LCA-BASED APPROACH TO DRIVE THE DEVELOPMENT OF A LOW-EMISSION PREFABRICATED WALL: A COMBINED EXPERIENCE BETWEEN UNIVERSITY AND ENTERPRISES/

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Abstract. The decarbonisation of the European construction sector requires a systematic transition towards low-emission building products and components. In this context, the updated Energy Performance of Buildings Directive (EPBD) introduces the mandatory assessment of Whole Life Carbon (WLC), thereby extending the regulatory focus beyond Operational Energy to include Embodied Carbon (EC) emissions associated with material production, construction processes, maintenance, and end-of-life stages. This paper contributes to the growing body of research on WLC implementation by presenting a combined academic–industrial study aimed at reducing EC in prefabricated components. The collaboration involves the Department of Architecture and Design at the Politecnico di Torino, the Sarotto Group, and Ricehouse s.r.l.

The research compares two technical solutions for prefabricated walls applied to a Sarotto Group's case study: the Klimasismico system, based on concrete and synthetic insulation, and an innovative RiceCycling Wall (RCW) prototype composed of rice husks, natural cement and geopolymeric foam. A WLC analysis was carried out according to the Life Cycle Assessment standards and the EU Level(s) framework, using generic datasets from OneClickLCA©. System boundaries encompass all the primary stages of the building life cycle: Production (A1-A3), Transport (A4), Construction (A5), Maintenance (B2), Repair (B3), Replacement (B4), Energy Use (B6), and End-of-Life (C1-C4).

Results highlight a reduction of approximately 11,500 kg CO_2e when substituting Klimasismico with the RCW, driven primarily by lower emissions in the Production and Replacement stages. However, the bio-based prototype increases Transportation and End-of-Life impacts due to its higher mass. In the near future, additional activities should be undertaken to enhance the final version of the RCW.

The study demonstrates that integrating bio-based materials and short supply-chain solutions can support the decarbonisation targets set by EPBD IV. It also highlights the importance of WLC studies in research as a guiding tool for innovation in construction systems.

Introduction. The construction sector is a significant contributor to the climate crisis, accounting for an estimated 34% of global energy demand and 37% of total greenhouse gas emissions (UNEP, 2024). In response, the European Union (EU) has implemented a suite of plans and strategies, including the Green Deal (European Commission, 2019), to achieve continental climate neutrality by 2050 through the decarbonisation of the construction sector (EU, 2021).

A crucial instrument in this process is the recent update of the Energy Performance of Buildings Directive - EPBD IV (EU 1275, 2024), which establishes a framework for enhancing the efficiency of the EU building stock by reducing energy demand and GreenHouse Gas (GHG) emissions. EPBD IV introduces the Whole Life Carbon (WLC) assessment as a core feature. WLC is an assessment that considers carbon equivalent emissions (CO2e) and removals (when they occur) throughout the building's life cycle, quantified by two mean indicators: the Operational Carbon (OC), which encompasses emissions from energy consumption during building operation (e.g., heating, cooling, and lighting), and the Embodied Carbon (EC), which accounts for CO2e emissions associated with construction materials, transport, site operations, maintenance, demolition, and waste management.

While EU policies (EU 1791, 2023) already support measures to reduce OC, addressing EC requires a harmonised effort across the construction sector's stakeholders – e.g., material manufacturers, designers, universities, and contractors.

Furthermore, effective decarbonisation strategies require the integration of circular economy principles, bio-based and low-carbon materials, design-for-disassembly approaches, and cost-effective solutions. The paper deals with the challenge of EC reduction by a cooperation program among the Department of Architecture and Design (DAD) of the Politecnico di Torino and two enterprises: 1) Sarotto Group, experienced in the prefabrication of Nearly Zero Energy Buildings (NZEB) in Narzole (CN, Italy); 2) Ricehouse s.r.l.specialiseded in the enhancement of rice waste for building material production, in Andorno Micca (BI, Italy).

