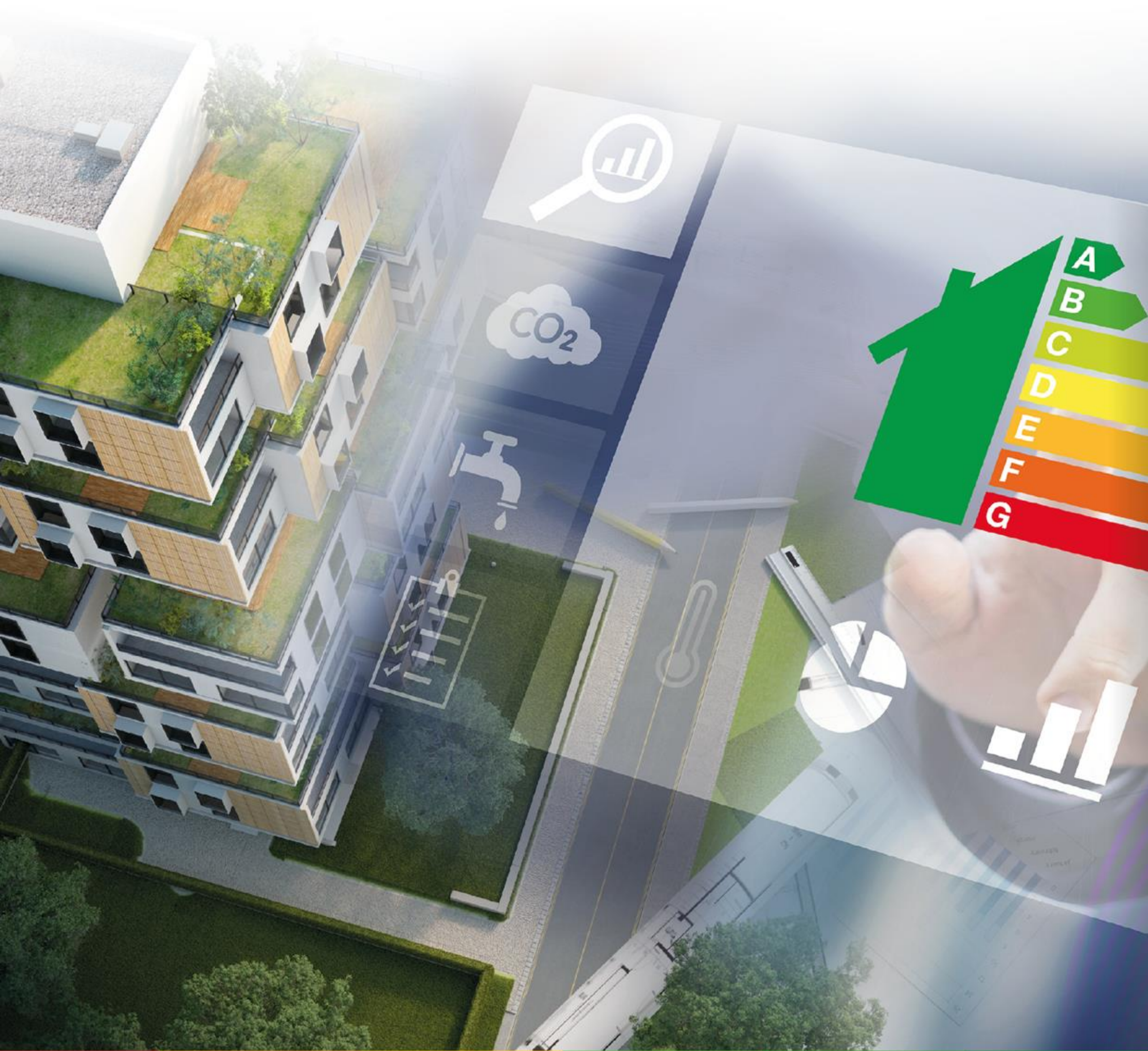
D3.5 Operational assessment methodology in complex level v2



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D3.5
Operational assessment methodology in complex level v2

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1.0	Leandro Ferrón (UDEUSTO)	10/06/2024	Final version ready for submission

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Executive Summary

This report is the continuation of deliverable 3.2 "Operational assessment methodology in omplex level v1". Its main axis is the description of the final operational indicators of the SmartLivingEPC project, whose objective is to develop a methodology to evaluate energy performance and sustainability at the neighborhood level. It consists of three chapters.

Chapter 1 serves as an introduction, outlining the objectives and scope of the deliverable.

Chapter 2 elaborates on the methodology for selecting operational KPIs. It details the refinement procedures, presents a final taxonomy of indicators for neighbourhood assessment, and includes thorough descriptions of each KPI. Each indicator is defined along with its calculation method and characteristics at both the energy and non-energy levels, highlighting its social implications. The section also includes the unit normalization process.

Chapter 3 examines the approach to scoring key operational performance indicators and introduces four weighting methods. The first method involves generic weighting, attributing equal weight to each indicator, resulting in an unbiased score. The second method utilizes participatory action methodologies to tailor the score to the unique needs, culture, and aspirations of each neighbourhood. The third method allows users to configure SmartLivingEPC label weights to refine property searches based on specific criteria. The fourth method involves a large-scale survey to gather user preferences across Europe, resulting in a European Score that reflects these responses. This chapter provides a detailed framework for operational performance evaluation at the neighbourhood level.

The report concludes by summarizing the key findings and contributions of the deliverable.

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List of Acronyms and Abbreviations

Term	Description
AROPE	At risk of poverty and/or exclusion
DHW	Domestic Hot Water
EPC	Energy Performance Certificate
EV	Electric Vehicle
GHG	Greenhouse gas emissions
GINF	Global Infrastructure Index
GIS	Geographic Information System
HDI	Human Density Index
IEQ	Indoor Enviromental Quality
LCA	Life Cycle Analysis
LCC	Life Cycle Cost
MI	Moran Index
MSCI	Circular Economy Index
NDVI	Normalized Difference Vegetation Index
NGO	Non Governmental Organization
PDI	Population Density Index
RES	Renewable Energy System
SRI	Smart Readiness Indicator
UGR	Unified Glare Rating

1 Introduction

1.1 Task description

Task 3.4 focuses on developing an operational methodology for the neighbourhood scale within the SmartLivingEPC framework. This involves considering operational energy aspects at the neighbourhood level and documenting infrastructure and smart sensor installations to measure their actual performance. Furthermore, it involves defining practices for the analysis of these measurements and identifying the evaluation and qualification scheme applicable to the neighbourhood scale. Furthermore, the task aims to establish neighbourhood-scale digital twin practices and outline the integration of measurement results from smart sensors installed in neighbourhood areas and buildings.

1.2 Background and Objectives

The primary objective is to develop an operational methodology at the neighbourhood scale, wherein the integration of infrastructure and smart sensor technologies plays a fundamental role, enabling accurate measurement and analysis of energy usage.
In addition, secondary objectives are:

- Define the set of key indicators necessary for operational evaluation at the neighbourhood level
- Establish standardized procedures for data collection, processing, and reporting
- Propose an operational rating that reflects the energy performance and sustainability of the entire neighbourhood.

