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Alpine Space

BAUHALPS

D1.3.2– Conceptualization of the online circularity maturity assessment tool

Lead Beneficiary: Ca' Foscari University Foundation (LP01 – FCF)
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Table of contents

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EXECUTIVE SUMMARY

This document presents the conceptual framework of a circularity maturity assessment tool designed to support the transition towards sustainable and circular buildings, in alignment with the sustainability principle of the New European Bauhaus (NEB). It integrates the 12 indicators identified (in deliverable D1.3.1 "Set of circularity maturity performing indicators") through a desk study that covered different sources on the broader theme of circular economy and on sustainable development applied to the building sector.

The document defines the methodology, assessment criteria, and overall structure and layout of the tool. Preliminary suggestions regarding the tool's configuration were shared with project partners to refine an initial concept grounded in a common understanding of its objectives and methodological approach.

The document is structured as follows:

- The section "Introduction and objective" provides the context for the development of the circularity maturity assessment tool within the overall project development and within Activity 1.3 "To assess the green transformation processes of the SMEs' building projects".
- The section "Methodological approach" describes the process of conceptualization of the assessment tool based on the identified performance indicators, its structure, and its functioning.
- The final section ("Conclusions") sums up the document with key findings and remarks.

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1. Introduction and objective

This section provides context for the development of the circularity maturity assessment tool within the overall project development and within the Activity 1.3. The overall objective of the assessment is to support SMEs and local building stakeholders in understanding, evaluating, and progressively improving the circularity level achieved in building projects. The concept of "maturity" aims at reflecting the adherence of the project under assessment to the circular economy principles, without requiring comparison to an externally defined level of acceptability.

Activity 1.3 consists of two phases:

A. a preliminary phase to identify a set of circularity performance indicators, which was developed through a co-design process involving partners and stakeholders in desk research, local and transnational workshops (described in D1.3.1);
B. and a subsequent phase to develop the assessment tool based on the identified indicators (D1.3.2). The sequence of activities characterizing Activity 1.3 – including desk research, thematic workshops, and local workshops – is illustrated in Figure 1. Subsequently, the main outputs of Activity 1.3 are positioned within the overall framework (Figure 2) and linked to the other activities within Work Package 1 "Building sector's cultural- and green-based model (particularly activities A1.1 "To engage local communities for the transformation of the building sector", A1.2 "To map traditional techniques and materials in building sector for the "genius loci" repository", and A1.4 "To develop a model for the green transformation with the uptake of advanced technologies in the manufacturing sector"), as well as those of Work Package 2 "Greener, beauty, and "together" for building in AS" (notably A2.1 "Preparatory actions to assess circularity performance of some buildings testing the toolkit" and A2.2 "Assessing circularity performance of building in the Alps with the toolkit").

The assessment tool (D1.3.2) is developed based on the set of circularity performance indicators (D1.3.1) and it represents one of the three core components of the "toolkit" (D1.4.2). The other two components are the "Methodology to engage local communities in the building transformation" (deliverable D1.1.1) and the "Genius Loci online repository" (deliverable D1.2.2).

