Assesses the improvements in the accuracy of energy performance data and the comprehensibility of EPCs for users post-upgrade.
User Satisfaction and Engagement: Gauges the level of user satisfaction with the EPC process and the extent of user engagement with energy performance improvements.
Energy Efficiency Improvement Metrics: Quantifies the changes in energy efficiency of buildings as a direct result of utilizing upgraded EPCs.
Enhanced value: Here, the evaluation centers around the extra advantages offered by the updated EPC framework. This includes examining its impact on decision-making processes and its relevance in current building practices. It is about understanding if the new framework adds significant value, such as making energy performance assessments more accurate, useful, and actionable for stakeholders:
Understanding Clarity: This aspect assesses the level of ease and clarity with which the stakeholders comprehend the advanced topics covered by the EPC process and how effectively they can use the digital tools provided. It is crucial that these sophisticated subjects are accessible and understandable to ensure proper utilization and benefit from the EPC process.

3.5.3 EPC assessor's assessment

This assessment is crucial for understanding the practical implications and acceptance of digital construction practices, Industry 4.0 building services, and the integration of smart meters and digital twins. By soliciting feedback from EPC assessors through carefully designed questions, this approach aims to measure the effectiveness, relevance, and impact of these advancements, thereby facilitating a more accurate, comprehensive, and user-friendly EPC process that aligns with the current needs and expectations of the construction industry.

2. **Question:** How effective do you find the use of smart meters in improving the operational EPC rating process?
   Answers:
   - Strongly Disagree
   - Disagree
   - Neither Agree nor Disagree
   - Agree
   - Strongly Agree

2. **Question:** The idea of a certification process based on digital construction practices and Industry 4.0 building services is important and relevant for the construction industry.

Answers:

- a. Strongly Disagree
- b. Disagree
- c. Neutral
- d. Agree
- e. Strongly Agree

3. **Question:** In your opinion, how significantly do digital twins impact the assessment of building performance for EPC ratings?
   Answers:
   - a. Strongly Disagree
   - b. Disagree
   - c. Neutral
   - d. Agree
   - e. Strongly Agree

4. **Questions:** I see value in a certification that is fully compatible with BIM literacy and retrieves information from smart meters and digital twins to assess the actual performance of a building.
   Answers:
   - a. Strongly Disagree
   - b. Disagree
   - c. Neutral
   - d. Agree
   - e. Strongly Agree

3.5.4 User's assessment

The User's assessment segment within the SmartLivingEPC project serves as a critical counterpart to the assessor's perspective, focusing on the user's experience and satisfaction with the upgraded SmartLivingEPC process. It captures the building owners' and occupants' views on the effectiveness of digital enhancements, the clarity of energy performance information, and the practical benefits of the improvements. This feedback is essential for evaluating the project's success in making SmarlivingEPCs more accessible, understandable, and actionable, ultimately aiming to increase engagement and promote energy-efficient practices among users.

6. **Questions**: How satisfied are you with the clarity and comprehensibility of the information provided in the upgraded EPCs?
   Answers:
   a. Very unsatisfied
   b. Unsatisfied
   c. Neutral
   d. Satisfied
   e. Very satisfied

7. **Question:** How effective do you find smart meters in giving you insights into your energy usage and potential savings?

   Answers:

a. Not Effective at All

b. Slightly Effective

c. Moderately Effective

d. Effective

e. Highly Effective

8. **Question:** I believe that integrating processes compatible with a digitally structured environment in construction is beneficial.
Answers:
   a. a. Strongly Disagree
   b. b. Disagree
   c. c. Neutral
   d. d. Agree
   e. e. Strongly Agree

3.6 KPI6: SRI integration into SmartLivingEPC assessment

3.6.1 Indicator Description

The "SRI integration into SmartLivingEPC assessment" Key Performance Indicator (KPI) in the SmartLivingEPC project aims to estimate the degree of coordination of the SRI with complementary asset assessments through the SmartLivingEPC platform. It is influenced by the possibility to leverage pre-existing data from the SmartLivingEPC platform to ease the data input for the SRI assessment, hence facilitating the work of the EPC assessor.

