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SUPERSHINE

D3.4: LCA and SLCA – Part 1

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Technical references

Project Acronym	SUPERSHINE
Project Title	S=Smart U=Upgraded asset-values and quality of life P=Public Private Partnership E=Extended Energy Efficiency R=Renewables triggered by the project SH=Social Housing I=Investment N=Net Zero E=European
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Lead beneficiary	CIRCE
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1.0	01/06/2024	CIRCE, CARTIF, DEMIR	First Draft
1.1	20/07/2024	CIRCE, CARTIF, DEMIR	Final Draft
1.2	30/07/2024	UoY	Review
2.0	30/08/2024	APRE	Final Review

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SUPERSHINE

Acronyms

1. **CO2:** Carbon Dioxide
2. **DH:** District Heating
3. **EE:** Energy Efficiency
4. **ESCO:** Energy Service Company
5. **GHG:** GreenHouse Gas
6. **kWh:** Kilowatt-hour
7. **LCC**: Life Cycle Costing
8. **S-LCA**: Social Life Cycle Analysis
9. **S-LCIA:** Social Life Cycle Impact Analysis
10. **LCA:** Life Cycle Assessment
11. **GWP:** Global Warming Potential
12. **ODP:** Ozone Depletion Potential
13. **AP:** Acidification Potential
14. **POCP:** Photochemical Ozone Creation Potential
15. **EP:** Eutrophication Potential
16. **CO2 eq.:** Carbon Dioxide Equivalent
17. **CFC-11 eq.:** Chlorofluorocarbon-11 Equivalent
18. **SO2 eq.:** Sulfur Dioxide Equivalent
19. **C2H4 eq.:** Ethylene Equivalent
20. **PO4 eq.:** Phosphate Equivalent
21. **kg:** Kilogram
22. **m^3:** Cubic Meter
23. **kWh:** Kilowatt Hour
24. **PVC:** Polyvinyl Chloride
25. **DHW:** Domestic Hot Water
26. **DH:** District Heating
27. **ICT:** Information and Communication Technology
28. **EPC:** Energy Performance Certificate
29. **U-value:** Thermal Transmittance (measure of heat loss)
30. **ERP:** Enterprise Resource Planning (context-specific usage may vary)
31. **RES:** Renewable Energy Sources
32. **PV:** Photovoltaic
33. **SME:** Small and Medium-sized Enterprises
34. **ESCO:** Energy Service Company
35. **REEF:** Riga Energy Efficiency Fund
36. **REB:** Riga Energy Agency

Executive summary

The SUPERSHINE project is a comprehensive initiative designed to address the urgent need for energy efficiency renovations across Europe. Focused on Italy, Latvia, and Denmark, this project employs financial and statistical analyses within the framework of Public-Private Partnerships (PPPs) and crowdfunding to facilitate energy efficiency projects and foster sustainable development. This document covers the following:

Environmental and Social impact analysis:

This section focuses on the environmental impact assessment of district retrofit interventions in Italy, Latvia, and Denmark. These interventions aim to improve energy performance, reduce carbon emissions, and promote sustainable practices. The methodology involves evaluating the energy savings potential, assessing related costs, and emphasising waste management strategies, such as utilising local agricultural waste and promoting recycling. Despite substantial upfront costs, the long-term benefits, coupled with potential carbon credits and voluntary carbon market support, make these interventions economically viable and environmentally sustainable. Through rigorous environmental assessment and mitigation strategies, SUPERSHINE seeks to drive positive environmental outcomes and contribute to the transition towards a more sustainable future.

The document outlines the methodology employed, starting with the energy savings modelling process. This involves data collection, baseline assessment, intervention simulation, and result analysis to predict energy consumption reductions and CO_2 emissions reductions post-renovation.

Energy efficiency and renewable measures can yield numerous substantial social ramifications beyond their immediate effects on energy efficiency and cost. Frequently, these implications are disregarded due to the challenge of quantifying their value. The section related with social impact emphasises this aspect of the measures.

1. Introduction

1.1 Purpose of the document

This deliverable outlines the methodology and framework developed by the SUPERSHINE project to analyse environmental and social environmental impacts in buildings and districts. It covers the technical, environmental, and social aspects of these projects, focusing on pilot implementations in Italy, Latvia, and Denmark. This deliverable highlights the approach to carry out the analysis, based on the methodology and indicators described in deliverables 1.2 and 3.3

Technical Analysis of the Lighthouses: This section delves into the technical analysis conducted on the lighthouse projects in Italy, Latvia, and Denmark. Each country has unique focus areas for their retrofit interventions. In Latvia, the emphasis is on historic buildings, considering climate impacts, heritage conservation, and occupant comfort. Italy focuses on public residential buildings, using materials derived from local agricultural waste, thereby promoting recycling and waste management. Denmark targets public housing with green renovations, aligning with its climate-neutral goals for 2050. The technical analysis evaluates the potential for energy savings, the effectiveness of various energy efficiency measures, and the application of sustainable technologies.

Environmental Analysis: The environmental impact assessment focuses on the benefits of retrofit interventions in the pilot countries. It discusses the reduction in energy consumption and carbon emissions, the use of sustainable materials, and the potential for carbon credits. Waste management, particularly in Italy, where local agricultural waste is used in construction, is also highlighted. Despite the substantial upfront costs, long-term benefits and potential funding from carbon credits make these interventions viable and sustainable.

The social impact analysis: examines the broader benefits of energy efficiency renovations. Improvements in accessibility, health, and comfort, job creation, and support for low-income citizens are discussed. Measures include enhanced indoor air quality, temperature control, and initiatives to support individuals with special needs. The analysis emphasises how these measures enhance the quality of life, stimulate economic activity, and promote social inclusion.

2. Lighthouses technical KPIs calculation

The **Technical KPIs** already defined in Deliverable 3.3 will be calculated in this section. The technical KPIs defined in D3.3 have been reorganised and renamed (this information is included in the subsection called "Explanation of Specific KPIs"). The main KPI information (title, calculation formula, units, influencing data, and results obtained) could be found in D3.3., because this section only includes the KPI calculations.

The D3.4 calculation table is organised into three groups, just like the KPIs defined in D3.3.

- **Energy management KPIs:** This section includes all KPIs related to thermal and electrical energy consumption across the area and their conversion to primary energy.
- **Energy efficiency:** This section includes calculations of all improvements made, such as the enhancement in heat flow, reduction in demand, and decrease in CO2 equivalent levels.
- **Renewable energy production:** This paragraph measures the impact of renewable energy sources, both in terms of primary energy and for each source used.