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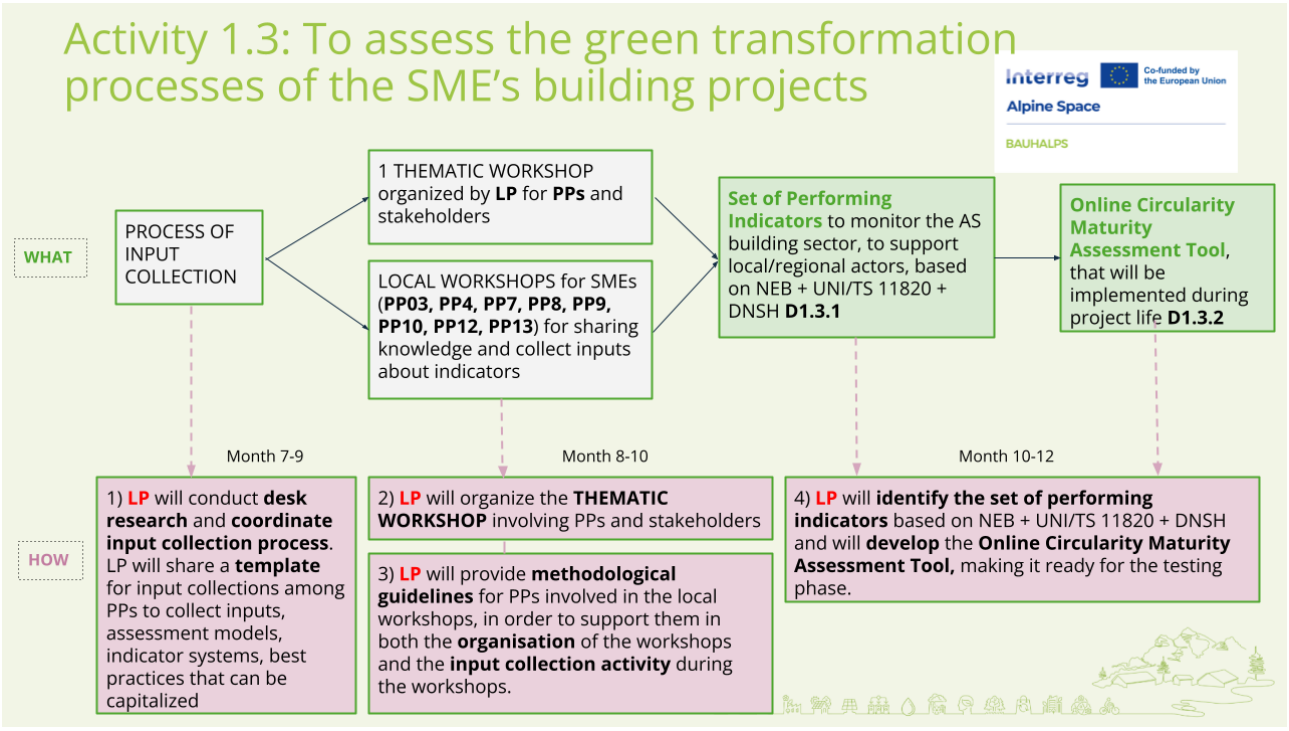

Figure 1. Roadmap of Activity 1.3.