Table 11: KPI 6 basic information

Name	Upgrade of operational EPC rating process
ID	KPI 6 - SRI integration into SmartLivingEPC assessment
Expected Impact	The integration of building automation and control systems intelligence into the EPC calculation procedure through the SRI scheme. Facilitation of work of assessors when performing SRI assessments through the SmartLivingEPC Web Platform
Description	An SRI assessment requires the identification of various input data, some of which are common with EPB assessments, and which may be contained in digital building models. The SmartLivingEPC Web Platform offers the possibility to leverage such data commonalities
Assessment Methodology	The methodology for assessing KPI 6 includes surveys EPC assessors. These surveys will capture their perceptions of the usability of the SRI component of the SmartLivingEPC Web Platform.
Unit of Measurement	The unit of measurement for the KPI is percentage. Higher percentages indicate greater acceptance and understanding.
Evaluation period	Tbd

3.6.2 Calculation Methodology

The calculation methodology involves analysing respondents' feedback on several aspects:

Data availability: Assess how easy and useful is to handle the input information on SRI.
Understand data input requirements - To understand key aspects of data collection, data Interoperability and data consistency regarding data input.
Understand data output requirements - To understand key aspects of data collection, data Interoperability and data consistency regarding data output.

3.6.3 EPC assessor's assessment

This assessment defines the view of the EPC assessor into the integration of the SRI. It help to understand the usability of the SRI tool into the web-platform and understand how easy it is to integrate the SRI data into the service required. Indicatively:

1 **Question:** How useful do you find the SmartLivingEPC Web Platform for the SRI assessment?

Answers: 0 to 100 scale slider, where 0 is "not useful at all" and 100 is "extremely useful".

2 **Question**: How difficult do you find manual uploading the SRI data into the EPC assessment (if this option was used)?

Answers: 0 to 100 scale slider, where 0 is “very difficult” and 100 is “easy”.

3 **Question:** How useful do you find the automatic upload of information for SRI from the BIM file assessment (if this option was used)?

Answers: 0 to 100 scale slider, where 0 is “not useful at all” and 100 is “extremely useful”.

4 **Question:** In your opinion, how useful is the cross reference between SRI and EPC assessment?

Answers: 0 to 100 scale slider, where 0 is “not useful at all” and 100 is “extremely useful”.

3.7 KPI7: Building sustainability synergies, Level(s) update.

3.7.1 Indicator Description

This indicator identified as KPI 7, focuses on establishing a synergistic scheme that integrates relevant instruments and components of the Level(s) framework. By incorporating specific sustainability indicators from the Level(s) scheme, this initiative seeks to provide enhanced and detailed information to users, fostering a life cycle approach to building energy performance.
The expected impact of this initiative is to achieve higher building performance with lower environmental impacts. This will be accomplished by increasing the rates of holistic renovations, thereby promoting new breakthroughs in building construction, operation, and management. The objective is to trigger the decarbonization of building stock by reducing greenhouse gas (GHG) emissions by 60% and improving energy efficiency by more than 20%. Advanced analytics and AI technologies will play a crucial role in achieving these goals, driving innovation-based growth in the construction and renovation sector.
By integrating the Level(s) sustainability indicators, this initiative will not only enhance the quality and depth of information available to users but also inspire and support a comprehensive life cycle approach. This approach is essential for discussing and improving the energy performance of buildings, ensuring that sustainability considerations are embedded throughout the building's life cycle.