The research was started by a WLC study of the current building, based on Life Cycle Assessment (LCA) standards UNI EN ISO 14040/44:2021, its building specs UNI EN 15978:2011 and UNI EN 15643:2021, and following the sustainable framework of Level(s) (Dodd et al., 2017). Additionally, the WLC was utilised to aid in the development of a new low-carbon prefabricated wall, which would replace the current one made of concrete and synthetic insulation, by combining rice husk and natural cement.

Although the wall element is currently being industrialised, within the paper, it was analysed by considering the production stage and other processes (such as construction) and by setting up scenarios (replacements, disposal, and recycling) that affect its life cycle using CO2e data. Overall, two WLCs were carried out. The former refers to the current building, and the latter refers to the hypothetical building, respectively: Biocasa (2007) and Ricecycling House (2025). The comparison shows how the EC is distributed on both buildings' life cycles and the potential benefits expected by the Ricecycling House. The contribution describes a research experience that combines the relationship between manufacturing innovation and the Circular Economy, as well as how innovation aligns with EPBD IV requirements and decarbonisation goals in the construction sector.

From Life Cycle Assessment to Whole Life Carbon. The European construction sector is a significant contributor to global warming, accounting for nearly 40% of carbon dioxide equivalent (CO_2e) emissions annually (Li et al., 2025). These releases are associated with the energy needs for cooling and lightning, but also with the materials and products, especially if their production involves the use of heat (like cement, glass, steel, brick, etc.), and processes related to the construction, maintenance, and demolition of buildings (Maduta et al., 2025). Preliminary forecasts indicate that as operational emissions decrease through energy efficiency improvements, embodied emissions from materials and construction become increasingly significant, sometimes accounting for over 60% of a new building's total life-cycle emissions (Röck et al., 2024).

Recognising these facts, the European Union (EU) developed a strategic framework of plans and programmes to tackle climate change and reach continental neutrality by 2050 (EU, 2021). In this context, reducing CO_2e emissions from the construction sector is one of the main challenges highlighted within the 'Fit for 55%' package (European Commission, 2021), which aims to cut them by 55% by 2030. Inside, it is worth noting the revision of the Directive on the Energy Performance of Buildings (EPBD IV) (EU 1275, 2024).

EPBD IV is a cornerstone policy aimed at accelerating the decarbonisation of Europe's buildings (both new and existing) by 2050 through enhanced requirements for energy efficiency, renovation, and reduction of building emissions. A key point of the Directive is the integration of WLC assessment, which combines the OC and EC emissions across the entire building life-cycle (from stage A to stage C). More specifically, WLC can be considered an in-depth Life Cycle Assessment (LCA) that focuses on the Global Warming Potential (GWP) indicator, which enables the assessment of the influence of different GHGs on climate change.

The EPBD IV timeline on the implementation of GWP requirements follows strict, legally binding deadlines:

- By 31 December 2025, the European Commission must amend Annex III of the EPBD IV to define a common assessment framework (EU 1275, 2024, Article 7, Section 3).
- By January 1, 2027, each State must define a roadmap for introducing limit emission values and targets for new buildings (EU 1275, 2024, Article 7, Section 5).
- By January 1, 2028, each new building (if its Useful Floor Area exceeds 1,000 m^2) must perform a WLC assessment (EU 1275, 2024, Article 7, Section 2a).
- By January 1, 2030, each new building must perform a WLC assessment and comply with the limit emissions values defined in 2027 (EU 1275, 2024, Article 7, Section 2b).

Recent studies, including those by the Buildings Performance Institute Europe (BPIE, 2024), highlight the growing adoption of the WLC approach in some EU Member States' regulations. These assessments, already mandatory in Denmark, England, France, the Netherlands, Norway, and Sweden, are often based on the Level(s) framework (Dodd et al., 2017). However, there are some differences (Ramboll and KU Leuven, 2022), since they were developed before the establishment of the EU's WLC vision.