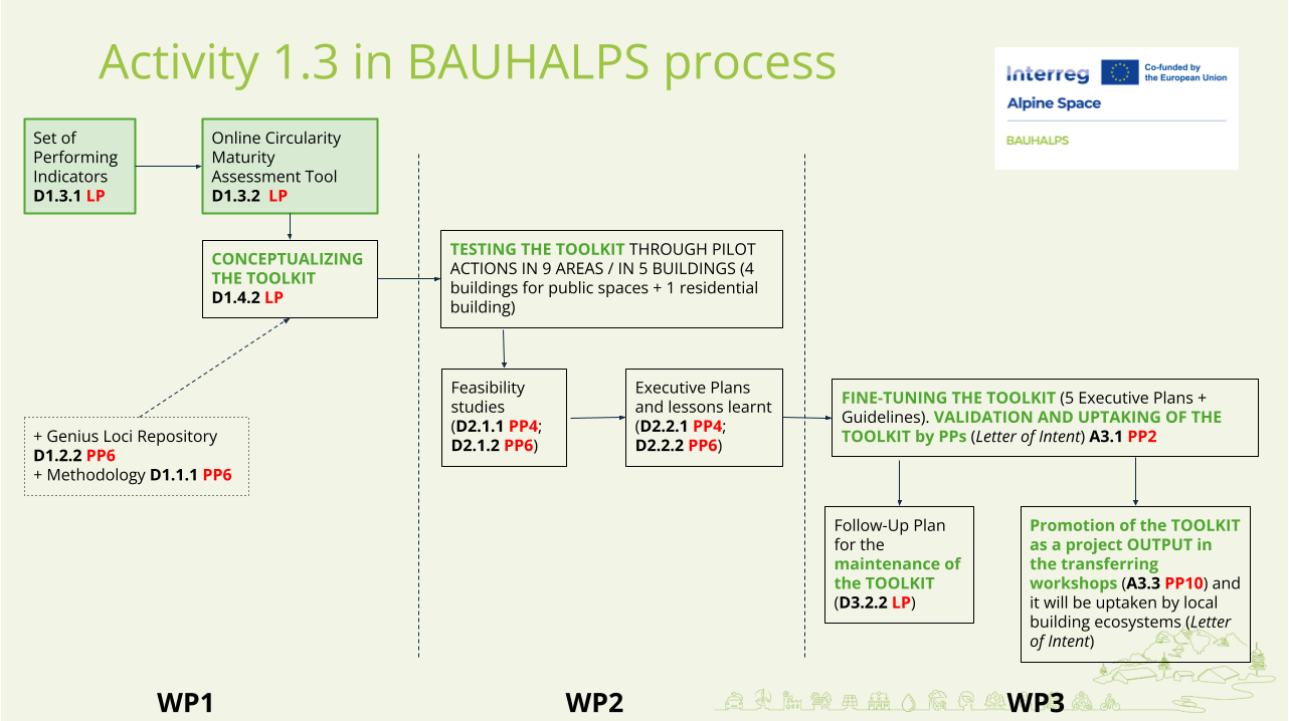

Figure 2. Overview of Act. 1.3. in the BAUHALPS project.

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Conceptualized within WP1, the toolkit will be tested in the pilot actions of WP2, specifically across nine worksites in nine cooperation areas, comprising both residential buildings and buildings with a public function (A2.1, A2.2).

Within Work Package 3 "Enhancing alpine building green transformation", the toolkit will be fine-tuned, validated, and adopted by project partners (Activity 3.1 "To finalize the toolkit to increase the green transformation of the building sector"). A follow-up plan for its maintenance will be developed (deliverable D3.2.2 "Partnership agreement for the follow-up"), and the toolkit will be promoted as a key project output through transfer activities, thereby supporting its uptake by local building ecosystems (Activity 3.3 "Disseminating BAUHALPS outputs and enlarging the network committed for their follow-up").

2. Methodological approach

The methodological approach adopted for the development of the circularity tool builds upon the 12 circularity indicators identified during the first phase of Activity 1.3, as presented in Table 1 below.

Main thematic area	Strategies and actions	Indicator title
Sustainable and circular design	Design for adaptability, deconstruction and modularity	Demolition contractor involvement and definition of a construction strategy
		Design intent for modularity, disassembly and adaptability
	Monitoring material data and traceability	Digital project management and material documentation
		Traceability of health-related material properties
	Implementation of life-cycle perspective	Assessment and mitigation of material-related health risks
		Integration of life-cycle approach in circular design
Materials and resources efficiency	Use of low-impact, recycled or recyclable materials	Prioritization of secondary, reused, and low-impact resources
		Embedding circularity in contractual and tender procedures
	Implementation of Near Zero Energy (NZE) buildings	Adoption of renewable energy strategies in the project
Waste management	Waste prevention and reduction	Circular management of construction and demolition waste

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Main thematic area	Strategies and actions	Indicator title
Connection between circularity and NEB criteria	Integrating *beauty* in circular strategies	Circular design effects on aesthetic and cultural qualities
	Integrating *togetherness* in circular strategies	Circular design effects on community value and participation

Table 1. Set of circularity indicators identified in deliverable D1.3.1. The indicators relate to the implementation of different strategies and actions, which are organized into main thematic areas.

A detailed description of the indicators, together with guidance on their assessment, is provided in deliverable D1.3.1.

Conceptualization of the circularity assessment tool

The circularity maturity assessment tool is structured into three independent assessment levels, hereafter referred to as *tiers*. The assessment can be conducted by selecting a single tier, without the need to complete all three. The tiers are defined as follows:

- **Tier 1 – Qualitative assessment**: indicators describe aspects that can be evaluated through expert judgement, observations, or descriptive criteria. They are formulated as questions requiring a binary – positive or negative – response;
- **Tier 2 – Semi-quantitative assessment**: indicators integrate qualitative and quantitative components by translating descriptive judgements into ordered Likert-type rating scales;
- **Tier 3 – Quantitative assessment**: indicators are expressed as ratios between measurable quantities. They require numerical data and produce a value ranging from 0 to 1.