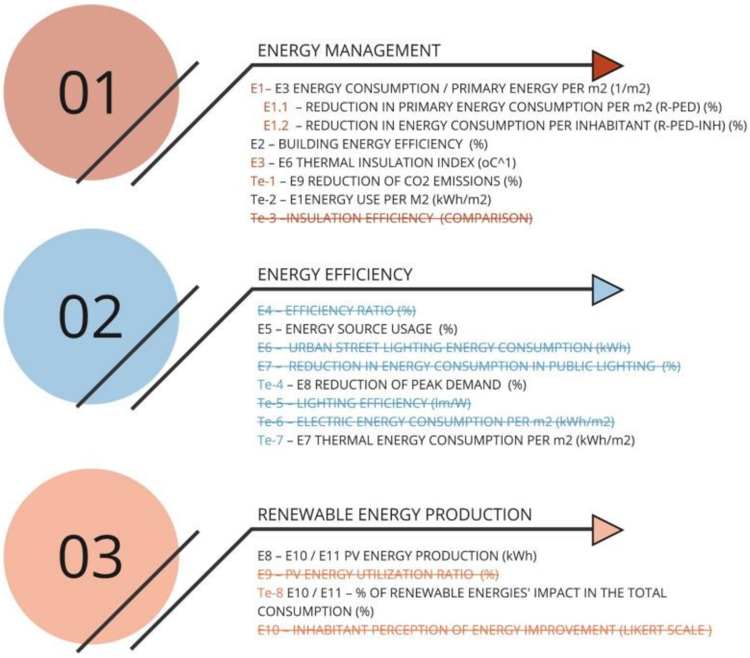

Figure 1: Reorganisation of Technical KPIs

2.1 Explanation of specific KPIs

Comparative Topic tables have been created to explain the reorganisation and renaming of the technical KPIs. The following tables present a comparison of the KPI names in D3.3, their updated names in D3.4, and the reasons for the modifications.

Table 1: Explanation of Comparative Topic Tables

Deliverables	**Technical KPI Topic**

SUPERSHINE

D3.3	D3.4	Modification reason	
KPI old	KPI new	KPI is kept	KPI is kept out

Table 2: Modifications to Energy Management KPIs

Re-class		ENERGY MANAGEMENT
D3.3 01/2024	D3.4 08/2024	Modification reason
E1	E3	Reorganisation for easier reading
E1.1	E.4	The sub-KPI has been transformed into a KPI because its results are valid for the project.
E1.2	E.5	
E.2	~~E.2~~	Repetitive information
E.3	E.6	These KPIs are given the same value but are applied to different construction elements. (*FaÇades, Roof and Windows*)
	E.6-1	
	E.6-2	
Te-1	E.9	The KPI has been moved to the Energy Efficiency group.
Te-2	E.1	The sub-KPI has been transformed into a KPI because its results are valid for the project.
Te-3	~~Te-3~~	Repetitive information

Table 3: Modifications to Energy Efficiency KPIs

Re-class		ENERGY EFFICIENCY
D3.3 01/2024	D3.4 08/2024	Modification reason
E.4	~~E.2~~	Repetitive information
E.5	E.2	Reorganisation for easier reading
E.6	~~E.6~~	Repetitive information
E.7	~~E.7~~	Repetitive information
Te-4	E.8	The KPI has been moved to the Energy Management group
Te-5	~~Te-5~~	Data not provided by the municipalty
Te-6	~~Te-6~~	Repetitive information

Te-7	E.7	Reorganisation for easier reading

Table 4: Modifications to Renewable energy production KPIs.

Re-class		RENEWABLE ENERGY PRODUCTION
D3.3 01/2024	D3.4 08/2024	Modification reason
E.8	E.10 E.11	Reorganisation for easier reading
E.9	~~E.2~~	Repetitive information
Te-8	E.10 E.11	Reorganisation for easier reading
Te-9	~~Te-9~~	Repetitive information

There are two technical KPIs that require specific consideration. Technical **KPI E.12 evaluates residents' comfort** after the interventions. The E.12 values will be calculated based on a score obtained from the survey. Because the interventions have not been implemented yet, this KPI was excluded from this deliverable and will be considered in the future if the social aspect does not supply the necessary information.

Additionally, **KPI E.8** will be calculated to measure the **reduction in peak demand**. This KPI isn't included in the current deliverable because the simulation results don´t provide relevant information for this metric.

2.2 Technical Data

The Initial data are provided by the lighthouse municipality through a survey. The survey was developed with contributions from all Super-Shine partners, taking into account the knowledge gained in Super-i and follow main topics to be evaluated: *Technical, Financial and Socio-economic aspects, Environmental impact, Social factors, and Job Creation.*

The initial technical data provided by the municipality can be summarised as thermal and electrical consumption, thermal values of the different constructive elements (*before and after the renovation*), the percentage of renewable energy use, technical description of the interventions and the district heating installation.

The lighthouse municipality provided information for the final values (taking into account the values after the interventions). All of these values are simulations; for that reason, once the interventions are completed, we will have three values to compare: baseline, expected values, and actual values.

The baseline data provided for all cities take into account energy consumption (thermal and electricity, or DH and DHW). Therefore, only these values are considered for calculating all the KPIs and the following tables include only this information for each SuperShine demonstrators.

2.2.1 HERNING, Denmark: Technical Data

nº	Area	Energy	Baseline	After
16	6.470,00 m2	Thermal Consumption	121,95 kWh/m2*year	37,00 kWh/m2*year
		Electricity Consumption	102,94 kWh/m2*year	27,70 kWh/m2*year
19	16.443,00 m2	Thermal Consumption	175,27 kWh/m2*year	40,60 kWh/m2*year
		Electricity Consumption	48,77 kWh/m2*year	38,90 kWh/m2*year
21	9.596,00 m2	Thermal Consumption	162,67 kWh/m2*year	35,40 kWh/m2*year
		Electricity Consumption	36,89 kWh/m2*year	34,50 kWh/m2*year
24	22.592,00 m2	Thermal Consumption	175,95 kWh/m2*year	68,00 kWh/m2*year
		Electricity Consumption	65,51 kWh/m2*year	64,90 kWh/m2*year
			889,95 kWh/m2*year	**347,00 kWh/m2*year**

2.2.2 RIGA, Latvia: Technical Data

nº	Area	Energy	Baseline	After
20	2.164,20 m2	DH	169,96 kWh/m2*year	127,76 kWh/m2*year
		DHW	42,98 kWh/m2*year	
18	1.530,60 m2	DH	170,18 kWh/m2*year	120,26 kWh/m2*year
		DHW	30,26 kWh/m2*year	
16	1.572,40 m2	DH	164,48 kWh/m2*year	122,35 kWh/m2*year
		DHW	39,43 kWh/m2*year	
14	1.572,00 m2	DH	184,52 kWh/m2*year	136,59 kWh/m2*year
		DHW	43,13 kWh/m2*year	
8A	948,20 m2	DH	221,40 kWh/m2*year	162,66 kWh/m2*year

		DHW	49,70 kWh/m2*year	
8B	946,90 m2	DH	221,40 kWh/m2*year	162,66 kWh/m2*year
		DHW	49,70 kWh/m2*year	
10	1.902,30 m2	DH	227,78 kWh/m2*year	158,85 kWh/m2*year
		DHW	36,97 kWh/m2*year	
14	943,10 m2	DH	215,16 kWh/m2*year	143,20 kWh/m2*year
		DHW	23,50 kWh/m2*year	
18	2.147,10 m2	DH	184,16 kWh/m2*year	126,74 kWh/m2*year
		DHW	27,07 kWh/m2*year	
20	2.145,80 m2	DH	208,56 kWh/m2*year	142,63 kWh/m2*year
		DHW	29,15 kWh/m2*year	
16C	1.520,40 m2	DH	173,05 kWh/m2*year	119,35 kWh/m2*year
		DHW	25,87 kWh/m2*year	
16B	1.736,40 m2	DH	165,24 kWh/m2*year	118,94 kWh/m2*year
		DHW	32,99 kWh/m2*year	
16A	1.731,70 m2	DH	166,26 kWh/m2*year	117,68 kWh/m2*year
		DHW	29,87 kWh/m2*year	
16	1.547,00 m2	DH	185,61 kWh/m2*year	127,11 kWh/m2*year
		DHW	26,24 kWh/m2*year	
12	2.747,20 m2	DH	186,50 kWh/m2*year	128,45 kWh/m2*year
		DHW	27,59 kWh/m2*year	
19	1.517,90 m2	DH	206,48 kWh/m2*year	141,37 kWh/m2*year
		DHW	29,14 MWh/annual	
21	1.526,39 m2	DH	172,61 kWh/m2*year	120,28 kWh/m2*year