The lack of harmonised methodologies poses challenges for cross-country comparisons and policy effectiveness. Discrepancies in life cycle stages and modules to be addressed, assumptions (e.g. average distances for transport, end-of-life scenarios, etc.), units (e.g. Useful Floor Area, Gross Floor Area, Heated Floor Area, etc.), and data sources can undermine the comparability of WLC results, making it difficult to set a common benchmark across Europe. Establishing common rules and guidelines (Koronen et al., 2025) and supporting the WLC's inclusion in the EU Countries' legislative framework are the main goals of the INDICATE LIFE project (Smith Innovation et al., 2024). Within this project, the Department of Architecture and Design (DAD) of the Politecnico di Torino is part of the Italian consortium. The department has gained experience on the subject of WLC through the #BuildingLife project (WGBC, 2021), the results of which led to the development of the Italian decarbonisation roadmap (GBC Italia, 2022) and the definition of the Italian methodology for calculating WLC (Andreotti and Giordano, 2024).

However, despite Italy's involvement in projects that support the integration of WLC into the design process and regulatory framework, the Italian Buildings Climate Tracker index shows that the Country is not on track to meet its 2030/2050 targets for building-stock decarbonisation (Elnagar et al., 2025).

Therefore, it is necessary to design buildings with a view to not only energy efficiency (Nearly Zero Energy Buildings), but also limiting GHG emissions throughout their life cycle (Nearly Zero Emission Buildings). This new paradigm requires joint action among designers, research centres and enterprises. In this sense, research into prefabricated, short supply chain, secondary raw material-based technological solutions, which involve both new buildings and renovation projects (FIGURE 1), represents a development course to be explored for achieving the EU's 2050 climate targets.

Decarbonisation as a driver of innovation: the Biocasa Sarotto case study. The research on innovative prefabricated solutions begins with a collaboration between the Department DAD and two enterprises: Sarotto Group, based in Narzole (CN, Italy), and Ricehouse s.r.l. based in Andorno Micca (BI, Italy).

Sarotto Group, experienced in the prefabrication of Nearly Zero Energy Buildings (NZEB), provides the case study: the BioCasa Sarotto. It is a single-family house built in 2007 in Narzole, organised on two above-ground levels with a Gross Internal Area (GIA) of 164 m^2 (FIGURE 2). The load-bearing structure is made of cast-in-place reinforced concrete, with a raft foundation and vertical pillars. The roof consists of a precast insulated predalles slab and a metal sheet covering, while the windows are double-glazed and made of aluminium frames. The primary prefabricated elements of the case study are the external and internal walls, which are manufactured using a patented system called Klimasismico. This system combines two concrete slabs (the internal one features a groove to accommodate electrical wiring) with an EPS panel in between.

Over the last few years, the Sarotto Group's willingness to find a more ecological prefabricated solution has led to a partnership with Department DAD, which has carried out research on agri-food waste as building materials (Carbonaro et al., 2021), and RiceHouse s.r.l., an enterprise specialising in the enhancement of rice waste for building material production. Their collaborative work resulted in the development of the RiceCycling Wall prototype, a prefabricated monolithic block composed of a natural mixture of rice husks, natural Prompt® cement, and mineral geopolymeric foam.

Before proceeding with the development of a building-scale mock-up, the research focused on a theoretical study of Whole Life Carbon emissions throughout the entire building life cycle (from production to demolition), comparing the Biocasa Sarotto under a real scenario (Klimasismico) and a hypothetical scenario (RiceCycling Wall). Along with sharing the same production and installation process, and also some functional features, like the internal groove to accommodate electrical wiring, the two systems are different in material composition and technological approach:

- Klimasismico (FIGURE 3) is a prefabricated sandwich wall composed of an inner layer of natural Prompt® cement and an outer layer of a mixture based on Portland cement, structural polymer fibres, and EPS granules, separated by an intermediate EPS insulation board. The double slab configuration combines secondary load-bearing function, thermal inertia and insulation performance.
- RiceCyclingWall (FIGURE 4) is a monolithic, prefabricated wall made from a natural mixture of rice husks (an agricultural by-product of dehusking), natural Prompt® cement, water, and mineral geopolymeric foam. From the inside, the system comprises closure panels crafted from pre-compressed rice straw and Prompt® binder, fixed to a steel stud frame. Moving towards the outside, a base coat of plaster is finished with a skim based on rice husks and natural binders, ensuring material continuity with the wall's core.