1.3 Scope of the deliverable

SmartLivingEPC will launch and introduce a new energy performance rating methodology applicable at the neighbourhood level. This methodology will be based on considering neighbourhood-scale energy infrastructure and services, integrated into the energy behaviors of individual building units. The final result is expected to be an operational methodology that details procedures for measuring, processing and reporting energy consumption data at the neighbourhood scale. This methodology will issue a certificate that will allow the operational energy performance of the neighbourhoods to be effectively evaluated, with the aim of achieving energy savings at that level. This report follows deliverable D3.2, titled "Operational Assessment Methodology at Complex Level v1." Its primary focus is on detailing the final operational indicators of the SmartLivingEPC project, which aims to develop a methodology for evaluating energy performance and sustainability at the neighborhood level. The report is structured into three chapters.

2 Key Performance Operational Indicators selection methodology

The operational energy performance indicators are crucial for policymakers in creating sustainable urban areas that meet residents' needs. With increasing environmental regulations and demand for eco-friendly solutions, identifying these indicators has become pivotal in urban planning.

These metrics quantify energy efficiency, environmental impact, and resident well-being, requiring a multidimensional approach. Energy performance indicators assess energy consumption and system efficiency, guiding strategies to reduce costs and carbon footprints.

Environmental indicators, such as greenhouse gas (GHG) emissions, identify areas for improvement and inform policies to promote sustainability. Based on the initial analysis of indicators presented in D3.2 "Operational methodology assessment in building complex level v1", a three-step methodology was implemented to refine the set:

- Proposal of an initial in-extenso set of indicators
- Contrast of the resulting Key Performance Indicators (KPI) against the most widely used indicators globally, in reference frameworks for assessing the sustainability of cities.

This approach yielded a refined indicator set, laying a strong foundation for a neighbourhood-scale energy rating scheme.

2.1 Key performance Operational Indicators refinement procedure

The process of defining indicators began with the creation and compilation of an extensive list of Key Performance Indicators at the urban scale. Initially, this list emerged from a brainstorming exercise among the partners, in which all the KPIs that were suggested were included, without a classification or synthesis process. The list was composed of 110 indicators, covering urban operational consumption and analyzed from various perspectives, including life cycle analysis (LCA), life cycle cost (LCC), energy parameters, non-energy aspects, proximity aspects and social perspective (Table 1).

Table 1: List in-extenso of Operational Key Performance Indicators identified

DIMENSION	CATEGORY	INDICATOR	USE	ENERGY	SOCIAL	LCA	LCC
Environmental	Neighbourhood Services	Urban Conditioning (District heating and cooling)	% of population using renewable and efficient urban heating/cooling systems	Annual energy used for heating/cooling	Days a year with ambient temperatures near to historical maximums and	Annual emissions intensity of heating/cooling	Annual costs of urban heating/cooling (EUR/(km2 · hab)) [1]

				(kWh/(km2 · hab))	minimums Thermal confort	(tCO2e/(km2 · hab))	
		Domestic Hot Water	% of population using renewable and efficient DHW systems	Annual energy used for DHW (kWh/(km2 · hab))	% of temperature variation between the neighbourhood and outskirts Thermal comfort	Annual emissions intensity of DHW (tCO2e/(km2 · hab))	Annual costs of urban DHW (EUR/(km2 · hab)) [1]
		Illumination	% of population that use street illumination of at least Eh 20 lux	Annual energy used for the street lighting network (kWh/(km2 · hab))	Light Pollution Index Unified Glare Rating (UGR) Visual Confort	Annual emissions produced by the street lighting (tCO2e/(km2 · hab))	Annual costs incurred for street lighting (EUR/(km2 · hab))
		Water distribution	% of population using water systems (there is the possibility that there are populations without access to water)	Annual energy used to provide water (kWh/(km2 · hab))	Water Poverty Index Water Quality Index	Annual emissions produced to provide the water (tCO2e/(km2 · hab))	Annual costs incurred to provide the water consumption (EUR/(km2 · hab))
		Sewage	% of population connected to water treatment plants with energy and material recovery	Annual energy used for the water treatment plants (kWh/(km2 · hab))	% of population connected to a water treatment plant Ecological Risk Index	Annual emissions intensity of the water treatment plants (tCO2e/(km2 · hab))	Annual costs of the water treatment plants (EUR/(km2 · hab))
		Service Station (fuels)	% of population that use service station / EV charging points	Annual energy used to keep service stations/charging points in operation (kWh/(km2 · hab))	Charging Infrastructure Index	Annual emissions produced by transportation needs (tCO2e/(km2 · hab))	Annual costs incurred for the transport needs (EUR/(km2 · hab))
		Electricity distribution	% of population using renewable and efficient electrical systems	Annual energy used to supply and distribute electricity (kWh/(km2 · hab))	Annual percentage of hours of electricity provision Global infrastructure index (GINF)	Annual electricity intensity (tCO2e / (km2 · hab) or (km2 · hab))	Annual electricity (EUR/(km2 · hab))
		Telecommunication services	% of population that use 5G network	Annual energy used to keep the telecommunication system	Annual percentage of hours of service provision Telecommunication	Annual emissions produced by the telecommunication system	Annual costs incurred for the telecommunication system

				(kWh/(km2 · hab))	Infrastructure Index	(tCO2e/(km2 · hab))	(EUR/(km2 · hab))
		Solid waste management	% of population implementing renewable and efficient Solid waste management	Annual energy used for the waste collection system (kWh/(km2 · hab))	Ecological Risk Index	Annual emissions produced by the waste collection system (tCO2e/(km2 · hab))	Annual costs incurred for the waste collection system (EUR/(km2 · hab))
	Urban Comfort	Heat Island	% of population using extra energy for cooling due to excess urban heat island temperatures	Annual of excess or defect energy used for heating/cooling due to the process of a heating island (kWh/(km2 · hab))	Days a year with temperatures near to historical maximums Thermal Confort	Annual of excess or defect emissions produced by the heating/cooling due to the heating island (tCO2e/(km2 · hab))	Annual cost for excess or defect energy intensity of heating/cooling due to the process of a heating island (EUR/(km2 · hab))
		Air quality [2]	% of population using extra energy for air filtering due to low air quality index	Annual energy used for ventilation (kWh/(km2 · hab))	Year Average Common Air Quality Index Moran Index (MI)	Annual emissions intensity produced by purified air blowing (tCO2e/(km2 · hab))	Annual costs incurred for purified air blowing (EUR/(km2 · hab))
		Noise	% of population that uses additional energy for noise insulating due to high ambient noise (green wall technologies)	Annual energy used for noise insulation (kWh/(km2 · hab)) (green wall technologies)	Year averange common City Noise-Air index	Annual emissions intensity of noise insulation systems (tCO2e/(km2 · hab)) (green wall technologies)	Costs of noise insulation systems (EUR/(km2 · hab))
	Energy	Energy Generation	% of population that uses local renewable energy generation services	Annual maximum use of the energy generation (kWh/(km2 · hab))	Self consumption (%) Thail Index Power Quality Index	Annual maximum emissions produced by the generation intensity (tCO2e/(km2 · hab))	Annual maximum costs incurred for the generation (EUR/(km2 · hab))
		Energy Storage	% of population that uses energy energy storage / local balancing services	Annual maximum use of the energy cumulative (kWh/(km2 · hab))	Autarky rate (%) Thail Index Power Quality Index	Annual maximum emissions produced by the cumulative intensity	Annual maximum costs incurred for the cumulative storage