Table 12: KPI 7 basic information

Name	Building sustainability synergies, Level(s) update
ID	KPI 7
Objective	The establishment of a scheme that allows for synergies with building sustainability relevant instruments and relevant parts of Level(s)
Description	Incorporate specific sustainability indicators of the Level (s) scheme, thus enhancing the information that will be provided to the user; inspire and support a life cycle approach when discussing energy performance of buildings.
Assessment Methodology	Surveys assessing clarity, depth, usefulness, and overall satisfaction; quantitative and qualitative data analysis.
Unit of Measurement	Likert scale ratings, percentages of positive responses.
Evaluation period	(To be determined)

3.7.2 Calculation methodology

The calculation methodology for KPI 7, "Building sustainability synergies, Level(s) update," involves a survey to gather quantitative and qualitative data from end-users. The survey questions are designed to assess the clarity, depth, usefulness, and overall satisfaction with the information provided by the Level(s) sustainability indicators. The responses will be analysed using Likert scale ratings, where each question's responses are converted into numerical values to calculate percentages of positive responses. For example, ratings of "Very clear" and "Clear" will be considered positive responses for clarity.

Survey Questions

Below are the detailed questions for the proposed survey:

A. Demographic Information:

1. What is your age group?
    - Under 18
    - 18-24

- 25-34
- 35-44
- 45-54
- 55-64
- 65 and over

2. What is your occupation?
    - Building Owner
    - Building Manager
    - Tenant
    - Other (please specify)

3. How familiar are you with Energy Performance Certificates (EPCs)?
    - Very familiar
    - Somewhat familiar
    - Not familiar

B. Clarity of Information:

1. How would you rate the clarity of the information provided by the Level(s) indicators?
    - Very clear
    - Clear
    - Neutral
    - Unclear
    - Very unclear

2. Did you find any part of the information confusing or unclear? If so, please specify.

C. Depth of Information:

1. How would you rate the level of detail in the information provided?
    - Very detailed
    - Detailed
    - Neutral
    - Lacking detail
    - Greatly lacking in detail

2. Is there any additional information you would have liked to see? Please specify.

D. Usefulness of Information:

1. How useful did you find the information for making decisions about building renovations or energy efficiency measures?
    - Very useful
    - Useful
    - Neutral
    - Not very useful
    - Not useful at all

2. Can you provide an example of how the information helped you make a decision?

E. Overall Satisfaction:

1. Overall, how satisfied are you with the information provided by the new SmartLivingEPC scheme?
    - Very satisfied
    - Satisfied
    - Neutral
    - Dissatisfied
    - Very dissatisfied

2. Would you recommend this scheme to others based on the information provided?
    - Yes
    - No

F. Open Feedback:

1. Do you have any additional comments or suggestions for improving the information provided by the Level(s) indicators?

3.8 KPI8: Technical systems audits integration to EPC assessment

3.8.1 Indicator Description

The "Technical Systems Audits Integration to EPC Assessment" Key Performance Indicator (KPI) in the SmartLivingEPC project aims to develop a methodology for operational EPCs that incorporates technical systems audits and adapts certificate ratings to the actual energy consumption of buildings. This KPI focuses on enhancing the accuracy and reliability of EPCs by including detailed evaluations of building technical systems, such as HVAC, , and aligning the ratings with real-world energy usage.

Table 13: KPI 8 Information

Name	Technical systems audits integration to EPC assessment
ID	KPI 8
Objective	The development of a methodology for operational EPCs towards incorporating technical systems audits and adapting the certificate ratings to the actual energy consumption of the building
Description	Enhance the accuracy and reliability of EPCs by incorporating detailed evaluations of building technical systems and aligning the ratings with real-world energy usage
Assessment Methodology	Surveys of EPC assessors and analysis of audit reports to evaluate the integration and impact of technical systems audits on EPC ratings.
Unit of Measurement	The unit of measurement for this KPI will be the percentage improvement in EPC accuracy and reliability, as determined by comparing pre- and post-integration audit results.
Evaluation Period	Tbd

3.8.2 Calculation Methodology

The calculation methodology involves several steps. First, technical systems audits will be conducted on pilot buildings to assess the performance of their HVAC, electrical, and plumbing systems. The findings from these audits will be integrated into the EPC assessments, adjusting the energy performance ratings to reflect actual energy consumption. Surveys will be distributed to EPC assessors to gather feedback on the integration process and its impact on the accuracy and reliability of EPCs. The results from these surveys will be analyzed and compared to the audit data to quantify the percentage improvement in EPC accuracy. This comparison will involve analyzing the variance between estimated and actual energy consumption before and after incorporating the audit findings. The collected data will be evaluated over different periods to track the progress and effectiveness of this integration methodology. Indicatively:

Questions for EPC Assessors and Building Tenants

EPC Assessor's Assessment

1. **To what extent do you believe that integrating technical systems audits improves the accuracy of EPC ratings?**
    - Not at all
    - To a small extent
    - To a moderate extent
    - To a great extent

- To a very great extent

2. **To what extent do you find that technical systems audits help in identifying actual energy consumption patterns of buildings?**
    - Not at all
    - To a small extent
    - To a moderate extent
    - To a great extent
    - To a very great extent
3. **How effective are the technical systems audits in highlighting areas for energy efficiency improvements?**
    - Not at all effective
    - Slightly effective
    - Moderately effective
    - Very effective
    - Extremely effective
4. **To what extent do you agree that the incorporation of technical systems audits into EPC assessments is important for the construction industry?**
    - Strongly Disagree
    - Disagree
    - Neutral
    - Agree
    - Strongly Agree

Building Tenant's Assessment

1. **To what extent do you believe that the EPC ratings provided after technical systems audits reflect the actual energy performance of your building?**
    - Not at all
    - To a small extent
    - To a moderate extent
    - To a great extent
    - To a very great extent

3.9 KPI9: Digital Building Logbooks integration to EPC assessment

3.9.1 Indicator Description

A digital building logbook (DBL) is essentially an all-in-one repository that will contain the whole building lifecycle data. As said a DBL is not conceived to be a standalone product but aggregates building related data generated various trusted sources (EPC, SRI, Levels, LEED, etc.). The DBL concept is at its early stages and may aspects like functionalities are not well defined. "Digital Building Logbooks integration to EPC assessment" KPI aims to define a roadmap to facilitate easy integration of EPC data with DBL. The KPI will evaluate the functionalities of existing digital logbook initiatives (functional requirements, data interoperability, and stakeholder privacy) and evaluate the requirements for EPC certification. The rationale being that a DBL can act as a primary data source for EPC

certification and at the same time as a repository of secondary data generated by EPC certification. Further DBL as single source of truth for all building related data.

3.9.2 Case 1

Table 14: KPI 9 basic information

Name	Upgrade of operational EPC rating process
ID	KPI 9 - Digital Building Logbooks integration to EPC assessment
Expected Impact	The development of an EPC, compatible with digital building logbooks. Roadmap definition for integration of EPC data with DBL
Description	DBL is a data repository and to ensure easy integration of EPC data with DBL there is need to understand functional requirements and interoperability aspects of a DBL. This ensure seamless to-and-fro access to DBL repository for EPC data
Assessment Methodology	The methodology for assessing KPI 9 includes surveys EPC assessors. These surveys will capture their perceptions of the usability of the DBL component.
Unit of Measurement	The unit of measurement for this KPI will be a System Usability Scale (SUS). The System Usability Scale (SUS) is a simple, ten-item scale giving a global view of subjective assessments of usability
Evaluation period	Tbd

3.9.3 Calculation Methodology

To use SUS[3], participants are asked to score the following 10 items with one of five responses that range from Strongly Agree to Strongly disagree:

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. 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.

3.9.4 Case 2

Table 15: KPI 9 basic information case 2

Name	Digital Building Logbooks integration to EPC assessment
ID	KPI 9 - Digital Building Logbooks integration to EPC assessment
Expected Impact	The development of an EPC, compatible with digital building logbooks Roadmap definition for integration of EPC data with DBL

[3] SUS - A quick and dirty usability scale, John Brooke

Description	DBL is a data repository and to ensure easy integration of EPC data with DBL there is need to understand functional requirements and interoperability aspects of a DBL. This ensure seamless to-and-fro access to DBL repository for EPC data.
Assessment Methodology	The methodology for assessing KPI 9 is define the functional requirements and data interoperability requirements of DBL and ensuring that the data generated and data requirements for SmartlivingEPC EPC is compatible with DBL.
Unit of Measurement	DBL is conceptual
Evaluation period	Tbd

3.9.5 Calculation Methodology

Since this KPI is related to the task 4.4 that aims to define a conceptual DBL, there are some limitations in evaluating the KPI. As said, most effective way to estimate the KPI is to focus on the interoperability aspects. So we can try to understand what are data requirements from pilots for EPC certification and if they are compatible with the conceptual DBL.