Regardless of the selected tier, the assessment of each indicator must be supported by appropriate reference documentation to ensure the validity of the responses provided. Progressing through tiers, simplicity, speed of analysis, and ease of implementation are progressively reduced. Conversely, objectivity, precision, reliability, and replicability increase.
Table 3 shows the indicators for each assessment tier. As shown in Table 3, the following two indicators, belonging to the category “Implementation of life-cycle perspective”, are not included in Tier 3:

- Assessment and mitigation of material-related health risks;
- Integration of life-cycle approach in circular design.

Their exclusion is justified by the difficulty of translating these indicators into objective and measurable quantitative metrics. Both indicators are predominantly qualitative and process-oriented in nature, requiring interpretative assessment rather than standardized numerical

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parameters. In the absence of robust quantitative measures, their inclusion in Tier 3 would not ensure methodological consistency.

To ensure thematic completeness of the Tier 3 assessment while preserving its quantitative structure, the two missing indicators are retained in their semi-quantitative formulation and subsequently normalized to a 0-1 scale. The original 0-3 rating scale is linearly converted into a standardized value between 0 and 1 through a min-max transformation, according to the following formula:

$$Score_{norm} = \frac{Score_{Tier2}}{3}$$

This linear rescaling ensures proportionality between assessment levels and preserves the ordinal structure of the original semi-quantitative scale. The conversion is illustrated in Table 2 below.

Tier 2 score	Normalized value
0	0.0
1	0.33
2	0.67
3	1.0

Table 2. Linear normalization of the tier 2 scale to a 0-1 range.

The normalized values are incorporated into the overall Tier 3 circularity level calculation, ensuring that the life-cycle perspective and material-related health risks remain embedded in the highest assessment level.

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Tier 1 – Qualitative assessment	Tier 2 – Semi-quantitative assessment	Tier 3 – Quantitative assessment
Provided there is local availability, has a demolition contractor been involved in the building project to conduct a deconstruction strategy (for new constructions) or a pre-demolition audit (for refurbishment projects)?	Level of integration of demolition or deconstruction expertise	Pre-demolition audit rate
Does the building project embed modular design and/or reconfigurable solutions that allow for disassembly and adaptability over time?	Degree of integration of modular and reconfigurable design solutions	Modular design integration
Does the building project implement digital tools and systems to support overall project management and the documentation of materials and components?	Level of adoption of digital tools and tracking systems	Tracking systems integration
Are traceability and documentation systems in place to monitor the health-related characteristics of materials (e.g. toxicity, emissions, contamination risks) over time?	Degree of implementation of material health traceability systems	Material health tracking systems integration
Does the project assess and mitigate potential health risks associated with the use of materials, both new and reused, throughout the building's life cycle?	Degree of integration of material-related health risk management	←
Does the building project adopt a life-cycle approach - ranging from life-cycle thinking to full LCA studies - to evaluate and optimize its environmental impacts, carbon footprint, water use, and to inform circular design and material choices?	Level of adoption of a life-cycle approach for project management	←
Does the building project prioritize the sustainable use of by-products, secondary materials, reused or upcycled components, or virgin renewable resources over conventional raw materials, while ensuring their technical suitability for the project?	Degree of use of secondary and renewable materials	Secondary and renewable resources rate
Have circular performance-based procurement criteria been included in contract specifications?	Level of integration of circular procurement criteria	Value share of procurement contracts with circularity criteria