						(tCO2e/(km2 · hab))	(EUR/(km2 · hab))
Social	Urban mobility	Public Transport	% of population that uses a public transport stop that is less than 500m away	Annual energy consumption of the public transport use (kWh/(km2 · hab))	% of population within 500 m of a public transport stop Transport sustainability index Walkability Index	Annual emissions produced by the transport needs of the population (tCO2e/(km2 · hab))	Annual costs of the transport needs of the population (EUR/(km2 · hab))
		Private Transport	% of population that uses a public or private car park that is less than 500m away	Annual energy consumption of the private transport use (kWh/(km2 · hab))	Presence of Low Emission Zone in the district	Annual emissions produced by the transport needs of the population (tCO2e/(km2 · hab))	Annual costs of the transport needs of the population (EUR/(km2 · hab))
		Accessibility	% of population that frequents different points of interest in the urban area, less than 500m away	Average energy consumption (kWh) to reach specific places based on the frequency of visits to those places	15-Minute City Index Walkability index	Average emissions produced (tCO2e) by the population to reach specific places	Average costs incurred (EUR) by the population to reach specific places (Recreational and cultural spaces, Educational, Health, Shopping, Public administration, Financial infrastructure)
	Economics	Logistics	% of population that requires loading and unloading of goods transported within a radius of 500 m distance	Annual energy consumption of logistic services in the neighbourhood (kWh/(km2 · hab))	MSCI Circular Economy Index	Annual emissions produced by logistic services in the neighbourhood (tCO2e/(km2 · hab))	Annual costs incurred by logistical services in the neighbourhood (EUR/ton)
		Real-life conditions	% of population within the AROPE rate	Energy consumption of buildings and urban areas, associated with behaviors linked to sociodemographic and	AROPE indicator (At risk of poverty and/or exclusion)	Emissions produced by buildings and urban areas, associated with socio-demographic and quality of life variables (tCO2e/(km2 · hab))	Costs incurred by buildings and urban areas, associated with socio - demographic and quality of life variables

				quality of life variables (kWh/(km2 · inhab))			(EUR/(km2 · hab))
Institutional	Urban Plannig	Urban Density	% of population that moves in areas of 50,000 inhabitants/km 2	Use of solar heat gains/energy savings (kWh/(km2 · hab))	Human density index (HDI) Population density index (PDI)	Annual emissions saved by the use of solar heat gains (tCO2e/(km2 · hab))	Annual costs saved by the use of solar heat gains (EUR/(km2 · hab))
	Green Areas	Urban green spaces / forests	% of population that uses or frequents green spaces and urban forests	Annual energy consumption to manage the urban green space / forest (kWh/(km2 · hab))	Vegetation index Normalized Difference Vegetation Index (NDVI)	Annual water and emissions produced from the management of green spaces (tCO2e/(km2 · hab))	Annual water costs to manage green spaces (EUR/(km2 · hab))
		Urban agriculture	% of population that uses or frequents places for urban agriculture	Annual energy consumption to manage the urban green space / forest (kWh/(km2 · hab))	Vegetation index Normalized Difference Vegetation Index (NDVI)	Annual water and emissions produced from management of green spaces (tCO2e/(km2 · hab))	Annual water costs to manage green spaces (EUR/(km2 · hab))

The indicators that emerged from the initial brainstorming were put to the consideration of the partners, who applied selection criteria and made suggestions according to their area of expertise. The resulting list was then subjected to an optimization process by contrasting the proposed KPIs with the indicators used in urban sustainability frameworks and neighborhood sustainability assessment tools adopted globally [1] (Table 2). By comparing the identified KPIs with those assessment frameworks and tools comprised of indicators that have been validated by the scientific community and through field testing, we were able to define which indicators should be maintained.

Table 2: Benchmarking of the list of identified Operational KPIs against those used in urban sustainability frameworks

DIMENSION	THEMATIC CATEGORIES	MOST POPULAR INDICATORS	*F **	APPEARANCES IN %	STATUS
Environmental	Climate change	Total CO2 emissions (tCO2/capita/year)	36	72%	already included
Environmental	Air quality	Annual mean concentrations of air pollutants: NO2, PM10, PM2.5 (μg/m3)	35	70%	already included
Environmental	Waste	Municipal waste generated—in kg per capita	34	68%	already included
Environmental	Water	Domestic water consumption (litres/capita/day/year)	32	64%	already included

Environmental	Waste	Municipal waste recycling rate (%)	30	60%	not already included / is not of interest
Environmental	Air quality	Number of times that the limit of pollutants the NO2, PM10, O3 is exceded	30	60%	is repeated (3)
Environmental	Land use	Shares of built-up area, forest, water, agricultural land, and other areas of the total city area (%)	30	60%	already included
Environmental	Energy	Share of a city's total energy consumption that comes from renewable sources as a share of the city's total energy consumption (%)	28	56%	already included
Social	Safety and security	Number of crimes reported annually per 1000 inhabitants	28	56%	not already included / is not of interest
Environmental	Mobility and transport	Modal split—percentage distribution of average daily journeys: on foot, public transport, motorised private transport, and bicycles	26	52%	already included
Economic	Employment	Unemployment rate (%)	26	52%	not already included / is not of interest
Social	Green space	Green area within the city (forests, parks, gardens, etc.) per inhabitant (m2/inhabitant)	26	52%	is repeated (8)
Economic	Employment	Employment percentage change since base year (%)	23	46%	not already included / is not of interest
Environmental	Water	Share of population connected to a public sewerage system and wastewater treatment system (%)	21	42%	is repeated
Environmental	Energy	Total consumption of electricity in kWh per capita	21	42%	already included
Economic	Economy	City product per capita	21	42%	not already included / is not of interest
Institutional	Participation	Voter turnout—% of adult population who voted in the last municipal, presidential, national, and EU parliamentary elections	20	40%	not already included / is not of interest
Environmental	Mobility and transport	Motorisation rate—number of personal automobiles per capita	16	32%	already included
Social	Health	Life expectancy at birth (male/female)	16	32%	not already included / is not of interest
Social	Social infrastructure	Connection to services—percentage of households connected to piped water, sewerage, electricity, gas distribution network, and broadband internet (%)	16	32%	is repeated
Social	Equity (social, economic)	Income distribution (Gini Coefficient)	15	30%	already included
Institutional	Environmental management	Number of enterprises and public and non-governmental organisations with certified Environmental Management Systems (IS014001/EMAS)	15	30%	not already included / is not of interest
Institutional	Governance	Total debt per capita of a municipality (in euros)	15	30%	not already included / is not of interest