Understand data input requirements- To understand key aspects of data collection, data Interoperability and data consistency regarding data input.

Understand data output requirements - To understand key aspects of data collection, data Interoperability and data consistency regarding data output

3.10 KPI10: Resident Perception of the Neighbourhood Rating Scheme

3.10.1 Indicator Description

The "Resident Perception of the Neighborhood Rating Scheme" KPI gauges user perception of the **SmartLivingEPC's new neighborhood scale rating system (NSLE).** It focuses on four key aspects: the perceived usefulness, this is, the degree to which users believe the SLEPC offers valuable insights, the perceived ease of use, through which it is expected to evaluate the level of intuitiveness and clarity of SmartLivingEPC for users of various technical knowledge, the intention to use, gauging residents' willingness to regularly integrate the SLEPC into their decision-making processes, and the privacy of personal data, assessing user comfort with how the SLEPC collects and utilizes their personal data. The validation of this KPI will involve gathering feedback from stakeholders engaged in the decision-making process and end users. Depending on the expected respondent sample, either a focus group or individual interviews will be conducted. Additionally, there will be discussions regarding whether the survey should target individuals who have received an NSLE or the general population being introduced to an NSLE for the first time.

Table 16: KPI10 basic information

Name	Resident Perception of the Neighborhood Rating Scheme.
ID	KPI 10
Expected Impact	The development of a new rating scheme for neighbourhood scale, based on the assessment of individual building units and on additional building complex parameters
Description	Integrate specific variables of the neighbourhood environment, both Asset and Operational; Deliver a certificate that compiles the complexity of the different dimensions of the built space, in a score that is easy to interpret by the end users and easy to adopt by city councils and policy makers.
Assessment Methodology	The methodology for evaluating KPI 10 includes surveys of building tenants and EPC evaluators. These surveys will capture their perceptions of the improved EPC process and the fit at the neighbourhood scale. An evaluation is proposed in two stages, pre-use and post-use.
Unit of Measurement	The unit of measurement for the KPI is percentage. Higher percentages indicate greater acceptance and understanding.
Evaluation period	Tbd

3.10.2 Calculation Methodology

Analysis of user responses will evaluate various aspects of the updated framework:
Promotion of better **communication and a sense of co-responsibility** among stakeholders.
Understandability of the EPCs for users and **general clarity** of the neighbourhood-scale EPCs.
User satisfaction with the updated EPC and their level of commitment to energy saving initiatives.
Perception of the **improvement in life quality** of the neighbourhood attributable to the updated EPCs.
Evaluate the additional benefits offered by the new framework, including its influence on stakeholder decision-making and its relevance to real estate transactions. Our goal is to understand whether the framework offers a primary **value proposition** to the market in neighbourhood-level energy performance assessments.

3.10.3 SmartLivingEPC policymaker's assessment

This evaluation is essential to measure feasibility and user acceptance, to incorporate neighbourhood-level dimensions into NSLE evaluations. Through questions posed to policymakers, this approach aims to measure

the effectiveness, value and overall impact of these improvements. Ultimately, this aims to refine the NSLE process, making it more accurate, informative and user-friendly for stakeholders, ensuring it aligns with their current needs and expectations.

> *Imagine that you have to face an important decision related to building energy policies (energy consumption levels, prohibition of inefficient materials or technologies, implementation of renewable energies, etc.) that could have different impacts for the inhabitants of the neighbourhoods (availability of energy services at the district level, rewards or penalties for energy performance, increase in the price of purchasing or renting homes, etc.). To inform yourself, you hope to find relevant data on the assessment of energy consumption of the neighbourhood in the information contained in the innovative SmartLivingEPC's neighbourhood scale rating system (NSLE).*

Pre-use assessment

Perceived Usefulness:

Question: In your opinion, can NSLE improve the energy savings of a neighbourhood?
Answers: 0 to 100 scale slider, where 0 is “no, it is not” and 100 is “yes, it is extremely”.