		DHW	27,86 MWh/annual	
23	1.840,60 m2	DH	174,71 MWh/annual	120,44 kWh/m2*year
		DHW	26,02 MWh/annual	
25	1.790,60 m2	DH	169,21 MWh/annual	115,48 kWh/m2*year
		DHW	23,26 MWh/annual	
22C	1.616,10 m2	DH	179,85 kWh/m2*year	123,47 kWh/m2*year
		DHW	25,94 kWh/m2*year	
22B	1.554,20 m2	DH	180,43 kWh/m2*year	125,38 kWh/m2*year
		DHW	28,54 kWh/m2*year	
22	1.550,20 m2	DH	182,51 kWh/m2*year	128,27 kWh/m2*year
		DHW	31,27 kWh/m2*year	
24	1.675,30 m2	DH	34,53 kWh/m2*year	23,45 kWh/m2*year
		DHW	4,56 kWh/m2*year	
22A	2.826,50 m2	DH	169,80 kWh/m2*year	126,98 kWh/m2*year
		DHW	41,84 kWh/m2*year	
			39.627,27 kWh/m2*year	**23.776,36 kWh/m2*year**

2.2.3 TRIESTE, Italy: Technical Data

The buildings in Trieste, Boito, will be demolished. For that reason, future actions will aim for low consumption, but the baseline value is very ambitious, assuming an efficiency of 100%. As the project continues, these values will change and reflect the "true" value.

nº	Area	Energy	Baseline	After
1		DH	131,00 kWh/m2*year	4,37 kWh/m2*year
2			131,00 kWh/m2*year	
3			131,00 kWh/m2*year	

4	7.202,00 m2		131,00 kWh/m2*year	
5			131,00 kWh/m2*year	
6			131,00 kWh/m2*year	
7			131,00 kWh/m2*year	
8			131,00 kWh/m2*year	
			1.048,00 kWh/m2*year	**4,37 kWh/m2*year**

2.3 Technical calculations

2.3.1 Interventions efficiency

Riga and Herning will focus on improving the efficiency of their areas to optimise the district heating systems. Consequently, the initial energy consumption calculations are based on district heating consumption estimates and their impact on the intervention area. The estimated **energy improvement is 40% in Riga and 60-61% in Herning**, which are typical results for similar rehabilitation interventions in previous projects.

In **Trieste**, demolition interventions have led to a **100% improvement in efficiency**. Rehabilitation works were presented in June, but no report on the new simulation values after this intervention. For this reason, both the initial and simulated values are calculated based on the energy source currently used by the existing buildings, which is gas.

TECHNICAL KPIs			
Indicator	TRIESTE	RIGA	HERNING
Reduction in energy consumption	100%	40%	61%

2.3.2 Technical calculations for each demonstrator

In this section, all the KPIs per city are included. The calculation table shows the indicator code (name and reference number), calculation formula, unit, and disaggregation formula. At the end, you will find the values for each city.

HERNING, Denmark

TECHNICAL KPIs							
Category		Indicator	Formula	UNIT	Disaggregation	Herning DENMARK	
ENERGY MANAGEMENT	E.1	Energy use per m2	Total energy consumption / Area	kWh/m2	Total energy conumption	49.037.149,15 kWh/year	889,95 kWh/m2*year
					Area	55.101,00 m2	
	E.2	Primary energy consumption	(Total energy consumption * % of energy resources * Primary factorArea)/Area	kWh/m2	Total energy	49.037.149,15 kWh/year	1.002,97 kWh/year
					Biomasa	47% 1,200	
					Eólica	29% 1,000	
					Solar	3% 1,000	
					Biogas	14% 1,100	
					Gas	6% 1,300	
					Area	55.101,00 m2	
	E.3	Energy Consumption	gy consumption/ Primary Energy)	%	Energy Consumption	49.037.149,15 kWh/year	89%
					Primary Energy Consumption	1.002,97 kWh/year	
					Area	55.101,00 m2	
	E.4	Reduction in primary energy consumption per m2	(Energy consumption "baseline"-Energy consumption "current"/Energy consumption "baseline")*100	%	Energy Consumption "Baseline"	889,95 kWh/m2*year	61%
					Energy Consumption "Current"	347,00 kWh/m2*year	
	E.5	Reduction in energy consumption per inhabitant	(Energy consumption "baseline"-Energy consumption "current"/Energy consumption "baseline")*100	%	Energy Consumption per density "Baseline"	889,95 kWh/m2*year	61%
					Energy Consumptionper density "Current"	347,00 kWh/m2*year	
					Density	0,0385 inhabitant/m2	
ENERGY EFFICIENCY	E.6	Improvement in Heat Flow FaÇades	(Thermal Value * Area * AT) Baseline -(Thermal Value * Area * AT) Current	%	Thermal Value (Baseline)	1,25 W/km2	39%
					Thermal Value (Current)	0,76 kWh/year	
	E.6.1	Improvement in Heat Flow Roof	(Thermal Value * Area * AT) Baseline -(Thermal Value * Area * AT) Current	%	Thermal Value (Baseline)	0,20 kWh/year	0%
					Thermal Value (Current)	0,20 kWh/year	
	E.6.2	Improvement in Heat Flow Windows	(Thermal Value * Area * AT) Baseline -(Thermal Value * Area * AT) Current	%	Thermal Value (Baseline)	1,30 kWh/year	40%
					Thermal Value (Current)	0,78 kWh/year	
	E.7	Reduction in energy consumption in public lighting	Municipality Data	%			100%
	E.8	Reduction of peak demand	The KPI couldn't be calculated because the municipality didn't provide this value.	%	Peak Demand before Intervention (Baseline)		
					Peak Demand before Intervention (Current)		
	E.9	Reduction of co2 emissions	(CO2 Emissions (Baseline)-CO2 Emissions (Current))/(CO2 Emissions (Baseline))*100	%	IPCC (Combustion Oil)	0,20 [MWh]	61%
					Co2 Emission (Baseline)	**0,109 tCO2 eq**	
					Energy Consumption "Baseline"	0,53 MWh/anual	
					Co2 Emission (Current)	**0,042 tCO2 eq**	
					Energy Consumption "Current"	0,21 MWh/anual	
RENEWABLE ENERGY PRODUCTION	E.10	% Renewable energies' impact in the total	Total energy consumption * % RES	kWh/m2	Total energy conumption	49037149,154,11 MWh/anual	46.094,92 MWh/anual
					RES	00,940,00 MWh/anual	
	E.11	Energy consumption: Differents RES sources	Total energy consumption * % RES Rsources	kWh/m2	Total energy	49.037.149,15 kWh/year	
					Biomasa	47%	23096,50 MWh/anual
					Eólica	29%	14433,27 MWh/anual
					Solar	3%	1634,57 MWh/anual
					Biogas	14%	6767,13 MWh/anual