Social	Safety and security	Number of traffic accidents per year per 1000 inhabitants	14	28%	not already included / is not of interest
Social	Health	Number of physicians and nursing personnel per 1000 inhabitants	13	26%	not already included / is not of interest
Social	Housing	Housing costs—% of the total disposable household income	13	26%	not already included / is not of interest
Social	Equity (social, economic)	Share of women and ethnic minorities in local government (%)	13	26%	not already included / is not of interest
Environmental	Mobility and transport	Total length of bicycle lanes in km per 1000 inhabitants	12	24%	Is not operational
Economic	Economy	Number of businesses per 1000 inhabitants	12	24%	not already included / is not of interest
Social	Education	Early childhood education—children under six years of age who are enrolled in early childhood education programs (%)	11	22%	not already included / is not of interest
Social	Housing	Average living area per person (m2)	11	22%	Is not operational
Social	Green space	Percentage of inhabitants living within 300 m or 15 min walk from public green space > 5000 m2 (%)	10	20%	is repeated
Social	Culture	Public expenditure on culture per 1000 inhabitants	10	20%	not already included / is not of interest
Environmental	Land use	Share of protected nature areas of the total city area (%)	9	18%	not already included / is not of interest
Social	Social infrastructure	Percentage of population living within 500 m of basic public services (%)	9	18%	is repeated
Institutional	Participation	Civic associations—number of voluntary non-profit organisations, including NGOs and political, sporting, or social organisations, registered or with premises in the city, per 1000 inhabitants	8	16%	not already included / is not of interest
Institutional	Urban planning	Existence of documents for inciting sustainable and strategic urban development	7	14%	not already included / is not of interest
Institutional	Environmental management	Share of eco-labelled products in public procurement by city authorities	7	14%	not already included / is not of interest

Column f* shows the number of frameworks in which the indicator appears.

In this way, Indicators that aligned with established frameworks were considered reliable, while those that required further study and validation were designated for possible exclusion.

2.2 Key performance Operational Indicators Taxonomy

Efforts were made to identify and eliminate closely correlated indicators, resulting in a final selection of KPIs based on criteria such as data availability, reliability, perceived usefulness, and ease of comprehension. This process marked the culmination of the KPI refinement phase. Table 3 presents a structured overview of indicators grouped into two dimensions: Environmental and Operative.

Table 3: Final list of Operational Key Performance Indicators

DIMENSION	CATEGORY	INDICATOR	OPERATIONAL	UNIT
Environmental	Neighbourhood services	Street Lighting and public area lighting	(Energy consumption by lighting in district areas * hours of use) / total kWh consumed by the neighbourhood*100	%
		District Energy Systems Heating	Heating load covered by efficient heating / Total heating load of district (where efficient is heat pumps and others to be defined) *100	%
		District Energy Systems Cooling	Cooling load covered by efficient cooling / Total cooling load of district (where efficient is a heat pump with a cool water source) *100	%
		Wastewater Treatment Consumption rate	Measured energy consumption of the Wastewater treatment / Total energy consumption of the neighbourhood *100	%
	Renewable Energies	RES ratio	Load covered by RES (on-site) / total energy consumption of district	%
Operational	Neighbourhood´s Building Functioning	Load Demand Factor [4]	district peak electricity load / district base electricity load *100	%
		EV Chargers Electricity Consumption rate	EV charging electricity consumption/ Total district electricity consumption *100	%
		EV Energy Load	EV charging load/ Total district electricity load *100	%
		Buildings (Aggregated energy KPIs) [3]	Total energy consumption from buildings / Total energy consumption from buildings within the assessed area *100	%
		Aggregated Heating KPIs	Heating - energy consumption from a single building / Total energy consumption of the building *100	%
		Aggregated Cooling KPIs	Cooling - energy consumption from a single building / Total energy consumption of the building *100	%
		Aggregated DHW KPIs	DHW - energy consumption from a single building / Total energy consumption of the building *100	%
		Aggregated Lighting KPIs	Lighting - energy consumption from a single building / Total energy consumption of the building *100	%
		Aggregated Appliances KPIs	Electrical Appliances - energy consumption from a single building / Total energy consumption of the building *100	%
		Aggregated GHG KPIs	Total greenhouse gas emissions (GHG) including those produced by the travel needs of the building / Total energy consumption of the building *100	%
		SmartLivingEPC Operational Rating	Mean distribution of Operational Rating EPC score	%
		SmartLivingEPC IEQ	Mean distribution of IEQ score	%
		SmartLivingEPC LCC	Mean distribution of LCC score	%
		SmartLivingEPC Non-Energy	Mean distribution of operational level non-energy analysis score	%

The table is structured in two main dimensions: Environmental and Operative. In the environmental dimension, the indicators are also classified into Neighbourhood Services and Renewable Energy. The Neighbourhood

Services category focuses on measurable essential services within the neighbourhood, while the Renewable Energy category is dedicated solely to the Renewable Energy System ratio indicator, which measures the proportion of renewable energy sources in the neighbourhood's energy mix. Within the Operative dimension, the indicators are grouped under a single category called "Neighbourhood's Building Operatory". This category encompasses a wide range of indicators related to various aspects of the operational performance of buildings within the neighbourhood. Additionally, the category includes holistic metrics such as SmartLivingEPC Operational Rating, IEQ (Indoor Environmental Quality), LCC (Life Cycle Cost) and non-energy related indicators. These metrics provide a comprehensive assessment of neighbourhoods' overall operational performance, considering both environmental sustainability and building-specific operational efficiency. Overall, the table provides a structured framework for conceptualizing and evaluating operational aspects of neighbourhood performance.

2.3 Key Performance Operational Indicators Description

The SmartLivingEPC Operational neighbourhood rating primary aim is to offer a comprehensive assessment of a neighbourhood's environmental impact, encompassing a variety of indicators that evaluate energy, non-energy and environmental aspects, among others. These indicators have been carefully crafted to align with European methodologies used for evaluating and disclosing the sustainability characteristics of urban areas. This section provides an elaborate overview of operational indicators at the neighbourhood level, presented in a tabular format for organized comprehension of each metric. The table structure includes the 'Indicator Name', 'Indicator Description' (comprising definition, calculation methodology, and potential data sources), and 'Unit and Source'. This systematic approach improves readability and ensures a clear understanding of the measurement and calculation basis for each indicator (Table 4).