The following paragraph summarises the WLC assessment of the two different prefabricated walls by applying them to the same building, the BioCasa Sarotto. To ensure comparability of the results, it was decided to maintain the geometry, orientation, and load-bearing structure unchanged, while assuming the U-value would remain constant. This approach enabled the specific contribution of the two wall systems to be isolated throughout the entire life cycle of the building, and more generally, the impact of choosing different prefabricated systems on reducing WLC emissions to be discussed.

Results: Klimasismico versus RiceCyclingWall. The WLC studies were carried out in accordance with the Level(s) guidelines (Dodd et al., 2017), employing generic data in line with the UNI EN 15804:2012+A2:2019 standard for the single indicator GWP. The assessments were performed using One Click LCA© software (Version: 0.46.4, Database version 7.6).

The system boundaries include modules A1 to A5, B2 to B4, B6, and C1 to C4. The main assumptions for the different life cycle modules are reported below, in line with the Italian methodology (Andreotti and Giordano, 2024) and with the framework currently under development within the European INDICATE LIFE project (Smith Innovation et al., 2024):

- A4 – Transport. Transport distances are defined by assuming 50 km for materials produced locally and 300 km for materials produced nationally.
- A5 – Construction. Impacts are based on generic datasets, except for the prefabricated elements, for which the Italian methodology (Andreotti and Giordano, 2024) is applied instead. The prefabrication process is assumed to contribute an additional 5% to the production-stage impacts (A1–A3).
- B2 – Maintenance. A value equal to 1% of the total impacts from A1 to A5 is assumed (Gibbons et al., 2025).
- B3 - Repair: A value equal to 25% of stage B2 is assumed (Gibbons et al., 2025).
- B4 - Replacement: In accordance with national and international standards, the Reference Study Period (RSP) of the building is set to 50 years. Replacement impacts (B4) are determined by the number of replacement cycles affecting each element and material during the RSP, based on their specific Service Life. Component lifetimes are set in line with the assumptions of the INDICATE LIFE project.
- B6 - For electricity consumption, a common scenario is adopted to isolate the contribution of prefabricated wall systems. As anticipated, it was assumed that the U-value of the modules does not vary between Klimasismico and RiceCycling Wall; consequently, energy consumption and gains are identical for both solutions.
- C1 - Deconstruction: A value equal to 1% of the cumulative impacts of stages A1–A5, B4, and C2–C4 is assumed (Ramboll et al., 2023).
- C2 - Transport: For end-of-life waste transport, an average distance of 50 km to a disposal facility by road is assumed (Andreotti and Giordano, 2024).
- C3, C4 - Waste Processing and Disposal: A 70–30% end-of-life scenario is adopted, where 70% of waste is sent to recovery processes (reuse, recycling, or incineration), and 30% is sent to landfills. Emission factors are based on the Department for Energy Security and Net Zero (DESNZ, 2024) database.

The assessment of the Biocasa Sarotto excludes: interior and exterior paints; electrical, plumbing and HVAC systems; fixed and movable furnishings; metal fasteners; non-standardised minor components (e.g., edge profiles and accessories); adhesive or non-structural joint materials.

TABLE 1 summarises the Whole Life Carbon results for the two scenarios analysed. The first column reports the life cycle stages and modules considered; the second column presents the GHG emissions, expressed in kgCO_2e, for the Business-as-Usual case (Biocasa Sarotto with Klimasismico). The third column shows the emissions associated with the alternative scenario, in which the walls are replaced by the RiceCycling Wall (RCW) system.