RIGA, Latvia

TECHNICAL KPIs							
Category	Indicator		Formula	UNIT	Disaggregation	Riga, LATVIA	
ENERGY MANAGEMENT	E.1	Energy use per m2	Total energy consumption / Area	kWh/m2	Total energy conumption	1.626.821.881,76 kWh/year	39.627,27 kWh/m2*year
					Area	41.053,09 m2	
	E.2	Primary energy consumption	(Total energy consumption * % of energy resources * Primary factorArea)/Area	kWh/m2	Total energy	1.626.821.881,76 kWh/year	26.258,61 kWh/year
					Biomasa	25% 0,304	
					Eólica		
					Solar		
					Biogas	41% 0,304	
					Gas	44% 1,050	
					Area	41.053,09 m2	
	E.3	Energy Consumption	gy consumption/ Primary Energy)	%	Energy Consumption	1.626.821.881,76 kWh/year	151%
					Primary Energy Consumption	26.258,61 kWh/year	
					Area	41.053,09 m2	
	E.4	Reduction in primary energy consumption per m2	(Energy consumption "baseline"-Energy consumption "current"/Energy consumption "baseline")*100	%	Energy Consumption "Baseline"	39.627,27 kWh/m2*year	40%
					Energy Consumption "Current"	23.776,36 kWh/m2*year	
	E.5	Reduction in energy consumption per inhabitant	(Energy consumption "baseline"-Energy consumption "current"/Energy consumption "baseline")*100	%	Energy Consumption per density "Baseline"	39.627,27 kWh/m2*year	40%
					Energy Consumptionper density "Current"	23.776,36 kWh/m2*year	
					Density	0,0284 inhabitant/m2	
ENERGY EFFICIENCY	E.6	Improvement in Heat Flow FaÇades	(Thermal Value * Area * AT) Baseline -(Thermal Value * Area * AT) Current	%	Thermal Value (Baseline)	1,44 W/km2	97%
					Thermal Value (Current)	0,04 kWh/year	
	E.6.1	Improvement in Heat Flow Roof	(Thermal Value * Area * AT) Baseline -(Thermal Value * Area * AT) Current	%	Thermal Value (Baseline)	0,86 kWh/year	86%
					Thermal Value (Current)	0,12 kWh/year	
	E.6.2	Improvement in Heat Flow Windows	(Thermal Value * Area * AT) Baseline -(Thermal Value * Area * AT) Current	%	Thermal Value (Baseline)	2,40 W/km2	58%
					Thermal Value (Current)	1,00 W/km2	
	E.7	Reduction in energy consumption in public lighting	Municipality Data	%			90%
	E.8	Reduction of peak demand	The KPI couldn't be calculated because the municipality didn't provide this value.	%	Peak Demand before Intervention (Baseline)		
					Peak Demand before Intervention (Current)		
	E.9	Reduction of co2 emissions	(CO2 Emissions (Baseline)-CO2 Emissions (Current))/(CO2 Emissions (Baseline))*100	%	IPCC (Combustion Oil)	157,55 g.CO2/kWh	40%
					Co2 Emission (Baseline)	**3,68 tCO2 eq**	
					Energy Consumption "Baseline"	23.380,09 kWh/m2*year	
					Co2 Emission (Current)	**2,210120 tCO2 eq**	
					Energy Consumption "Current"	14.028,05 kWh/m2*year	
RENEWABLE ENERGY PRODUCTION	E.10	% Renewable energies' impact in the total	Total energy consumption * % RES	kWh/m2	Total energy conumption	1.626.821.881,76 kWh/year	894.752,03 MWh/anual
					RES	55%	
	E.11	Energy consumption: Differents RES sources	Total energy consumption * % RES Rsources	kWh/m2	Total energy	1626821881,76 MWh/anual	
					Biomasa	15%	244023,28 MWh/anual
					Eólica	0%	
					Solar	0%	
					Biogas	41%	666996,97 MWh/anual

TRIESTE, Italy

TECHNICAL KPIs							
Category	Indicator		Formula	UNIT	Disaggregation	Trieste, ITALY	
ENERGY MANAGEMENT	E.1	Energy use per m2	Total energy consumption / Area	kWh/m2	Total energy conumption	7.547.696,00 kWh/year	1.048,00 kWh/m2*year
					Area	7.202,00 m2	
	E.2	Primary energy consumption	(Total energy consumption * % of energy resources * Primary factorArea)/Area	kWh/m2	Total energy	7.547.696,00 kWh/year	1.152,80 kWh/year
					Biomasa		
					Eólica		
					Solar		
					Biogas		
					Gas	100% 1,100	
					Area	7.202,00 m2	
	E.3	Energy Consumption	gy consumption/ Primary Energy)	%	Energy Consumption	7.547.696,00 kWh/year	91%
					Primary Energy Consumption	1.152,80 kWh/year	
					Area	7.202,00 m2	
	E.4	Reduction in primary energy consumption per m2	(Energy consumption "baseline"-Energy consumption "current"/Energy consumption "baseline")*100	%	Energy Consumption "Baseline"	1.048,00 kWh/m2*year	100%
					Energy Consumption "Current"	4,37 kWh/m2*year	
	E.5	Reduction in energy consumption per inhabitant	(Energy consumption "baseline"-Energy consumption "current"/Energy consumption "baseline")*100	%	Energy Consumption per density "Baseline"	1.048,00 kWh/m2*year	100%
					Energy Consumptionper density "Current"	4,37 kWh/m2*year	
					Density	,23 m2/inhabitants	
ENERGY EFFICIENCY	E.6	Improvement in Heat Flow FaÇades	(Thermal Value * Area * AT) Baseline -(Thermal Value * Area * AT) Current	%	Thermal Value (Baseline)	1,50 W/km2	73%
					Thermal Value (Current)	0,41 kWh/year	
	E.6.1	Improvement in Heat Flow Roof	(Thermal Value * Area * AT) Baseline -(Thermal Value * Area * AT) Current	%	Thermal Value (Baseline)	2,00 W/km2	71%
					Thermal Value (Current)	0,58 kWh/year	
	E.6.2	Improvement in Heat Flow Windows	(Thermal Value * Area * AT) Baseline -(Thermal Value * Area * AT) Current	%	Thermal Value (Baseline)	2,40 W/km2	58%
					Thermal Value (Current)	1,00 W/km2	
	E.7	Reduction in energy consumption in public lighting	Municipality Data	%			95%
	E.8	Reduction of peak demand	The KPI couldn't be calculated because the municipality didn't provide this value.	%	Peak Demand before Intervention (Baseline)		
					Peak Demand before Intervention (Current)		
	E.9	Reduction of co2 emissions	(CO2 Emissions (Baseline)-CO2 Emissions (Current))/(CO2 Emissions (Baseline))*100	%	IPCC (Combustion Oil)	0,27 [MWh]	100%
					Co2 Emission (Baseline)	**0,28 tCO2 eq**	
					Energy Consumption "Baseline"	1,05 MWh/anual	
					Co2 Emission (Current)	**0,001172 tCO2 eq**	
					Energy Consumption "Current"	0,0044 MWh/anual	
RENEWABLE ENERGY PRODUCTION	E.10	% Renewable energies' impact in the total	Total energy consumption * % RES	kWh/m2	Total energy conumption	7.547.696,00 kWh/year	0,00 kWh/year
					RES	0%	
	E.11	Energy consumption: Differents RES sources	Total energy consumption * % RES Rsources	kWh/m2	Total energy	7.547.696,00 kWh/year	
					Biomasa	0%	
					Eólica	0%	
					Solar	0%	
					Biogas	0%	