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Tier 1 – Qualitative assessment	Tier 2 – Semi-quantitative assessment	Tier 3 – Quantitative assessment
Have circular performance-based procurement criteria been included in contract specifications?	Degree of reliance on renewable or recovered energy sources	Share of energy from renewable or recovered sources in the project's total energy consumption
Does the building project allow for the prevention of construction and demolition waste through reuse and other forms of valorization of the residues from construction activities?	Level of implementation of C&D waste prevention and valorization practices	Circular recovery rate
Do circular design choices influence - positively or negatively - the aesthetic, cultural, and contextual qualities of the building project? How, conversely, do these values influence circular design strategies? Is there evidence of any meaningful interaction between circularity and architectural or cultural expression?	Degree of circular design integration in aesthetic and cultural value	Local sourcing intensity
Do circular design choices influence - positively or negatively - social inclusion, user participation, and a sense of community belonging within the project? How, conversely, do these values influence circular design strategies? Is there evidence of any meaningful interaction between circularity and local community participation and involvement?	Degree of circular design integration in social inclusion	Degree of circular design integration in social inclusion

Table 3. Complete indicator set for each assessment tier.

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3. Conclusions

This deliverable has presented the conceptual framework and operational structure of the circularity maturity assessment tool developed within Activity 1.3. Building upon the 12 circularity indicators defined in Deliverable D1.3.1, the document translates the theoretical indicator set into a multi-tier assessment tool designed to support its practical application in building projects, to be tested in pilot actions. The three-tier architecture – qualitative (Tier 1), semi-quantitative (Tier 2), and quantitative (Tier 3) – ensures flexibility in application while maintaining methodological robustness. The possibility of selecting a single tier independently allows the tool to be adapted to different project contexts, levels of data availability, and technical capacity. At the same time, the progressive structure of the tiers reflects a clear trade-off between ease of use and analytical precision: higher tiers require more detailed data but ensure greater objectivity, replicability, and comparability of results. The conceptualization phase has also clarified the methodological boundaries of the tool. Certain indicators related to the implementation of a life-cycle perspective were not included in the quantitative tier due to their predominantly qualitative and process-oriented nature. This decision ensures methodological coherence and prevents the introduction of metrics that could compromise the reliability of the assessment.

Overall, the circularity maturity assessment tool represents a structured and scalable instrument to support the evaluation of circular strategies in the building sector within the Alpine Space context. The next phase of implementation and testing in pilot cases will allow validation of the tool's functionality, identification of potential refinements, and further consolidation of its methodological robustness.

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Annex I – Guide to the use of the circularity assessment tool

The current version of the tool is an Excel file consisting of the following 4 worksheets:

- pilot project details;
- *tier 1* assessment;
- *tier 2* assessment;
- *tier 3* assessment.

As represented[1] in Table 4, the *pilot project details* worksheet includes three tables requiring the input of general project information, location data, and details concerning the professionals involved in the assessed project.

General project data	
Project name/title	
Building area	
Type of intervention	
Project phase	
Brief description of the intervention	
Project start year	
Year of project completion	
Location and site information	
Country	
Full address	
Coordinates or cartographic reference	
Current land-use zoning	
Existing constraints	
Property ownership	
Appointed professionals	
Planners/architects	
Developer/construction company	
Project manager	
Construction manager	
Certifier/auditor	

Table 4. Informative tables from the pilot project details worksheet.

[1] Due to readability constraints, screenshots of the tool's spreadsheets are not included in this document. Their content is accurately reproduced through dedicated tables to ensure clarity and consistency of presentation.

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The information collection template described above has been developed in continuity with the requirements already defined within the framework of the *Genius Loci* (Act. 1.2). For certain fields, a completion note indicates the need to select one of several available options from a drop-down menu.

As shown in Table 5, the *tier 1* worksheet contains the set of qualitative indicators. Each indicator consists of a title and a short description formulated as a question. The indicators are complemented by additional notes that serve as guidance for the assessment.