The final row provides the total WLC value for each system: 284,074 kg CO_2e, corresponding to 1,732.16 kg CO_2e/m², for the Klimasismico solution, and 272,603 kg CO_2e, equivalent to 1,662.21 kg CO_2e/m², for the RCW solution.

The comparison between the two prefabricated wall systems shows, first, a reduction in emissions in favour of the RCW scenario. When shifting from the Klimasismico to the RCW system, the total value decreases from 284,074 kg CO_2e to 272,603 kg CO_2e, resulting in a savings of 11,471 kg CO_2e for the entire building component, equivalent to approximately 70 kg CO_2e/m². This result represents a modest yet meaningful reduction, which must be interpreted in relation to the breakdown by life cycle stages reported in TABLE 1.

The primary contribution to this reduction stems from the production stages (A1–A3) and the replacement stage (B4). In A1–A3, the RCW system shows lower emissions than the Klimasismico one, already generating an initial benefit at the production stage. This advantage is then amplified in stage B4, which, from a methodological perspective, reflects the repeated replacement cycles of components over the building's reference service life.

Alongside these benefits, the adoption of the RCW system also leads to counterbalancing effects in other stages of the life cycle. In particular, it is heavier than the Klimasismico system, which leads to higher impacts for the transport process to the construction site (A4) and, at the End-of-Life, for waste transport to authorised facilities (C2). Similarly, in the C3–C4 stages of waste processing and disposal, following the adopted methodology and BEIS emission factors, impacts are primarily a function of the quantity of material sent to recovery or landfill. Consequently, the increased mass associated with the RCW system does not generate GWP benefits at this stage. In fact, it causes an increase in emissions compared to the Klimasismico, which partially offsets the advantages obtained in the production and replacement stages.

To analyse the contribution of the different parts of the building, TABLE 2 reports the material mass and associated kgCO_2e emissions, broken down by building parts and elements in accordance with the classification proposed in Level(s) (Dodd et al., 2017, User Manual 2, Table 11, parameter 4.3).

The first column identifies the main building parts, while the second column lists the corresponding technical elements. The third column provides the quantity of material (kg) associated with each component for the two design scenarios (Klimasismico/RCW), and the fourth column presents the CO_2e emissions (kgCO_2e) attributed to the same elements. Where values are identical across the two scenarios, a single figure is reported.

A close reading of TABLE 2 provides insight into the overall quantities of materials involved in the building element. Foundations, structural frames, floor slabs, roof, floors, and internal partitions all contribute substantial masses that define the embodied-carbon *baseline* of the building. Within this context, the amount of material associated with the opaque vertical skin—although not the dominant component in absolute terms—is far from negligible, falling within the same order of magnitude as other key elements.

At the same time, the table shows that—with the sole exception of the façades—all masses and emissions remain identical across the two scenarios, confirming that the analysis focused exclusively and deliberately on the opaque vertical skin.

Passing from the Klimasismico to the RCW system, the mass of the external opaque envelope increases significantly (from 47,749 to 101,085 kg), while the associated CO_2e emissions decrease (from 38,525 to 27,054 kg CO_2e). This result indicates that, despite being heavier, the RCW system has a lower embodied carbon per unit of mass. The increased weight is coherently reflected in the impacts of the transport and end-of-life stages: higher masses result in greater loads to be transported both to the construction site (A4) and to end-of-life treatment facilities (C2), contributing to the higher values observed in these modules for the RCW scenario. Moreover, the reduction in production and replacement impacts, driven by the different material composition and technological nature of the wall system, is substantial enough to offset these penalising effects, ultimately leading to a lower whole-life carbon value at the building scale, as shown in TABLE 1.