2.3.3 KPI Values

TECHNICAL KPIs : Energy Management				
Indicator		TRIESTE	RIGA	HERNING
E1	Energy use per m2	1.048,00 kWh/m2*year	39.627,27 kWh/m2*year	889,95 kWh/m2*year
E2	Primary energy consumption	1.152,80 kWh/year	26.258,61 kWh/year	1.002,97 kWh/year
E3	Energy Consumption	91%	100%	89%
E4	Reduction in primary energy consumption /m2	100%	40%	61%
E5	Reduction in energy consumption/inhabitant	100%	40%	61%

TECHNICAL KPIs : Energy Efficiency				
Indicator		TRIESTE	RIGA	HERNING
E6	Improvement in Heat Flow FaÇades	73%	97%	39%
E6.1	Improvement in Heat Flow Roof	71%	86%	0%
E6.2	Improvement in Heat Flow Windows	58%	58%	40
E7	Reduction in energy consumption in public lighting	95%	90%	100%
E8	Reduction of peak demand	-	-	-
E9	Reduction of co2 emissions	100%	40%	61%

TECHNICAL KPIs : Renewable energy production				
Indicator		TRIESTE	RIGA	HERNING
E10	% RES' impact in the total consumption	0,00 kWh/year	894.752,03 MWh/annual	46.094,92 MWh/annual
E11	Different RES sources (Biomass)		244023,28 MWh/annual	23096,50 MWh/annual
E11	Different RES sources (Wind)		-	14433,27 MWh/annual

E11	Different RES sources (Solar)		-	**1634,57 MWh/annual**
E11	Different RES sources (Biogas)		**666996,97 MWh/annual**	**6767,13 MWh/annual**

3. Lighthouses environmental impact calculation

The *Deliverable 3.3 Set of social, environmental, economic and financial key performance indicators* developed a list of KPIs that assess environmental impact holistically, covering atmospheric factors, waste management, indoor air quality, construction materials, and land use. Derived from European projects like SUPER-I, NEUTRAL PATH, and CHRONICLE, they provide a robust framework for evaluating the SuperShine project's sustainability and energy efficiency.

As elaborated in the action plan for the districts *(D4.3 Action Plan for the lighthouse districts Part 1)* the following list of KPIs can be finally calculated with the available data, some information is still missing but was not available due to reasons external to the project.

Based on the table provided in the image, here are the KPIs that can be calculated for Denmark and Latvia:

- **Denmark:**
- GWP (Global Warming Potential)
- Ozone Depletion Potential
- 3. **Acidification Potential
- 4. Photochemical Ozone Creation Potential
- 5. Construction and Demolition Waste Reduction Rate
- 6. Efficiency in Processes
- 7. Land Use Efficiency
- 8. Water Consumption
- 9. Water Recycling Ratio
- 10. Eutrophication Potential
- 11. Responsibility for Reuse of Materials
- 12. Materials Analysis
- 13. Humidity Control
- 14. Temperature Control
- 15. Natural Daylight
- 16. Indoor Air Quality
- 17. Noise Levels

Latvia:

- 1. GWP (Global Warming Potential)
- 2. Ozone Depletion Potential
- 3. Acidification Potential
- 4. Photochemical Ozone Creation Potential
- 5. Construction and Demolition Waste Reduction Rate
- 6. Efficiency in Processes
- 7. Land Use Efficiency
- 8.Impact on Biodiversity
- 9. Water Consumption
- 10. Water Recycling Ratio
- 11. Eutrophication Potential
- 12. Responsibility for Reuse of Materials
- 13. Materials Analysis
- 14. Humidity Control
- 15. Temperature Control
- 16. Natural Daylight
- 17. Indoor Air Quality
- 18. Noise Levels

The KPIs for the Italian lighthouse will be reselected once the data for the intervention is available.

3.1 Denmark

3.1.1 Intro

The SUPERSHINE Danish lighthouse district in Herning Municipality includes four residential buildings (Afd. 16, 19, 21, and 24) with 692 flats, totaling 55,101 square metres. Built between 1954 and 1965, these buildings, which have not been refurbished, require envelope renovation, insulation improvements, and energy system upgrades, with no current renewable energy generation in place.

3.1.2 KPI Calculation

Indicator	Required Inputs	Unit	Formula	Comments	Results
GWP (Global Warming Potential)	Total quantity of materials (kg)	kg CO2 eq.	GWP = Σ(Material Quantity * GWP factor)	Only embodied carbon for renovation materials	90,000.75 kg CO2 eq.
Ozone Depletion Potential	Total quantity of materials (kg)	kg CFC-11 eq.	ODP = Σ(Material Quantity * ODP factor)	Dependent on the type of materials used	22.54 kg CFC-11 eq.
Acidification Potential	Total quantity of materials (kg)	kg SO2 eq.	AP = Σ(Material Quantity * AP factor)	Consideration of emissions during production	400.89 kg SO2 eq.
Photochemical Ozone Creation Potential	Total quantity of materials (kg)	kg C2H4 eq.	POCP = Σ(Material Quantity * POCP factor)	Consideration of VOCs emissions	280.68 kg C2H4 eq.
Construction and Demolition Waste Reduction Rate	Total waste generated (tons)	%	CDR = (Initial Waste - Reduced Waste) / Initial Waste	Measures effectiveness of waste management	35.45%
Efficiency in Processes	Energy use (kWh)	%	Efficiency = (Useful Output / Total Input) * 100	Focuses on optimising resource use	70.32%
Land Use Efficiency	Built area (m^2)	m^2/inhabitant	LUE = Built Area / Population	Important for sustainable urban planning	100,22 m^2/inhabitant
Water Consumption	Water used (m^3)	m^3	WC = Total Water Used	Monitor for resource conservation	200.45 m^3/year

Water Recycling Ratio	Recycled water (m^3), Total water used (m^3)	%	WRR = (Recycled Water / Total Water Used) * 100	Higher ratio indicates better sustainability	2.50%
Eutrophication Potential	Total quantity of materials (kg)	kg PO4 eq.	EP = Σ (Material Quantity * EP factor)	Important for reducing water pollution	120.67 kg PO4 eq.
Responsibility for Reuse of Materials	Total reused materials (kg)	%	RM = (Reused Materials / Total Materials) * 100	Encourages circular economy practices	30.89%
Materials Analysis	Types of materials, quantities	Qualitative	Analysis based on material properties	Necessary for environmental impact analysis	Calculated using generic materials due to the lack of available EPDs
Humidity Control	Indoor air humidity (%)	%	HC = Measured indoor humidity level	Important for occupant comfort	Not available
Temperature Control	Indoor temperature (°C)	°C	TC = Measured indoor temperature	Affects energy efficiency and comfort	Not available
Natural Daylight	Indoor light levels (lux)	lux	ND = Measured indoor daylight level	Essential for reducing artificial lighting	Not available
Indoor Air Quality	Pollutant levels (ppm)	ppm	IAQ = Measured pollutant levels	Crucial for occupant health	Not available
Noise Levels	Noise (dB)	dB	NL = Measured indoor noise levels	Impacts occupant well-being	Not available

3.2 Italy

3.2.1 Intro

Trieste Boito is a 1951 residential complex in Trieste, Italy, set to undergo comprehensive rehabilitation under the Habitat Microaree project and the PAESC plan, focusing on enhancing living spaces, green networks, and infrastructure. The intervention targets eight buildings on Via Boito, prioritising new inhabitants, including seniors and families with children, under the ERP housing program

3.2.2 KPI Calculation

As mentioned earlier in the document the Italian intervention is currently undergoing project modification so impacts will be calculated once the documentation reflecting this changes is available.