Question: In your opinion, is the neighbour assessed by a NSLE more appealing in the real estate sector?
Answers: 0 to 100 scale slider, where 0 is “no, it is not” and 100 is “yes, it is extremely”.

Question: In your opinion, do you see potential commercial value in NSLE?
Answers: 0 to 100 scale slider, where 0 is “no, it is not” and 100 is “yes, it is extremely”.

Perceived Ease of Use:

Question: Does NSLE provide enough clear and understandable information to the user?
Answers: 0 to 100 scale slider, where 0 is “not at all” and 100 is “extremely clear and understandable”.

Question: In your opinion, how easy was it to make decisions using the information provided by the NSLE?
Answers: 0 to 100 scale slider, where 0 is “extremely difficult” and 100 is “extremely easy”.

Question: Does NSLE offer the configuration options you need to make a decision?
Answers: 0 to 100 scale slider, where 0 is “no, not at all” and 100 is “yes, is extremely customizable”.

Intention to Use:

Question: Do you plan to use NSLE regularly in your work?
Answers: 0 to 100 scale slider, where 0 is “no, not at all” and 100 is “yes, every day”.

Privacy of Personal Data:

Question: Do you feel data privacy is respected while using NSLE?
Answers: 0 to 100 scale slider, where 0 is “no, not at all” and 100 is “yes, extremely secure”.

Post-use assessment

Question: How often have you used the NSLE in the previous month?
Answers: 0 to 100 scale slider, where 0 is “no, not at all” and 100 is “yes, every day”.

Question: Would you recommend the NSLE to a friend or a family member?
Answers: 0 to 100 scale slider, where 0 is “no, not at all” and 100 is “yes, definitely”.

Question: Would you keep using this tool for longer?
Answers: 0 to 100 scale slider, where 0 is “no, not at all” and 100 is “yes, definitely”.

Question: Do you have to propose any additional functionality/ies that you think would be useful/necessary?

3.10.4 SmartLivingEPC User’s assessment

User evaluation plays a central role in SmartLivingEPC project, providing a perspective that focuses on residents' experience with the SmartLivingEPC's neighbourhood scale rating system (NSLE). The goal is to understand their perception of the effectiveness of the improvements implemented, the clarity of the energy performance information presented, and the practicality of these changes in your daily life. Additionally, the user-centered approach can boost user participation and encourage the adoption of energy efficiency practices within the community.

Pre-use assessment

Perceived Usefulness:

Question: In your opinion, can NSLE improve the **energy savings** in your neighborhood?
Answers: 0 to 100 scale slider, where 0 is “no, it is not” and 100 is “yes, it is extremely”.

Question: In your opinion, is the neighbour assessed by a NSLE more a**ppealing for the real estate** sector?
Answers: 0 to 100 scale slider, where 0 is “no, it is not” and 100 is “yes, it is extremely”.

Question: How useful do you find the information contained in NSLE to understand the **quality of life** in the neighbourhood assessed?

Answers: 0 to 100 scale slider, where 0 is “not useful at all” and 100 is “extremely useful”.

Question: How useful do you find the information contained in NSLE in understanding the **energy consumption / cost** in your neighbourhood?

Answers: 0 to 100 scale slider, where 0 is “not useful at all” and 100 is “extremely useful”.

Perceived Ease of Use:

Question: Does NSLE provide enough **clear and understandable information** for you?
Answers: 0 to 100 scale slider, where 0 is “no, not at all” and 100 is “yes, extremely clear and understandable”.

Question: How satisfied are you with the **clarity and comprehensibility of the information** provided in the NSLE?

Answers: 0 to 100 scale slider, where 0 is “no, not at all” and 100 is “extremely satisfied”.