Lessons learned and outlooks. The paper presents a joint university–industry experience aimed at reducing embodied carbon in a prefabricated wall system, utilising WLC assessment as a decision-support tool in the design process. From a quantitative standpoint, the case study reveals that replacing the Klimasismico system with the RiceCycling Wall prototype results in an emissions reduction of approximately 11,500 kg CO_2e, corresponding to approximately 70 kg CO_2e/m², by addressing a single technological element in a building already designed as an NZEB. The breakdown by life cycle stages highlights that the benefit is concentrated in the Production stages (A1–A3) and in the Replacement stage (B4), whereas the Transport (A4) and End-of-Life stages (C2–C4) are penalised by the increased mass of the RCW system.

From a methodological standpoint, the study confirms the usefulness of WLC assessment, carried out in accordance with LCA standards, UNI EN 15804:2012+A2:2019, and the Level(s) framework, as an operational tool for comparing alternative prefabricated solutions in a controlled manner. Keeping geometry, load-bearing structure and energy performance unchanged made it possible to isolate the contribution of the opaque vertical envelope alone and to directly link material choices (bio-based, short supply chain, etc.) to the decarbonisation goals set by EPBD IV and by the Italian WLC methodology.

The study has some limitations related to the use of a single case study, a prototype that has not yet been industrialised, and partially generic data; nevertheless, it confirms the potential of WLC as a practical tool to steer product innovation in line with EPBD IV. Future developments may concern the optimisation of the RCW system (mass, stratigraphy, primary data) and the extension of the approach to other prefabricated components and to additional environmental and performance indicators.

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Figures.
FIGURE 1 - (a) Prefabricated temporary house (Circular Economy Building) with wood-based recycled elements by ARUP, London, photo by Simon Kennedy, courtesy of Arup Associates; (b) Prefabricated wall made of rice by-products by RiceHouse for a renovation project (Torri Risorsa), Milan, photo by Tiziana Monteristi, https://blog.ricehouse.it/pannelli-isolanti-estetici-la-bellezza-naturale-che-circonda-la-casa.
FIGURE 2 - The Biocasa Sarotto, (a) South-east elevation, photo by Mauro Sarotto; (b) Longitudinal section, authors' elaboration.
FIGURE 3 - Klimasismico, (a) Stratigraphy. From ext. to int.: 1. Fibre-reinforced exterior plaster, 2. Outer slab with Portland cement, 3. EPS, 4. Galvanised steel single-frame truss, 5. Inner slab with Prompt® cement, 6. Services cavity, 7. Plasterboard panel, authors' elaboration; (b) Photo from a full-scale mock-up, photo by Mauro Sarotto.
FIGURE 4 - RiceCycling Wall, (a) Stratigraphy. From ext. to int.: 1. Plaster with a skim based on rice husks and natural binders, 2. Monolithic element made by rice husks, natural Prompt® cement, water, and mineral geopolymeric foam 3. Steel stud frame, 4. Services cavity, 5. Pre-compressed rice straw board and Prompt® binder, authors' elaboration; (b) Photo from a full-scale prototype, photo by Mauro Sarotto.

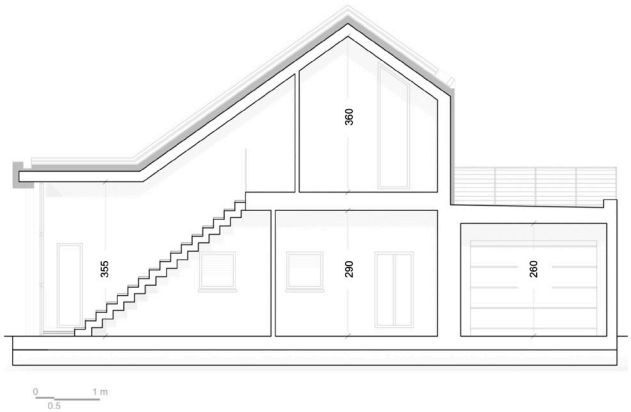
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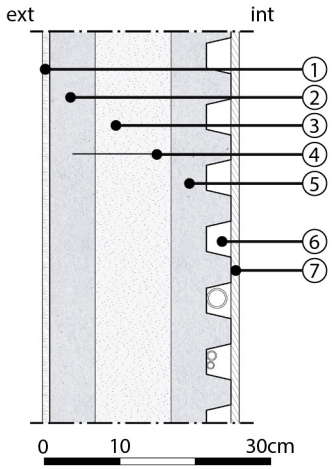