Table 4: SmartLivingEPC Operational Key Performance Indicators description

INDICATOR NAME	INDICATOR DESCRIPTION	UNIT
Street Lighting and public area lighting	Public Lighting and the lighting of public areas refers to the availability and levels of artificial night public lighting, road sign lighting and advertising elements. Lighting not only impacts aspects of energy consumption, but also extends to broader aspects, such as accessibility, the feeling of personal security, road safety and psychological comfort. This indicator expresses the consumption produced by the lighting of the ground areas of the neighbourhood, during the use hours, divided by the total kWh consumed in the neighbourhood, multiplied by 100. For its definition, the area to be evaluated must be delimited, and the consumption of the installation must be measured during the hours of use of the installation.	%
District Energy System Heating	The district energy system indicator refers to the amount of energy used by centralized systems that provide heating to multiple buildings or residences in a specific area or district. Since this is a building property, it is proposed to measure the indicator as the heating load covered by efficient heating divided by the total heating load of the district (where we understand as "efficient" the heating pumps heat and others to be defined), multiplied by 100. From a social perspective, this indicator can be addressed through the concept of energy poverty, defined as a situation in which individuals or households cannot afford adequate	%

	levels of essential energy services, such as heating, cooling, lighting and the use of household appliances. This concept highlights the intersection of economic, social and environmental vulnerabilities. Energy poverty impacts living conditions, health problems and social exclusion.	
District Cooling System Cooling	The district energy system indicator refers to the amount of energy used by centralized systems that provide cooling to multiple buildings or residences in a specific area or district. Since this is a building property, it is proposed to measure the indicator as the cooling load covered by efficient cooling divided by the total cooling load of the district (where we understand as "efficient" the cooling pumps heat and others to be defined), multiplied by 100. From a social perspective, this indicator can be addressed through the concept of energy poverty, defined as a situation in which individuals or households cannot afford adequate levels of essential energy services, such as heating, cooling, lighting and the use of household appliances. This concept highlights the intersection of economic, social and environmental vulnerabilities. Energy poverty impacts living conditions, health problems and social exclusion.	%
Wastewater Treatment Consumption rate	The ''Wastewater Treatment consumption rate" indicator refers to the consumption of wastewater treatment systems. Wastewater services have relevant positive environmental and social effects, but they could produce significant impact by consuming energy, producing emissions, by-products, and waste to be disposed of. This indicator expresses the energy consumption produced by the wastewater system over the total energy consumption of the neighbourhood, multiplied by 100. The data that make up this indicator come from municipal GIS maps.	%
RES ratio	The "RES ratio" indicator evaluates the use of renewable energy systems within the assessed district. In practical terms, the indicator shows the load covered by renewable energy systems (on-site RES) divided by the total energy consumption of the district, multiplied by 100. The social impacts of a low value for the "RES ratio" indicator can be excessive consumption of energy from the grid, lack of energy autonomy and high payments for consumption, mainly affecting populations with fewer resources.	%
Load Demand Factor	The Load Demand Factor corresponds to the ratios between the actual energy consumption (kW) and the maximum power recorded (demand) for that period of time. In the case of the "Load Demand Factor" of a neighbourhood, it is proposed to take into account the measurement of the maximum electrical load of the district, divided by the base electrical load of the district, multiplied by 100.	%
EV Chargers Electricity Consumption rate	The indicator "Consumption of EV chargers" evaluates the consumption of the installed EV charger service with respect to the total electrical consumption of a neighbourhood. This rate will be determined by the measurement of the electricity consumption of EV chargers in kWh divided by the total electricity consumption, multiplied by 100.	%
EV charger Energy Load	The EV Charger Energy Load indicator proposes to measure the electrical energy load of the EV charger infrastructure in a period of time divided by the total electrical energy load that the EV charger could give in that period of time. Example, for a week it will be the total energy consumption divided by [7*24*nominal power of the EV charger], multiplied by 100.	%
Buildings (Aggregated energy KPIs)	The "Buildings (Aggregated energy KPIs)" indicator shows the level of consumption of energy in a building. This indicator is derived directly from the buildings located in the area to be assessed. If information is not available on all the buildings in the neighbourhood, we will seek to have at least one Buildings (Aggregated energy KPIs) for each type of building, based on its characteristics. The indicator answers to the total	%

	energy consumption from buildings divided by the total area of buildings, multiplied by 100.	
Aggregated Heating KPIs	The “Aggregated Heating KPIs” indicator shows the level of consumption of energy intended for heating in a building. This indicator is derived directly from the buildings located in the area to be assessed. If information is not available on all the buildings in the neighbourhood, we will seek to have at least one Buildings Heating KPIs indicator for each type of building, based on its characteristics, its year of construction, etc. The indicator is the measured energy consumption of the Heating System of a single building, divided by the total energy consumption of the building, multiplied by 100.	%
Aggregated Cooling KPIs	The “Aggregated Cooling KPIs” indicator shows the level of consumption of energy intended for cooling in a building. This indicator is derived directly from the buildings located in the area to be assessed. If information is not available on all the buildings in the neighbourhood, we will seek to have at least one Buildings Cooling KPIs indicator for each type of building, based on its characteristics, its year of construction, etc. The indicator is the measured energy consumption of the Cooling System of a single building, divided by the total energy consumption of the building, multiplied by 100.	%
Aggregated DHW KPIs	The “Aggregated DHW KPIs” indicator shows the level of consumption of energy intended for Domestic Hot Water in a building. This indicator is derived directly from the buildings located in the area to be assessed. If information is not available on all the buildings in the neighbourhood, we will seek to have at least one Buildings DHW KPIs indicator for each type of building, based on its characteristics, its year of construction, etc. The indicator is the measured energy consumption of the Domestic Hot Water system of a single building, divided by the total energy consumption of the building, multiplied by 100.	%
Aggregated Lighting KPIs	The “Aggregated Lighting KPIs” indicator shows the level of consumption of energy intended for lighting in a building. This indicator is derived directly from the buildings located in the area to be assessed. If information is not available on all the buildings in the neighbourhood, we will seek to have at least one Buildings Lighting KPIs indicator for each type of building, based on its characteristics, its year of construction, etc. The indicator is the measured energy consumption of the Lighting system of a single building, divided by the total energy consumption of the building, multiplied by 100.	%
Aggregated Appliances KPIs	The “Aggregated Appliances KPIs” indicator shows the level of consumption of energy intended for Appliances in a building. This indicator is derived directly from the buildings located in the area to be assessed. If information is not available on all the buildings in the neighbourhood, we will seek to have at least one Buildings Appliances KPIs indicator for each type of building, based on its characteristics, its year of construction, etc. The indicator is the measured energy consumption of the Electric Appliances of a single building, divided by the total energy consumption of the building, multiplied by 100.	%
Aggregated GHG KPIs	The “Aggregated GHG KPIs” indicator shows the level of Greenhouse gas emissions in a building. This indicator is derived directly from the buildings located in the area to be assessed. If information is not available on all the buildings in the neighbourhood, we will seek to have at least one Buildings GHG KPIs indicator for each type of building, based on its characteristics, its year of construction, etc. The indicator answers to the Total Greenhouse Gas Emissions (including those produced by the travel needs of the building) divided by the total buildings within the neighbourhood, multiplied by 100.	%
SmartLivingEPC Operational Rating	The “SmartLiving EPC Operational Rating” indicator is a score that shows the energy consumption derived from the use of a building. This indicator is taken directly from the buildings. It is defined as the percentage of buildings per area with a high SmartLinvingEPC score (tentatively A, B or C) over the total buildings in the evaluated neighborhood. If the SmartLinvingEPC score is not available for all the buildings in the area, we will seek to have at least one SmartLiving EPC Operational Rating for each	Score in %