Question: Does NSLE offer the configuration options you need to **make decisions** related to where you live?
Answers: 0 to 100 scale slider, where 0 is “no, not at all” and 100 is “yes, is extremely customizable”.

Intention to Use:

Question: Do you think **integrating information about your neighbourhoo**d’s energy performance into the NSLE is beneficial?

Answers: 0 to 100 scale slider, where 0 “strongly disagrees” and 100 is “strongly agreed”.

Question: Do you think you will use the NSLE **regularly**?
Answers: 0 to 100 scale slider, where 0 is “no, not at all” and 100 is “yes, very often”.

Privacy of Personal Data:

Question: Do you think your **personal information and data** are secure using an NSLE?
Answers: 0 to 100 scale slider, where 0 is “no, not at all” and 100 is “yes, extremely secure”.

Post-use assessment

Question: How often have you **used** the NSLE in the previous month?
Answers: 0 to 100 scale slider, where 0 is “no, not at all” and 100 is “yes, every day”.

Question: Would you **recommend** the NSLE to a friend or a family member?
Answers: 0 to 100 scale slider, where 0 is “no, not at all” and 100 is “yes, definitely”.

Question: Would you **keep using** the NSLE for longer?
Answers: 0 to 100 scale slider, where 0 is “no, not at all” and 100 is “yes, definitely”.

Do you think that the **recommendations** provided by the NSLE are useful in your case?

Answers: “yes”; “no”

Do you plan to **implement** the recommendations provided by the NSLE?

Answers: “yes”; “no”

If you answered "no" to the previous question, tell why you will not follow the NSLE recommendations:

Financial Constraints.
High Upfront Costs.
Limited Awareness.
Split Incentives.
Lack of Access to Information.

Regulatory Barriers.
Technical Challenges.
Institutional Barriers.
Perceived Risk.
Lack of Incentives.
Tenant Behaviour.
Cultural or Social Norms.
Other (Specify)

Question: Do you have to propose any additional functionality/ies that you think would be useful/necessary?

3.11 KPI11: AI services support to EPC assessment

3.11.1 Indicator Description

The "AI Services Support to EPC Assessment" Key Performance Indicator (KPI) in the SmartLivingEPC project aims to develop artificial intelligence (AI) services that support building performance assessment, leading to the creation of next-generation Energy Performance Certificates (EPCs). This KPI focuses on leveraging AI technologies to enhance the accuracy, efficiency, and comprehensiveness of EPC assessments, providing more reliable and actionable insights into building energy performance.

Table 17: KPI 11 Basic information

Name	AI services support to EPC assessment
ID	KPI 11
Objective	The development of AI services supporting the building performance assessment and as a consequence the next generation EPCs
Description	Leverage AI technologies to enhance the accuracy, efficiency, and comprehensiveness of EPC assessments, providing more reliable and actionable insights into building energy performance.
Assessment Methodology	Surveys of EPC assessors and analysis of AI-supported EPC reports to evaluate the impact of AI services on EPC assessments.
Unit of Measurement	The unit of measurement for this KPI will be the improvement percentage in EPC assessment accuracy and efficiency due to AI integration. 5 point Likert scale of acceptance.
Evaluation Period	Tbd

3.11.2 Calculation Methodology

The calculation methodology involves integrating AI services into the EPC assessment process and evaluating their impact on the accuracy, efficiency, and comprehensiveness of the assessments. Initially, AI algorithms will be developed and applied to analyze building performance data, identifying patterns and generating insights that support EPC assessments. Surveys will be conducted with EPC assessors to gather feedback on the effectiveness and usability of the AI tools. Additionally, the accuracy and efficiency of AI-supported EPC assessments will be compared to traditional methods by analyzing the variance in energy performance predictions and the time taken to complete assessments. The collected data will be evaluated over different periods to measure the progress and effectiveness of AI integration in EPC assessments. Indicatively:

Questions for EPC Assessors and Building Tenants

EPC Assessor's Assessment

1. **To what extent do you believe that AI services improve the accuracy of EPC assessments?**
    - Not at all
    - To a small extent
    - To a moderate extent
    - To a great extent
    - To a very great extent