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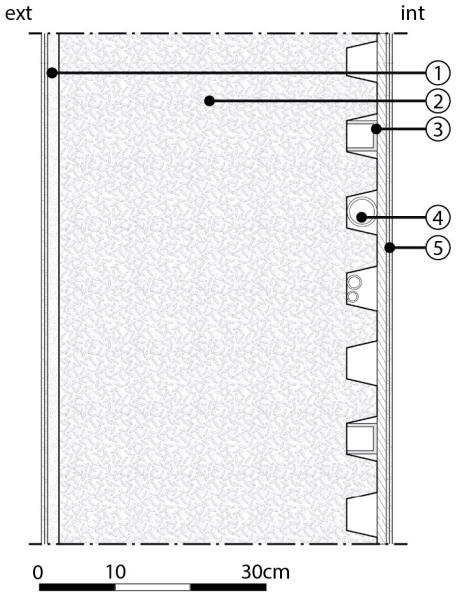




Table 1. Breakdown by life cycle stages and modules of the WLC results of the two system alternatives.

Life-cycle stages and modules	Biocasa Sarotto (Klimasismico) [kg CO_2e]	Biocasa Sarotto (RiceCycling Wall - RCW) [kg CO_2e]
A1-A3 Construction	90,769	84,064
A4 Transport	1,381	2,639
A5 Construction	4,778	4,457
B2, B3 Maintenance, Repair	1,212	1,140
B4 Replacement	96,361	90,594
B6 Energy consumption	86,240	86,240
C1 Demolition	1,947	1,834
C2 Transport	794	962
C3, C4 Waste, Disposal	593	674
WLC	**284,074**	**272,603**

Table 2. Mass and CO_2e emissions by building parts and elements, according to the Level(s) classification, for the two prefabricated wall systems (Klimasismico and RiceCycling Wall).

Building parts	Building elements	Quantity [kg]		CO_2e emissions [kg CO_2e]	
		Klimasismico	RiceCyclingWall	Klimasismico	RiceCyclingWall
Foundations (substructure)	Basements	90,200		12,310	
Load-bearing structural frame	Frame (beams, columns and slabs)	20,160		2,707	
	Upper floors	25,689		10,098	
Façades	External wall systems, cladding	47,749	101,085	38,525	27,054
	Façade openings	3,064		36,313	
	Shading devices	904		24,695	
Roof	Structure	19,832		5,960	
	Weatherproofing (insulation)	456		3,345	
	Weatherproofing (waterproofing)	670		942	
	Finishing	3,780		5,511	
Non-load-bearing elements	Ground floor slab	26,939		39,010	
	Internal walls	8,434		8,932	
	Internal doors	184		696	
	External doors	2,891		6,076	
	Stairs	406		775	
Landscaping	Fencing, railings and walls	698		1,938	
TOT		252,053	305,389	197,833	186,362

BETWEEN EPHEMERALITY AND PERMANENCE /

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Abstract. The textile material, known and used for thousands of years, was and is ephemeral by its very physical materiality: that of the natural raw material from which it is made. The perishability of natural raw materials (whether of plant or animal origin), which degrades relatively quickly, having a limited life cycle, has also led to the disappearance of objects made with them. The 20th century, among its many inventions and innovations, also brought us synthetic textile materials which, through their chemically formulated life, seem to enjoy perpetuity, which is not sustainable and does not correspond to a natural life cycle and therefore, in a way, neither to our transient nature. In recent decades, research has revealed the possibility of having new natural sources of raw materials and possibilities for recycling synthetic materials. The article does not deal with textiles per se, but rather their presence as a variable architectural form. The theoretical investigation dedicated to the connection between architecture and textiles, which has developed especially in the last twenty years after Marc Garcia coined the term Architextiles, together with the technical possibilities and research in the field, have given impetus both to the positioning of textiles on another level of importance and to the multiplication of the use of textiles also at the exterior of the architectural object. Once the field of investigation was opened, it was proven that textiles are very present in architecture, both under the classic uses inside and outside (with new, high-performance materials, with special characteristics) and as a means of communication. For the case analyses, the tent was chosen as the subject of study, as an architectural object which, beyond its materiality, subject to the passage of time, became permanent through the development of its typology as a cultural archetype.