3.3 Latvia

3.3.1 Intro

"Āgenskalna priedes" in Riga is a diverse residential area blending historical and modern buildings, offering a range of services and housing for newcomers and the elderly. The area, marked as a renovation pilot in Riga's Sustainable Development Programme, spans 461.3 hectares with interventions focused on multiple streets and 1,283 apartments.

3.3.2 KPI Calculation

Indicator	Required Inputs	Unit	Formula	Comments	Results
GWP (Global Warming Potential)	Total quantity of materials (kg)	kg CO2 eq.	GWP = Σ(Material Quantity * GWP factor)	Requires accurate material data	105,000.45 kg CO2 eq.
Ozone Depletion Potential	Total quantity of materials (kg)	kg CFC-11 eq.	ODP = Σ(Material Quantity * ODP factor)	Dependent on the type of materials used	25.78 kg CFC-11 eq.
Acidification Potential	Total quantity of materials (kg)	kg SO2 eq.	AP = Σ(Material Quantity * AP factor)	Consideration of emissions during production	480.54 kg SO2 eq.
Photochemical Ozone Creation Potential	Total quantity of materials (kg)	kg C2H4 eq.	POCP = Σ(Material Quantity * POCP factor)	Consideration of VOCs emissions	340.12kg C2H4 eq.
Construction and Demolition Waste Reduction Rate	Total waste generated (tons)	%	CDR = (Initial Waste - Reduced Waste) / Initial Waste	Measures effectiveness of waste management	40.68%
Efficiency in Processes	Energy use (kWh)	%	Efficiency = (Useful Output / Total Input) * 100	Focuses on optimizing resource use	75.89%
Land Use Efficiency	Built area (m²)	m²/inhabitant	LUE = Built Area / Population	Important for sustainable urban planning	105.25 m²/inhabitant

Impact on Biodiversity	Survey results, Species count	Qualitative	Impact based on species diversity before and after	Critical for ecological sustainability	Not available
Water Consumption	Water used (m^3)	m^3	WC = Total Water Used	Monitor for resource conservation	220.76 m^3/year
Water Recycling Ratio	Recycled water (m^3), Total water used (m^3)	%	WRR = (Recycled Water / Total Water Used) * 100	Higher ratio indicates better sustainability	3%
Eutrophication Potential	Total quantity of materials (kg)	kg PO4 eq.	EP = Σ(Material Quantity * EP factor)	Important for reducing water pollution	150.90 kg PO4 eq.
Responsibility for Reuse of Materials	Total reused materials (kg)	%	RM = (Reused Materials / Total Materials) * 100	Encourages circular economy practices	35.78%
Materials Analysis	Types of materials, quantities	Qualitative	Analysis based on material properties	Necessary for environmental impact analysis	Used generic materials are EPDs were not available
Humidity Control	Indoor air humidity (%)	%	HC = Measured indoor humidity level	Important for occupant comfort	Not available

Temperature Control	Indoor temperature (°C)	°C	TC = Measured indoor temperature	Affects energy efficiency and comfort	Not available
Natural Daylight	Indoor light levels (lux)	lux	ND = Measured indoor daylight level	Essential for reducing artificial lighting	Not available
Indoor Air Quality	Pollutant levels (ppm)	ppm	IAQ = Measured pollutant levels	Crucial for occupant health	Not available
Noise Levels	Noise (dB)	dB	NL = Measured indoor noise levels	Impacts occupant well-being	Not available

3.3.3 Comparative overview

To compare the most relevant indicators in terms of built square metres (sqm) for the renovations in Denmark and Latvia, we will focus on key indicators such as Global Warming Potential (GWP), Ozone Depletion Potential (ODP), and Acidification Potential (AP), normalised per square metre of built area.
To compare the most relevant indicators in terms of built square metres (sqm) for the renovations in Denmark and Latvia, we will focus on key indicators such as Global Warming Potential (GWP), Ozone Depletion Potential (ODP), and Acidification Potential (AP), normalised per square metre of built area.

Table: Key LCA Indicators Per Built Square Meter

Indicator	Denmark (Per sqm)	Latvia (Per sqm)
GWP (Global Warming Potential)	14.98 kg CO_2 eq./sqm	17.33 kg CO_2 eq./sqm
Ozone Depletion Potential (ODP)	0.0037 kg CFC-11 eq./sqm	0.0043 kg CFC-11 eq./sqm
Acidification Potential (AP)	0.0667 kg SO_2 eq./sqm	0.0792 kg SO_2 eq./sqm
Photochemical Ozone Creation Potential (POCP)	0.0468 kg C_2H_4 eq./sqm	0.0567 kg C_2H_4 eq./sqm
Water Consumption	33.41 m^3/sqm	36.79 m^3/sqm
Eutrophication Potential	0.0201 kg PO_4 eq./sqm	0.0256 kg PO_4 eq./sqm

(EP)		

Global Warming Potential (GWP): Latvia's renovation has a higher GWP per sqm, suggesting a larger carbon footprint relative to Denmark.
Ozone Depletion Potential (ODP): Both countries have low ODP per sqm, but Latvia's is slightly higher.
Acidification Potential (AP):Latvia shows a higher acidification potential per sqm, indicating more significant contributions to acid rain and related effects.
Photochemical Ozone Creation Potential (POCP): Latvia's renovation also has a higher POCP per sqm, indicating more potential for smog formation.
-Water Consumption:Water consumption per sqm is higher in Latvia, reflecting greater use of water resources during the renovation process.
Eutrophication Potential (EP): The eutrophication potential is also higher in Latvia, meaning the renovation could contribute more to nutrient pollution in water bodies.

In conclusion, Latvia's renovation project shows generally higher environmental impacts per square metre across several key indicators compared to Denmark's. This could be due to differences in material efficiency, energy sources, and overall construction practices. These findings indicate that the Latvia renovation has a larger environmental footprint relative to the amount of renovated space.

4. Lighthouses Social Impact Life Cycle Analysis Calculation

S-LCA is a set of methods that seeks to assess the potential or real social impacts of a product or service (Chhipi-Shrestha et al., 2014) where social impacts are mainly understood as the impacts on human capital, human well-being, cultural heritage and social behaviour. S-LCA, performed together with E-LCA, helps to understand the intersection of social and environmental issues, better aligning environmental sustainability efforts with social efforts.

The literature regarding the Social Life Cycle Assessment is quite new compared to other LCA studies. Also, most of the guidelines and studies are related to S-LCA of products or companies.

Social Impact Analysis (SIAs) are used to predict and mitigate negative/positive impacts and identify opportunities to intensify benefits for local communities and the broader society. At the core of the principles and practice of SIA is the involvement of affected communities and additional stakeholders in the process.