	typology of building, selected based on its characteristics, year of construction, materials, etc.	
SmartLivingEPC IEQ	The “SmartLiving EPC IEQ” indicator is a score that shows the indoor environment quality of a building. This indicator is taken directly from the buildings. It is defined as the percentage of buildings per area with a high SmartLinvingEPC score (tentatively A, B or C) out of the total buildings in the evaluated neighborhood. If the SmartLinvingEPC IEQ score is not available for all the buildings in the area, we will seek to have at least one SmartLiving EPC Operational Rating for each type of building, selected based on its characteristics, year of construction, materials, etc.	Score in %
SmartLivingEPC LCC	The “SmartLiving EPC LCC'' indicator is a score that condenses the inventory of materials and processes used throughout the life cycle of a building to obtain the overall economic costs of a building. This indicator is taken from the buildings. It is defined as the percentage of buildings per area with a high SmartLinvingEPC score (tentatively A, B or C) out of the total buildings in the evaluated neighborhood. If the SmartLinvingEPC LCC score is not available for all the buildings in the area, we will seek to have at least one SmartLiving EPC Operational Rating for each typology of building .	Score in %
SmartLivingEPC Non-Enenrgy	The “SmartLiving EPC non-Energy” indicator is a score that shows the impact of non-energy aspects on a building. This indicator is taken from the buildings. It is defined as the percentage of buildings per area with a high SmartLinvingEPC score (tentatively A, B or C) over the total buildings in the evaluated neighborhood. If the SmartLinvingEPC non-Energy score is not available for all the buildings in the area, we will seek to have at least one SmartLiving EPC Operational Rating for each typology of building .	Score in %

Note that the detailed descriptions in the central column extend past the KPI calculation methodology to explore potential social impacts [5, 6, 7]. Factoring in the social aspects of each indicator enables stakeholders to make informed decisions supporting the development of sustainable communities.

3 Operational Key Performance Indicators Scoring

Once the most relevant indicators for the operational assessment of neighbourhoods have been determined, it is necessary to establish a weighting of their impact on the evaluation to define a final rating. Conceptually, this weighting of indicators can be considered from different perspectives. In this proposal, four methodological approaches are developed, each focusing on different axes:

1. **Generic Operational Rating:** This approach involves a weighting proposal with an equitable distribution of weights, giving equal importance to all indicators.
2. **Neighbour´s Operational Rating:** This approach is developed based on the preferences of the neighbourhoods to be evaluated, utilizing participatory action methodologies. This allows for the weights of the indicators to be actively defined by community members, reflecting their specific needs and priorities.
3. **Individual Preferences Operational Rating:** This approach proposes to make available to individual users the possibility of configuring the weighting of the indicators according to their own interests.
4. **European Operational Rating:** This approach is based on user preferences at the European level, defined through a large-scale survey. It provides a weighting proposal that reflects the collective preferences of European residents.

In the following sections, the scope and implementation of each of these methods are described and discussed in detail.

3.1 Generic Weighting of Operational Key Performance Indicators

The first methodological weighting alternative is to attribute the same value to each indicator, assigning a uniform weight of 5.26% to each proposed KPI. This approach ensures that all aspects are given equal importance, promoting a balanced evaluation framework that minimizes the impact of individual, political, or cultural biases. However, by applying equal weights, the methodology assumes that each indicator contributes equally to the overall evaluation. While this simplifies the evaluation process and avoids biases that could arise from differential weighting, it also overlooks unique characteristics and priorities that could be significant in certain neighbourhoods. For example, some areas might prioritize energy efficiency and the adoption of renewable energy more than others, or specific transportation needs might emerge from engaging with residents. These particular nuances of each neighbourhood would be obscured when using a homogenized weighting of indicators.

Table 5: Example of SmartLivingEPC neighbourhood rating system indicators with default weighting

DIMENSION	CATEGORY	INDICATOR	UNIT	PROJECT VALUE	AGREED SCALE VALUES
Environmental	Neighbourhood Services	Street Lighting and public area lighting	%	100	5,26%
		District Energy Systems Heating	%	13	5,26%
		District Energy Systems Cooling	%	0	5,26%
		Wastewater Treatment Consumption rate	%	35	5,26%

		RES ratio	%	12	5,26%
	Renewable Energies	Load Demand Factor	%	15	5,26%
Operative	Neighbourhood´s Building Operatory	EV Chargers Electricity Consumption rate	%	21	5,26%
		EV Energy Load	%	20	5,26%
		Buildings (Aggregated energy KPIs)	%	70	5,26%
		Aggregated Heating KPIs	%	15	5,26%
		Aggregated Cooling KPIs	%	0	5,26%
		Aggregated DHW KPIs	%	20	5,26%
		Aggregated Lighting KPIs	%	5	5,26%
		Aggregated Appliances KPIs	%	30	5,26%
		Aggregated GHG KPIs	%	9	5,26%
		SmartLivingEPC Operational Rating	%	65	5,26%
		SmartLivingEPC IEQ	%	90	5,26%
		SmartLivingEPC LCC	%	35	5,26%
		SmartLivingEPC Non-Energy	%	84	5,26%
					100%

Table 5 provides a detailed representation of the uniform weighting approach. In this example, the rating calculated as the vector product of the two vectors PROJECT VALUE and DEFAULT WEIGHT yields a rating score of 33.61.

3.2 Weighting of Operational Key Performance Indicators through Participatory Action Methodologys

Continuing with indicator weighting methodologies, in this approach it is proposed to adjust KPI weights to better reflect the specific needs or culture of neighbourhood residents or policymakers. In this case, the use of participatory action methodologies is promoted, involving all neighbourhood agents in the process of preparing the SmartLivingEPC assessment. This approach ensures that the weighting of indicators aligns with the unique needs and cultural aspects of neighbourhood stakeholders. There are several advantages of this methodology, as follows:

1. When the certificate is used to identify vectors of improvement in a neighbourhood, different communities may assign different levels of importance to the aspects covered in the certificate. This approach respects the identity and needs of the different neighbourhoods, allowing them to be reflected in the final result.
2. This alternative allows citizens who want to use the certificate to select a neighbourhood to live in to define their own set of weightings based on their interests and needs. This flexibility is achieved by ensuring that the SLEPC technological platform allows any user of the certificate to modify this section, customizing the weighting to their specific needs.
3. The use of different weights provides policymakers with a neighbourhood score that does not allow direct comparisons between cities or neighbourhoods, thus avoiding confrontation and promoting a more harmonious adoption of the SmartLivingEPC. This makes the tool easier to assimilate and implement from both a political and administrative perspective.

Table 6 presents a summary of the suggested steps to carry out a participatory action methodology that involves all parties in the process of weighting indicators of the SmartLivingEPC neighbourhood rating system. This participatory approach facilitates a comprehensive understanding of the local context, ensuring that the final evaluation reflects the true priorities and needs of the neighbourhood [8, 9, 10, 11]. Additionally, it empowers residents by involving them in the decision-making process, thereby increasing the acceptance and relevance of the resulting certificate.