Introduction - textiles between ephemeral and permanence. This article is part of the author's ongoing research, spanning approximately 30 years, at the intersection of architecture and textiles. One of the subthemes of the research, which has been addressed before but is recurrent with a tendency to become permanent, is the relationship between the ephemerality of the textile material itself and its millennial and contemporary presence in our lives, both on a personal level and in terms of architectural space.

Textiles, known and used for thousands of years, were and are ephemeral due to their physical materiality: that of the natural raw material from which they are made. Given its wide range of uses, from clothing people to "dressing houses" (or even building houses out of textiles), we have few examples left from centuries past, and especially from millennia ago. The perishability of natural raw materials (whether of plant or animal origin), which degrade relatively quickly and have a limited life cycle, has also led to the disappearance of objects made from them. The remaining evidence has sometimes been preserved by chance, in extreme conditions (such as the world's oldest carpet, found in a Scythian tomb preserved in the ice of the Pazyryk Valley in the Altai Mountains of Siberia, after about 2,500 years) or through care taken for life after death (objects found in the tombs of Egyptian pharaohs), although even these, when we intrude into their isolated environment, become fragile and easily destructible. In the vast majority of cases, precious objects have been preserved, objects of cult or of great artistic or intrinsic value, thus receiving attention and being passed down from generation to generation.

We can take our country as an example, where most of the preserved textile heritage is at most a few centuries old, with older examples found in cult textiles (especially those used in worship), while popular textiles are only about 200-250 years old.

The use of natural materials, which are biodegradable by their very structure, meant that for millennia there was practically no textile waste. In addition, production was relatively limited (there was no overproduction) and valuable items were passed down from generation to generation, often documented (dowry sheets, wills, donations, etc.).

The 20th century, among its many inventions and innovations, also brought us synthetic textiles, which, due to their chemical composition, seem to enjoy eternal life. We were thrilled when, in 1935, Dupont patented Nylon. After enthusiastically and ubiquitously using synthetic textiles, we realized that they are not sustainable, are difficult to degrade, and, apart from the immense resources used for their manufacture—as in the entire textile industry, in fact—they pollute our planet to a much greater extent than we could have imagined. So now, a century later, we realize that the life cycle of materials, especially textiles, was natural and corresponded, in a way, to our own transient nature. Now we want to be able to eliminate (most) of the objects made of synthetic materials, but we are unable to do so. Or, at least not in our lifetime. And so we are looking for solutions to a problem that we have created ourselves, with our ingenuity, thirst for knowledge, and inventiveness. Solutions have begun to be found, such as the recovery of objects and their introduction into one of the phases of circularity—10 phases, from recovery to refusal (Kirchher et al., 2017)—but these solutions often run into the difficulty of separating the materials from which complex objects are made. In addition to combining materials, our inventions and innovations and complex technologies have succeeded in introducing special qualities and resistance to each material, which often makes the recycling process more difficult. Greater mechanical strength of the material also means greater effort is required to destroy or transform it. Its elasticity requires innovative solutions if we want to tear a piece apart. Resistance to UV rays or high temperatures poses other problems in the recycling process. The very dismantling of a complex object and sorting it by material type is a difficult process that is only just beginning to be carried out with the help of technology (rather than manually), through optical (microscopic) identification of the type of fiber.

Beyond research dedicated to recycling synthetic materials, in recent decades, both fundamental research conducted by major institutes and