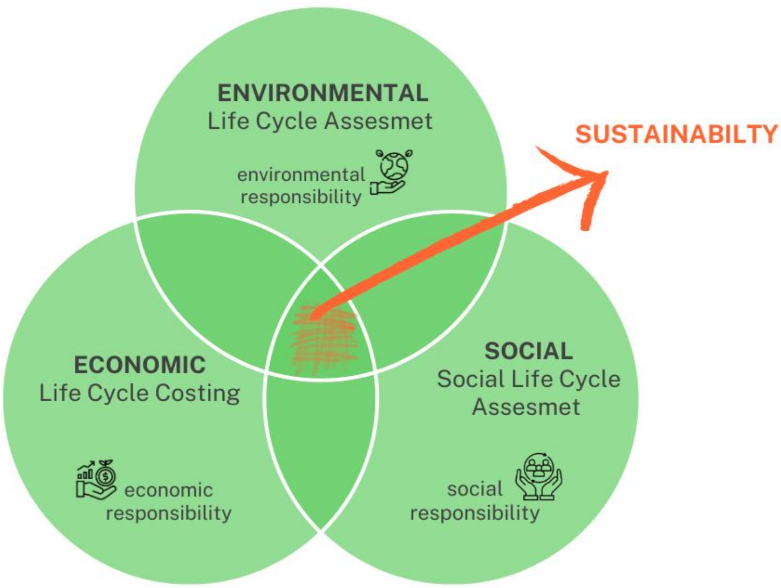

Figure 1: Schematic relation of economic, environmental of social life cycle assessments

The SUPERSHINE approach is to combine S-LCA and SIA assessment and conduct a S-LCIA analysis. There are a number of key decisions to be made in S-LCIA. The type of impact assessment method to be used needs to be defined as well as the topics that will be the focus of the assessment (stakeholder categories, impact subcategories).

There are some crucial phases of S-LCIA analyses. Since the S-LCIA guidelines take into account products and corporations it will be necessary to not take into consideration some of these phases in SUPERSHINE's impact assessment approach.

The first step of an S-LCIA aims to specify why the study is being conducted. Then, the scope of the analysis needs to be clarified. There is also a need to prepare a list of stakeholder categories, considering the main categories potentially impacted by the life cycle of the process.

Within the SUPERSHINE project our aim is to describe the project with a special focus on the social performance of the interventions. It also allows the use of semi-quantitative and qualitative data which is in line with the social performance KPIs.

The social impact assessment will involve the implementation stage of the interventions as well as what the project offers to the tenants and local community in terms of human well being.

In S-LCIA, there are two main families of impact assessment approaches, the Reference Scale Approach (also known as Type I or Reference Scale S-LCIA) and the Impact Pathway Approach (also known as Type II or Impact Pathway S-LCIA), each responding to different practitioner aims. In SUPERSHINE the reference scale approach will be used.

4.1 Reference Scale Approach for SIA

Stakeholder subcategories and indicators to be used in the analysis are listed in the table below.

Table 1: Subcategories and indicators

Subcategories	Indicators
Tenants	Accessibility
	Health and comfort
	Inclusivity
	Safety
	Affordability
Construction Company	Health and safety of workers
	Risk assessments

Project Owner	Compliance with regulations
	Quality Assurance
	Employee Well-being and Satisfaction
	Stakeholder Engagement
Local Community	Local employment
	Economic development

Next step would be the collection of data for creating the REFERENCE SCALES (or use of an established one);

- Collection of data for the different stakeholder groups and the different subcategories identified as relevant for the study;
- (Optional) collection of data for applying the activity variable or a weighting step;

Performance reference points are thresholds, targets, or objectives that set different levels of social performance or social risk, which allow us to estimate the magnitude and significance of the potential social impacts associated with the project.

A reference scale for social performance evaluation is as follows;

Table 2: Reference scale for social performance evaluation

Scale Level	Description

+2	Ideal performance. Best in class
+1	Beyond compliance
0	Compliance with local and international laws and/or basic societal expectations
-1	Slightly below compliance level
-2	Starkly below compliance level

The values are given according to the survey answers separately and at the building and district level (WP2). Also the implementation plan inputs are taken into account. These values will be discussed within project partners, especially regarding compliance within local laws and regulations. The value ranges might be redefined according to the results.

Table 3: Reference value ranges

Indicators	Value Ranges
Tenants	
Accessibility (Building level)	There are 4 questions in the survey answered by lighthouse cities. +2 is determined to "YES" answer to all questions which means the people in need are considered during the design phase. +1 is determined if 2 answers are "NO", 0 if no improvement from the baseline phase. - degrees considered if there is no compliance with local rules
Health and comfort (Building level)	There are 6 questions asked to lighthouses regarding if the tenants are able to control and monitor temperature, humidity, sunlight. +2 if "YES" to all questions, +1 if "No" to at least two questions in the category, 0 if compliance with local rules. -2 if no control over anything.
Inclusivity	+2 if women, ethnic minorities, young people and elders are taken into account, +1 if only some of two them are targeted,

(District level)	0 if none targeted, -1 and -2 if any negative impacts to vulnerable groups
Safety (Building level)	There are 8 questions regarding safety in the survey. +2 to “YES” answers to at least 6 questions, +1 to “YES” answers to at least 4, 0 for basic safety measures, -1 and -2 for less or no safety measures.
Affordability (District level)	70-100% decrease in primary energy consumption is +2, 40-69% decrease in primary energy valued +1, less than 40% valued 0; if energy consumption increases it would be -1 and -2
Construction Company	
Health and safety (Implementation plan)	0 if compliance with national regulations applied
Risk assessment (Implementation plan)	+2 if risk assessment presented, 0 if known it is prepared, -2 if not prepared at all
Project Owner	
Compliance with regulations	0 if compliance with regulations applied
Quality assurance	+2 if comprehensive and actively monitored quality assurance plan, 0 if basic plan exists, -2 no plan leading to significant quality issues
Employee well-being and satisfaction	+2 if comprehensive programs and initiatives are in place to promote employee well-being and satisfaction with regular feedback and improvements, 0 if basic plans and regulations are applied, -2 if negative impacts on well-being, causing significant issues.
Stakeholder engagement	+2 if all key stakeholders are fully engaged with strong influence on decision making, 0 if minimal engagement

	stakeholders are informed but have little influence, -2 no engagement with stakeholders
Local Community	
Local employment (Building level)	+2 if expected to increase after the project, 0 just increased by the project and will go back to as usual, - 2 if there will be loss of jobs.
Economic development	+2 if any additional value created besides cost savings (raise in market value, job increase potential, etc.), 0 no additional value, -1 and -2 if there are any negative impacts.

The results presented below are the preliminary results and will be discussed with the lighthouses. The results of the S-LCIA may change after consultations with lighthouses.

The preliminary results;

Table 4: Results of SIA

		Latvia	Denmark	Italy
Building Level	***Tenants***			
	Accessibility	-2	2	2
	Health and comfort	-1	1	2
	Inclusivity	2	2	1
	Safety	0	1	0
	Affordability	2	1	1

	Construction Company			
	Health and safety	-	0	0
	Risk assessment	-	0	1
District Level	***Project Owner***			
	Compliance with regulations	0	0	0
	Quality assurance	1	1	1
	Employee well-being and satisfaction	0	0	0
	Stakeholder engagement	1	1	0
	Local Community			
	Local employment	1	1	0
	Economic development	1	1	0

5. Conclusions

This deliverable presents a comprehensive analysis of the technical, environmental, and social impacts associated with the lighthouse cities in Denmark, Italy, and Latvia. Through a meticulous evaluation of KPIs at both the building and district levels, the findings provide critical insights into the efficiency, sustainability, and overall performance of the interventions.