Indicator	Assessment guide comments	Indicator assessment
Demolition contractor involvement and definition of a construction strategy Provided there is local availability, has a demolition contractor been involved in the building project to conduct a deconstruction strategy (for new constructions) or a pre-demolition audit (for refurbishment projects)?	- A demolition contractor is a specialized professional responsible for planning and carrying out the safe, efficient, and compliant dismantling, removal, or clearance of buildings, structures, or other man-made facilities. - The pre-demolition audit is an activity resulting in the inventory of materials and components arising from the future demolition or renovation projects, and their management and recovery options (European Commission, 2017, EU Guidelines for the Waste Audits).	YES/NO
Design intent for modularity, disassembly and adaptability Does the building project embed modular design and/or reconfigurable solutions that allow for disassembly and adaptability over time?	- Modular design (or modularity) refers to designing products by organizing sub-assemblies and components as distinct building blocks (i.e., modules) that can be integrated through configuration to fulfill customer and engineering requirements (Tseng M., Wang Y., Jiao R., 2018. Modular Design). - Reconfigurable solutions encompass three design principles for adaptability: - Versatility, defined as the ability to accommodate different functions with minor system changes; - Convertibility, defined as the ability to accommodate substantial changes in user needs by making modifications; - Expendability, defined as the characteristic of a system to accommodate a substantial change that supports or facilitates the addition of new space, features, capabilities and capacities.	YES/NO

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	- The scope of application of modularity and design for disassembly principles (following a proper examination) spans across five levels: - Systems: adaptable construction works that can change to suit changing requirements. In some cases, entire modular buildings can undergo wholesale disassembly, movement, and re-use; - Elements: major structural part of a construction work (e.g. a roof, foundation, wall); - Component or assembly: combination of several subcomponents that are often non-structural (e.g., valves, solar panels); - Subcomponent: smaller pieces of the components (e.g., the duct system of a heating or cooling system; the glazing used for curtain walls; gaskets in piping systems, or controllers and software in a fire protection system); - Material: basic materials to which a product can be reduced, and that can be re-used or serve as a feedstock in the recycling process to produce other materials.	

Table 5. Representation of the tier 1 worksheet, including the description of the indicators and guidance comments for their assessment.

To complete the qualitative assessment of the indicators, users are required to answer each question by selecting one of the available options from a drop-down menu.
As shown in Table 6, the *tier 2* worksheet contains the set of indicators in a semi-quantitative form. In this configuration, indicators are assessed using an ordered value scale ranging from 0 to 3. As in *tier 1*, the indicator value can be selected via a dedicated drop-down menu.

Indicator	Indicator assessment	Scale interpretation
Demolition contractor involvement and definition of a construction strategy Level of integration of demolition or deconstruction expertise	0 / 1 / 2 / 3	0 - NO ADDRESSING No demolition contractors or deconstruction experts appointed; no audit conducted. 1 - PARTIAL ADDRESSING Experts appointed, but no deconstruction strategy defined or pre-refurbishment audit conducted. 2 - EXTENSIVE ADDRESSING Experts appointed and preliminary audit/strategy defined, but with limited coverage or scope.

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		3 - FULL ADDRESSING Experts appointed early in the design phase; comprehensive pre-demolition strategy defined or pre-refurbishment audit carried out, including identification of reusable materials and selective dismantling opportunities.
Design intent for modularity, disassembly and adaptability Degree of integration of modular and reconfigurable design solutions	0 / 1 / 2 / 3	0 - NO INTEGRATION No modular or reconfigurable solutions are included in the design. 1 - PARTIAL INTEGRATION Limited modular or reconfigurable elements are present, but adaptability is minimal or not systematically planned. 2 - SUBSTANTIAL INTEGRATION Several modular or reconfigurable solutions are included, enabling partial adaptability to future changes in function, layout, or use. 3 - FULL INTEGRATION The building design is fully modular and reconfigurable, allowing for high adaptability and easy reconfiguration over time with minimal structural or functional constraints.

Table 6. Representation of the tier 2 worksheet, showing the indicators in semi-quantitative form and the corresponding assessment scale.

Table 7 presents the *tier 3* worksheet, which reports the quantitative assessment of the indicators. For this level, the calculation formulas of the indicators are embedded in the sheet, all expressed as ratios. The assessor can enter the numerator and denominator values in the designated cells, with the result automatically computed in the adjacent column. For some indicators, additional guidance comments are also provided to support the evaluation process.