Table 6: Generic proposal of steps to carry out a participatory action methodology with the community

STAGE	STEP	DESCRIPTION
Stage 1: Scope Definition	Step 1: Defining the Evaluation Area	Identify the physical, administrative, natural, or cultural boundaries of the neighbourhood. Consider aspects such as the homogeneity of the urban fabric, physical barriers, or the presence of distinctive elements. Document the boundaries on a map or sketch.
	Step 2: Stakeholder Identification	Develop a comprehensive list of stakeholders involved in the neighbourhood, including: residents, owners, tenants, shops, health centers, educational institutions, among others. Representatives of the city council, construction companies, and consultants. Specialized urban evaluators. Other relevant actors, such as neighbourhood associations, cultural entities, or business groups.
Stage 2: Awareness and Call to Action	Step 3: Awareness Campaign	Design a communication campaign to inform residents about the participatory urban evaluation project. Use diverse communication channels, such as posters, brochures, social networks, informative meetings, or gatherings in public spaces. Emphasize the importance of citizen participation and the impact of the SmartLivingEPC.
	Step 4: Call for Participatory Workshops	Define the dates, times, and places for participatory workshops. Consider accessibility for residents, including schedules compatible with different activities and adequate spaces for group meetings. Use established communication channels to disseminate the call.
Stage 3: Participatory Evaluation	Step 5: Urban Aspects Identification Workshop	Gather residents in a participatory workshop led by an expert facilitator. Present the SmartLivingEPC neighbourhood rating scheme and its objectives. Facilitate a brainstorming session to raise awareness among residents regarding the different urban aspects with which they interact daily and their related indicators. Record all ideas in a visible way for all. Group ideas into the taxonomy categories: Neighbourhood services, Renewable Energies, Neighbourhood´s Building Operatory.
	Step 6: Prioritization and Weighting Workshop	Divide participants into small groups. Ask each group to analyze the identified KPIs and prioritize the most relevant ones for evaluation. Use voting or consensus techniques to establish a relative weighting for each indicator Share the results of each group and discuss the different weightings assigned. Reach a

		consensus on the final weighting of the SmartLivingEPC neighbourhood indicators.
	Step 7: Qualitative and Quantitative Data Collection	Define data collection instruments for each prioritized indicator. The instruments will be a variety of sensors. Have the consent of residents for the installation and data collection with sensors.
Stage 4: Analysis and Conclusions	Step 8: Results Analysis	Analyze the qualitative and quantitative data collected in relation to the weighting established for each Indicator. Identify patterns, trends, and areas for improvement in each evaluated urban aspect. Synthesize the findings into a comprehensive report.
	Step 9: Recommendations Development	Based on the results of the participatory evaluation, formulate concrete recommendations to improve differents aspects of the neighborhood, such as energy efficieny, quality of life, urban mobility, etc. Consider the different perspectives and needs expressed by residents during the participatory process. Prioritize recommendations based on their viability, impact, and feasibility. Present the recommendations to the relevant stakeholders.

In contrast to generic indicator weighting, this participatory approach ensures that the weighting of each indicator reflects the priorities and perspectives of community members, stakeholders, and policymakers [13, 14]. Table 7 illustrates an example rating scale for stakeholders to assign weights to indicators based on their perceived relevance. Each KPI is classified according to the weighting defined collaboratively by the neighbours: 1) Very relevant: 0.5%; 2.) Relevant: 0.25%; 3) Interesting to consider: 0.12%; 4)Minimally relevant: 0.07%; and 5.) Completely irrelevant: 0.06%.

The "Weighting" column reflects the importance assigned to each rating category within the overall evaluation framework. The total weighting for all rating categories sums to 1, ensuring balanced consideration of all KPIs.

Table 7: Tentative rating scale to collaboratively assign weights to Operational KPIs

RATING SCALE FOR STAKEHOLDERS	VALUE CODE	WEIGHTING
Highly Relevant	1	0.5
Relevant	2	0.25
Interesting to consider	3	0.12
Minimally Relevant	4	0.07
Completely Irrelevant	5	0.06
		1

Table 8 showcases the indicators put forward by the SmartLivingEPC neighbourhood evaluation framework

Table 8: Example of Co-developed SmartLivingEPC neighbourhood rating system indicators applying participatory action methodologies with the community

DIMENSION	CATEGORY	INDICATOR	UNIT	PROJECT VALUE	AGREED SCALE VALUES	CO-DEVELOPED WEIGHTING
Environmental	Neighbourhood Services	Street Lighting and public area lighting	%	100	2	1,17%
		District Energy Systems Heating	%	13	2	1,17%
		District Energy Systems Cooling	%	0	2	1,17%
		Wastewater Treatment Consumption rate	%	35	5	16,67%
		RES ratio	%	12	3	2,40%
	Renewable Energies	Load Demand Factor	%	15	4	12,50%
Operative	Neighbourhood´s Building Operatory	EV Chargers Electricity Consumption rate	%	21	1	2,00%
		EV Energy Load	%	20	2	1,17%
		Buildings (Aggregated energy KPIs)	%	70	5	16,67%
		Aggregated Heating KPIs	%	15	4	12,50%
		Aggregated Cooling KPIs	%	0	1	2,00%
		Aggregated DHW KPIs	%	20	1	2,00%
		Aggregated Lighting KPIs	%	5	3	2,40%
		Aggregated Appliances KPIs	%	30	5	16,67%
		Aggregated GHG KPIs	%	9	2	1,17%
		SmartLivingEPC Operational Rating	%	65	3	2,40%
		SmartLivingEPC IEQ	%	90	2	1,17%
		SmartLivingEPC LCC	%	35	3	2,40%
		SmartLivingEPC Non-Energy	%	84	3	2,40%
						100,00%

In Table 8, the "Project Value" column displays the actual performance metrics for each indicator within the evaluated neighbourhood. The "Agreed Scale Values" column provides numerical values assigned to each indicator, which were determined through the participatory process outlined in Table 4. Lastly, the "Co-developed Weighting" column indicates the significance attributed to each indicator in the comprehensive evaluation scheme. Calculating the Rating involves multiplying each KPI value by the weight assigned by the community and then summing these products. This process yields a final rating score of 34.60.

3.3 Weighting of Operational Key Performance Indicators for Individual Users

The SmartLivingEPC neighbourhood rating scheme's built-in flexibility allows users to adapt the weighting of indicators based on their individual priorities. Two illustrative examples of this feature's utility in the SmartLivingEPC system include tenants looking for rental properties and real estate investors. Tenants might seek rentals in neighbourhoods with specific attributes, such as proximity to certain buildings (schools, health centers, workplaces, etc.), walkability, public transportation connections, or green spaces. Similarly, real estate investors looking to purchase properties can use the system to find areas with specific characteristics by adjusting the indicator weightings to fit their search requirements.

Users can access an online platform where they can assign weights to the indicators according to their criteria. This platform will have a user-friendly interface, allowing users to modify the importance of each indicator based on their preferences and priorities. The platform will offer various options for adjusting the indicator weightings and provide guidance and support during the configuration process, ensuring users make informed decisions and obtain optimal results from their evaluations. Overall, this feature increases the flexibility and usability of the SmartLivingEPC platform, enabling users to tailor the evaluation process to meet their specific needs and goals.