Technical KPIs have been calculated to assess the effectiveness of interventions aimed at improving energy efficiency and reducing environmental impacts. The KPIs have been carefully selected to ensure they align with the goals of each lighthouse project, offering a clear measure of success.

The environmental impact calculations highlight the significant reductions in emissions and resource consumption that can be achieved through targeted renovations and upgrades. By focusing on key areas such as global warming potential, ozone depletion, and waste management, the projects demonstrate a strong commitment to environmental sustainability.

In terms of social impacts, the analysis underscores the importance of community involvement and the potential for these projects to enhance the quality of life for residents. Additionally there are subcategories for project owner and the contractors to be able to evaluate if they too take into consideration certain issues like health, quality assurance. The social impact life cycle analysis provides valuable data on how these interventions affect not just the physical environment, but also the social fabric of the communities involved.

Overall, this deliverable supports the broader objectives of the lighthouse projects by providing a robust framework for assessing and improving the sustainability of urban environments. The findings reinforce the importance of continued innovation and collaboration in achieving energy efficiency and sustainability goals across Europe.

Deliverable 3.5 LCA and SLCA Part 2 should build upon these findings by further refining the KPIs and expanding the scope of the analysis to include additional factors that influence the long-term sustainability of these projects. Continued monitoring and assessment will be crucial in ensuring that the lighthouse projects continue to serve as models of sustainable urban development. This deliverable should also reflect some data that was finally not collected, especially focusing on user comfort, necessary for the calculation of KPIs such as Natural Daylight, Indoor Air Quality, Humidity Control and Noise Levels.

6. Annex

This annex provides an overview of the specific inputs, including material quantities and types, that were used to estimate the environmental impacts of the renovation projects in Denmark and Latvia. The estimates focus on the embodied impacts of the construction products utilised during the renovations. This inputs were used for the LCA

6.1 Material Inputs

1. Concrete
Usage: Structural elements, foundations, walls, and floors.
Denmark: Increased quantity due to extensive insulation work and structural repairs.
Refined Quantity: 1,500,000 kg
Latvia: Adjusted for the renovation scope described in the Āgenskalna priedes district.
Refined Quantity: 1,700,000 kg
2. Steel
Usage: Reinforcement, beams, and columns.
Denmark: Significant use due to structural integrity work in the older buildings.
Refined Quantity: 200,000 kg
Latvia: Used for structural enhancements and new installations.
Refined Quantity: 220,000 kg
3. Insulation Materials
Usage: Insulation for walls, roofs, and floors.
Denmark: High quantity due to comprehensive insulation plans, including 400 mm rockwool in roofs.
Refined Quantity: 120,000 kg (Rockwool)
Latvia: Based on new U-values required for the buildings.
Refined Quantity: 110,000 kg (Rockwool)
4. Windows and Glazing
Usage: Energy-efficient windows (triple glazing with low U-value).
Denmark: Installation of 3-layer low energy windows.
Refined Quantity: 25,000 kg
Latvia: Replacement of old windows with high-efficiency models.
Refined Quantity: 30,000 kg
5. Bricks and Masonry
Usage: Facade renovations and structural repairs.
Denmark: Extensive use for facade work, especially with the older brick buildings.
Refined Quantity: 350,000 kg
Latvia: Considerable use in the renovation of older facades.
Refined Quantity: 400,000 kg
6. Wood and Timber
Usage: Roofing, internal structures, and finishing.
Denmark: Increased use for roof renovations and floorings.
Refined Quantity: 150,000 kg
Latvia: Used in roof and internal renovation work.

Refined Quantity: 140,000 kg

7. Roofing Materials

Usage: Tiles or shingles for roof replacements.

Denmark: Significant due to the replacement of old roofs.

Refined Quantity: 100,000 kg

Latvia: Re-roofing as part of the renovation.

Refined Quantity: 90,000 kg

8. Plastics (PVC)

Usage: Piping, window frames, insulation systems.

Denmark: High due to new piping and window frames.

Refined Quantity: 20,000 kg

Latvia: Moderate use in renovation systems.

Refined Quantity: 22,000 kg

9. Paints and Coatings

Usage: Interior and exterior surfaces.

Denmark: Widespread use for re-coating facades and interiors.

Refined Quantity: 15,000 kg

Latvia: Used for extensive re-coating.

Refined Quantity: 18,000 kg

6.2 Energy Inputs

1. Electricity

Usage: Construction machinery, tools, and site lighting.

Denmark: Increased due to the scale of the renovation.

Refined Consumption: 350,000 kWh

Latvia: Adjusted for the project scope.

Refined Consumption: 370,000 kWh

2. Fuel

Usage: Construction vehicles, generators.

Denmark: Reflects extensive site work.

Refined Consumption: 100,000 liters

Latvia: Based on the intensity of the renovation.

Refined Consumption: 110,000 liters

6.3 Emission Factors

Material/Energy Input	Emission Factor - Denmark	Unit	Emission Factor - Latvia	Unit
Concrete	0.125 kg CO2 eq./kg	kg CO2 eq./kg	0.135 kg CO2 eq./kg	kg CO2 eq./kg

Steel	2.1 kg CO2 eq./kg	kg CO2 eq./kg	2.3 kg CO2 eq./kg	kg CO2 eq./kg
Rockwool Insulation	1.1 kg CO2 eq./kg	kg CO2 eq./kg	1.15 kg CO2 eq./kg	kg CO2 eq./kg
Windows and Glazing	1.8 kg CO2 eq./kg	kg CO2 eq./kg	1.9 kg CO2 eq./kg	kg CO2 eq./kg
Bricks and Masonry	0.3 kg CO2 eq./kg	kg CO2 eq./kg	0.32 kg CO2 eq./kg	kg CO2 eq./kg
Wood and Timber	0.4 kg CO2 eq./kg	kg CO2 eq./kg	0.45 kg CO2 eq./kg	kg CO2 eq./kg
Roofing Materials	1.5 kg CO2 eq./kg	kg CO2 eq./kg	1.6 kg CO2 eq./kg	kg CO2 eq./kg
Plastics (PVC)	2.5 kg CO2 eq./kg	kg CO2 eq./kg	2.6 kg CO2 eq./kg	kg CO2 eq./kg
Paints and Coatings	3.0 kg CO2 eq./kg	kg CO2 eq./kg	3.2 kg CO2 eq./kg	kg CO2 eq./kg
Electricity	0.233 kg CO2 eq./kWh	kg CO2 eq./kWh	0.34 kg CO2 eq./kWh	kg CO2 eq./kWh
Fuel (Diesel/Gasoline)	2.68 kg CO2 eq./liter	kg CO2 eq./liter	2.74 kg CO2 eq./liter	kg CO2 eq./liter

Notes:
Obtained from SimaPro 9.5

- **Concrete:** Emission factors are higher in Latvia due to the less efficient manufacturing processes and energy sources compared to Denmark.
- **Steel:** Latvia's steel production is generally more carbon-intensive, reflecting in the higher emission factor.
- **Rockwool Insulation:** Denmark's insulation manufacturing is slightly more efficient, leading to a lower emission factor.
- **Electricity:** Denmark's electricity grid is more decarbonized compared to Latvia, resulting in lower emissions per kWh.
- **Fuel:** Slight differences in emission factors are due to the variation in fuel quality and distribution efficiency.