Indicator formula	**Indicator values**	
	Numerator	**Denominator**
B_r/B_a	B_r = number of building products for which high-quality reutilization has been identified	B_a = total number of building products that were subjected to pre-demolition audit
$\frac{V_{mod}+V_{rec}}{V_{TOT}}$	- V_{mod} = volume of modular and/or prefabricated components - V_{rec} = usable volume in which walls, systems and finishes allow for non-structural reconfiguration	V_{TOT} = total internal volume

Table 7. Representation of the tier 3 worksheet, showing the indicators in quantitative form and the corresponding calculation formula.

At the end of the indicator list, the overall *circularity level* is displayed and automatically calculated as the average of the indicator values (Figure 3). Regardless of the assessment tier

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applied, the circularity outcome is always based on project-specific data and contextual conditions. The resulting score should not be interpreted as representing or being comparable to a predefined minimum acceptable level of circularity. For this reason, the results should be understood within a continuous improvement perspective, reflecting the progressive adoption of circular economy principles over time. Its interpretation must take into account relevant enabling and constraining factors, such as the availability of budget, time and resources, regulatory compliance requirements, and technical feasibility.

CIRCULARITY LEVEL	**#DIV/0!**

Figure 3. Circularity level index in the tier 3 worksheet.

In both the *tier 2* and *tier 3* worksheets, results are presented through two graphical visualizations using Kiviat (radar) charts. At each assessment level, the scores are aggregated through arithmetic averaging across two dimensions: (i) strategies and actions, and (ii) main thematic areas. The aggregated results are displayed in the charts positioned next to the tables reporting the corresponding numerical values, as illustrated in Figure 4 and Figure 5. This type of visualization supports the identification of underperforming areas where corrective actions can be planned and implemented.

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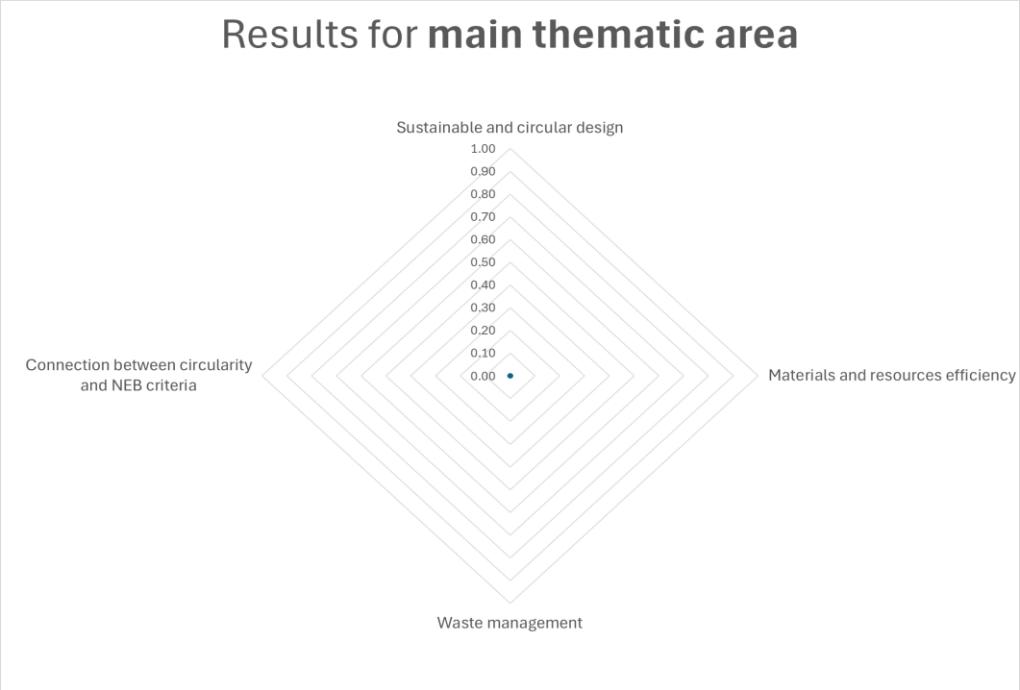

Figure 4. Kiviat chart for the visualization of the results of the tier 2 assessment, aggregated into strategies.

Figure 5. Kiviat chart for the visualization of the results of the tier 3 assessment, aggregated into main thematic areas.

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