3.4 Weighting of Operational Key Performance Indicators Based on European Users' Preferences

The establishment of a rating system that mirrors the preferences of European inhabitants was deemed a valuable component within the SmartLivingEPC labeling framework. This rating mechanism seeks to incorporate the varied perspectives and priorities of nations across Europe, establishing a comprehensive assessment framework oriented toward user preferences. To realize this objective, an extensive survey was undertaken, aiming for broad participation from European countries to ensure that viewpoints from diverse regions were fairly considered and integrated into the process. The list of selected countries was made up of the 27 member countries of the European Union, and, due to their close commercial, political and cultural ties, was extended to Norway, Switzerland and the United Kingdom. The percentage of participation of each country was defined as the number of inhabitants of the country over the number of inhabitants of the total number of selected countries (Table 9). It should be noted that it is conceivable this approach could also be applied at the national or regional level.

Table 9: Survey countries participation quota

COUNTRY	POOL SIZE	PERCENTAGE
United Kingdom	36,597	8%
Ireland	1,118	1%
Germany	3,643	8%
France	1,441	8%
Spain	1,23	7.0%
Austria	297	1%
Belgium	428	2%
Bulgaria	133	2%
Croatia	145	2%
Cyprus	32	0%
Czech Republic	276	2%
Denmark	224	1%
Estonia	297	2%
Finland	193	4%
Greece	1,058	3%
Hungary	705	2%
Italy	2,783	7.0%
Latvia	234	3%
Lithuania	122	3%

Luxembourg	<25	0%
Malta	<25	0%
Netherlands	1,596	3%
Norway	221	4%
Poland	3,426	7.0%
Portugal	3,619	3%
Romania	252	4%
Slovakia	106	4%
Slovenia	273	3%
Sweden	641	5%
Switzerland	29	1%

Following that, the outcomes derived from the semantic slider implemented within the survey underwent segregation into 5 quintiles to facilitate analysis. In this instance, the determination of indicator weighting was conducted by referencing the median values obtained for each individual indicator.

Table 10: Proposed rating scale of KPI weights

RATING SCALE FOR EUROPEAN USERS	VALUE CODE	WEIGHTING
Extremely relevant	5th quintile	0.5
Very relevant	4th quintile	0.25
Moderately relevant	3rd quintile	0.12
Slightly relevant	2nd quintile	0.07
Not relevant at all	1rt quintile	0.06
		1

Following this step, a weighting process was executed, assigning higher scores to indicators with the highest medians and gradually diminishing their weight for those with lower medians: the initial 4 KPIs deemed highly relevant, the next 4 KPIs considered relevant, followed by the subsequent 4 regarded as interesting to consider, the succeeding 4 rated as minimally relevant, and the last 3 labeled as completely irrelevant (Table 10). This phase facilitates the attribution of relative importance to each indicator based on its perceived relevance in the survey responses. By employing this weighted approach, it ensures that indicators perceived as most crucial by respondents receive greater emphasis in the overall evaluation process.

Table 11: Example of the application of operational indicators from the SmartLivingEPC neighbourhood rating system weighted according to the preferences of European Users

DIMENSION	CATEGORY	INDICATOR	UNIT	PROJECT VALUE	MEANS SURVEY RESULTS	EUROPE SCALE VALUES	EUROPE WEIGHTING
Environmental	Neighbourhood Services	Street Lighting and public area lighting	%	100	62,88	2	1,75%
		District Energy Systems Heating	%	13	66,92	3	3,00%
		District Energy Systems Cooling	%	0	62,74	2	1,75%
		Wastewater Treatment Consumption rate	%	35	63,49	3	3,00%

		RES ratio	%	12	67,52	3	3,00%
	Renewable Energies	Load Demand Factor	%	15	63,22	2	1,75%
Operative	Neighbourhood ´s Building Operatory	EV Chargers Electricity Consumption rate	%	21	58,92	1	2,00%
		EV Energy Load	%	20	57,47	1	2,00%
		Buildings (Aggregated energy KPIs)	%	70	76,36	5	12,50 %
		Aggregated Heating KPIs	%	15	75,04	5	12,50 %
		Aggregated Cooling KPIs	%	0	69,36	4	6,25%
		Aggregated DHW KPIs	%	20	70,4	4	6,25%
		Aggregated Lighting KPIs	%	5	69,77	4	6,25%
		Aggregated Appliances KPIs	%	30	71,35	5	12,50 %
		Aggregated GHG KPIs	%	9	68,25	4	6,25%
		SmartLivingEPC Operational Rating	%	65	73,46	5	12,50 %
		SmartLivingEPC IEQ	%	90	63,25	2	1,75%
		SmartLivingEPC LCC	%	35	65,92	3	3,00%
		SmartLivingEPC Non-Energy	%	84	53,17	1	2,00%

Ultimately, a calculation was executed to divide the allocated weight value by the total number of indicators for each level. This procedure yielded a percentage-based European user weighting value for each indicator (Table 11) In this instance, the multiplication of the vectors PROJECT VALUE and DEFAULT WEIGHTING yielded a rating of 36,56.

4 Conclusions

This deliverable presents a refined set of indicators for the evaluation of operational performance at the neighbourhood level, forming the basis for a comprehensive, accurate, and practical energy rating scheme. The methodology employs a meticulous selection process that incorporates expert judgment, stakeholder input, and alignment with global frameworks. The selected indicators cover a wide range of energy performance aspects, such as street lighting, district energy heating and cooling systems, wastewater treatment consumption, and renewable energy, among others, integrating a complete taxonomy to evaluate neighbourhood performance. Identification of the data source, verification of data integrity, and normalization of units were key considerations during the development of the indicator set.

Additionally, four weighting alternatives were proposed for the developed indicators, using precise mathematical procedures and addressing the diverse needs of stakeholders in neighbourhood assessment. These weightings are translated into a unique score, expressed numerically (1-100%) for each case within the SmartLivingECP framework. The initial rating option is a generic rating, where uniform weights are assigned to all indicators. The second option is a Neighbourhood Rating, which advocates for participatory methodologies to empower community members to actively define indicator weights. The third option is a seteable plataform aviable for individual users, and the fourth option is a European Rating, which reflects the preferences of European residents determined through an extensive opinion survey. The four methodologies developed and proposed in this document offer significant flexibility for the implementation of SmartLivingEPC at the neighborhood level. This flexibility ensures that the certification system can accommodate the diverse needs of a wide range of potential users, including individual residents, communities dedicated to sustainable living practices, municipal authorities engaged in urban development and sustainability planning, and other governmental agencies tasked with environmental policy enforcement. By addressing the specific needs of these varied user groups, the SmartLivingEPC certification system ensures a versatile and comprehensive approach to energy performance and sustainability, encouraging broader implementation and maximizing its positive impact on the environment.

Illustrative examples include scenarios in which a community seeks an assessment of its neighbourhood based on its own criteria, respecting its distinctive cultural environment and making the analysis non-comparable to other places. Similarly, an individual embarks on a neighbourhood search guided by the personal interests of residents or investors. Additionally, a municipality strives to understand specific or general aspects of two or more neighbourhoods, evaluating them using evenly weighted indicators to ensure comparability of results.

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