2. **To what extent do you find AI services helpful in identifying energy performance patterns of buildings?**
    - Not at all
    - To a small extent
    - To a moderate extent
    - To a great extent
    - To a very great extent
3. **How effective are AI services in enhancing the efficiency of the EPC assessment process?**
    - Not at all effective
    - Slightly effective
    - Moderately effective
    - Very effective
    - Extremely effective
4. **To what extent do you agree that integrating AI services into EPC assessments is important for the construction industry?**
    - Strongly Disagree
    - Disagree
    - Neutral
    - Agree
    - Strongly Agree

Building Tenant's Assessment

1. **To what extent do you believe that the EPC ratings provided after integrating AI services reflect the actual energy performance of your building?**
    - Not at all
    - To a small extent
    - To a moderate extent
    - To a great extent
    - To a very great extent
2. **To what extent do you find the information provided by AI-supported EPCs useful in managing your building's energy consumption?**
    - Not at all useful
    - Slightly useful
    - Moderately useful
    - Very useful
    - Extremely useful
3. **How satisfied are you with the clarity and comprehensibility of the EPC information after the integration of AI services?**
    - Very unsatisfied
    - Unsatisfied
    - Neutral
    - Satisfied
    - Very satisfied
4. **To what extent do you agree that incorporating AI services into EPC assessments will lead to better energy management practices?**
    - Strongly Disagree
    - Disagree
    - Neutral
    - Agree
    - Strongly Agree

These questions aim to capture the perceptions and experiences of both EPC assessors and building tenants regarding the integration of AI services into EPC assessments. They help in evaluating the impact of AI technologies on the accuracy, efficiency, and comprehensiveness of EPC ratings.

4 Conclusions

This deliverable has successfully established and implemented a comprehensive framework for evaluating and assessing its impact from multiple perspectives: technical, economic, environmental, and social within the SmartLivingEPC project. This achievement is a testament to the project's rigorous methodology and stakeholder-centric approach. At the core of this evaluation framework are the Key Performance Indicators (KPIs) defined to measure the project's technological efficiency and its success in achieving initial objectives. These KPIs were meticulously developed to cover various aspects of the project's impact and were informed by inputs from EPC assessors, and end-users. The relevance and accuracy of these KPIs were ensured through a detailed and consistent methodology, enabling an effective evaluation of the project's results. Tailored questionnaires were a crucial component of this approach, distributed to different stakeholder groups to align with the nature of the KPIs and the respondents' experience in the field of energy efficiency and EPC issuance procedures. The feedback collected from these questionnaires provided valuable insights into the acceptance and understanding of the SmartLivingEPC platform and its novel indicators, highlighting areas such as the integration of operational ratings, BIM technologies, and Smart Readiness Indicators (SRI). The perspectives of EPC assessors, end-users, and project partners were systematically gathered to assess various facets of the project's impact. EPC assessors provided insights into the acceptance and effectiveness of the SmartLivingEPC platform, identifying potential improvements and understanding the solution's impact on the energy sector. End-users offered feedback on their awareness and acceptance of the platform and their motivations for renovation and energy savings. Through both numerical analysis and qualitative surveys, the SmartLivingEPC project conducted a comprehensive assessment, capturing a holistic view of its impacts. The high levels of acceptance and positive feedback from stakeholders confirmed the project's success in meeting its objectives and achieving the expected impacts.

HE Grant Agreement Number: 101069639
Document ID:
WP<n.>/D/IR

Advanced Energy Performance Assessment towards Smart Living in Building and District Level

https://www.smartlivingepc.eu/en/

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https://twitter.com/SmartLivingEPC

https://www.youtube.com/channel/UC0SKa-20tiSabuwjtYDqRrQ

This project has received funding from the European Union's Horizon Europe research and innovation programme under the grant agreement number 101069639. The European Union is not liable for any use that may be made of the information contained in this document, which is merely representing the authors' view.