GAZİOSMANPAŞA BİLİMSEL ARAŞTIRMA DERGİSİ (GBAD)
Gaziosmanpasa Journal of Scientific Research
ISSN: 2146-8168
http://dergipark.gov.tr/gbad
Research Article

Cilt/Volume : 15
Sayı/Number: 1
Yıl/Year: 2026
Sayfa/Pages: 55-69

***Alınış tarihi (Received)*:** 31.12.2025
***Kabul tarihi (Accepted)*:** 09.01.2026

Evaluation of Material Selection Impact on Replacement-based Embodied Carbon Emissions: A Case Study in Tokat

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ABSTRACT: Embodied carbon emissions play a critical role in mitigating climate change in the built environment. Reducing the embodied carbon footprint has become increasingly important across distinct areas. Construction activities have a remarkable impact on embodied carbon emissions. During building use, material and component obsolescence, or the end of their service lifetime, triggers building replacements. These replacement-based construction activities lead to embodied carbon emissions. The replacements vary due to distinct material and component choices and have variations in embodied carbon emissions. Hence, this study aims to assess the impact of material selection on embodied carbon emissions for building replacements in the scope of a representative building in Tokat. The embodied carbon emissions of replaceable building elements and components were manually calculated for the use phase of the buildings. In this regard, two distinct replacement-based scenarios were created for the reference building. While conventional materials were selected for replacements in the first scenario, low-carbon materials were chosen in the second. The results revealed that 36% of embodied carbon emissions (12.7 t CO2e) can be reduced by choosing more environmentally friendly materials with lower carbon emissions, such as wooden, water-based, and emulsion-based materials. The waterproofing membranes, roofing tiles, windows, and interior doors were significant elements and components in the case study, helping reduce total embodied carbon emissions. The results showed the importance of material selection for building replacements, which is crucial for architects, engineers, and decision-makers to provide more sustainable solutions within the scope of replacement-based embodied carbon emissions.

***Keywords** – Embodied carbon emissions, Material selection, Low-carbon materials, Buildings, Built Environment*

1. Introduction

Reducing carbon emissions in the built environment has become increasingly important due to their contribution to climate change. Buildings, as part of the built environment, contribute to embodied carbon emissions during use and construction phases (Cabeza et al., 2022; Bayraktar et al., 2023). The buildings need replacement during the use phase; therefore, material selection is crucial due to its impact on carbon emissions (UNEP, 2023). Comparative analyses help decision-makers optimize the environmental impacts of building construction through different material choices (Barbhuiya and Das, 2023). Hence, replacement-based embodied carbon emissions should be considered at the beginning of construction, and scenarios should be developed to detect potential decreases in embodied carbon emissions.

Embodied carbon emissions from cradle to gate were assessed in A module, and those from cradle to grave were evaluated by including B and C modules in addition to A module in accordance with EN 15978 (Sturgis, 2017). There is limited representation of replacements in carbon emissions calculations, and distinct service-life assumptions for building components lead to variations in estimates (Z. Chen et al., 2025). Moreover, various studies evaluate embodied carbon emissions from cradle to gate by considering A1-A3 phases. Additionally, there are fewer efforts toward a cradle-to-grave approach that covers carbon emissions from reuse and end-of-life parts (Bacheva and Raposo Grau, 2025). Cabeza et al. (2021) conducted a literature review on embodied energy and carbon of materials and highlighted that most studies used the cradle-to-gate approach. Additionally, the authors highlighted the limited available data on this topic and the need for further research. On the other hand, Myint and Shafique (2024) conducted two distinct case studies to compare carbon emissions from them using different types of materials and revealed that the scenario with low-carbon materials resulted in a 39%-40% decrease in carbon emissions. However, the authors only considered embodied carbon emissions from material production and transportation.

Furthermore, Balasbaneh et al. (2019) analysed the carbon emissions and costs of five types of walls and defined distinct percentages for repair and replacement under flooding at low and high levels, as well as in non-flooding situations. They suggested using bricks in flood zones as an optimized solution and timber in non-flood zones in Malaysia, considering both emissions from cradle to grave and costs. On the other hand, Dsilva et al. (2023) assessed the embodied carbon emissions from A1-A3 phases for a building in Dubai by focusing on structural materials. The authors revealed that using green concrete and steel led to a 26% decrease in carbon emissions. They highlighted new recyclable materials, and distinct technologies can be integrated for circular built environment applications. Given the new technologies, Bradford et al. (2025) conducted a case study to assess embodied energy, carbon emissions from cradle to gate, and costs for walls made from distinct materials. They revealed that wood-framed walls resulted in lower costs and lower carbon emissions than cementitious 3D-printed walls. Even though 3D-printed walls can be a solution to the housing crisis, developing more environmentally friendly materials is suggested to achieve cementitious 3D-printed walls with lower emissions than their wood-based alternatives. The review by D. Chen et al. (2025) identified trends and advancements in embodied carbon emissions of office buildings in China, accounting for material production, transportation, and construction. They suggested renovating rather than demolishing, selecting recycled materials to promote circularity, and choosing low-carbon materials. Their study emphasized the importance of governments setting embodied carbon benchmarks to manage embodied carbon budgets in future projects effectively.

Huang et al. (2025) reviewed embodied carbon assessments integrated with BIM (building information modelling) and showed that there is a lack of component-level design approaches at the early stages of projects. They highlighted the importance of aligning design decisions on embodied carbon emissions with regional benchmarks, while suggesting the establishment of flexible, standardized databases for life-cycle inventory. Furthermore, Jeleniewicz et al. (2025) conducted a case study using a small modular house with a 35-square-meter footprint in Poland and assessed circularity and the carbon emissions from A1-A3 (production) and C3 (waste management) phases, and the D (recycling potential) stage. Their comparison of two distinct structural materials revealed that timber had lower carbon emissions, even though integrating steel with timber structures is needed to comply with circularity principles.

The literature review highlighted the importance of material selection, considering embodied carbon emissions, in the early design phase. The A module, especially the A1-A3 phases, was mainly studied using a cradle-to-gate approach. However, replacements in the B module and end-of-life parts in the C module for a cradle-to-grave approach should also be integrated into existing building cases instead of hypothetical ones. Moreover, replacement-based embodied carbon evaluations are essential and should not be underestimated. In this regard, this study assessed the material selection impact on embodied carbon emissions of a case house in Tokat due to building replacements, considering material production and transportation (A1-A4 phases), replacement (B4 phase), waste transportation and disposal (C2 and C4). Considering this objective, two distinct scenarios were created to compare the impacts of conventional and low-carbon material selections on carbon emissions and to identify potential carbon-emissions reductions.

2. Material and Methods

The life cycle assessment was conducted to quantify embodied carbon emissions due to replacements for a reference building in Tokat, Türkiye.The AutoCAD drawings of a typical one-storey reinforced concrete building, provided by the T.C. Ministry of Environment, Urbanisation and Climate Change (MoEUCC, n.d.), served as the reference residential building, and a Revit model was created based on them. The gross floor area of the case study, derived from the Revit model, is 121 square meters. The building has distinct spaces, including an entrance hall, two types of living rooms, a kitchen, two bedrooms, a bathroom, a small hall, a toilet, a storage room, and two verandas. The reference building was examined as a case study to calculate replacement-based embodied carbon emissions, and the Revit model of the created building was used to extract quantities of replaceable building elements and components (Figure 1).

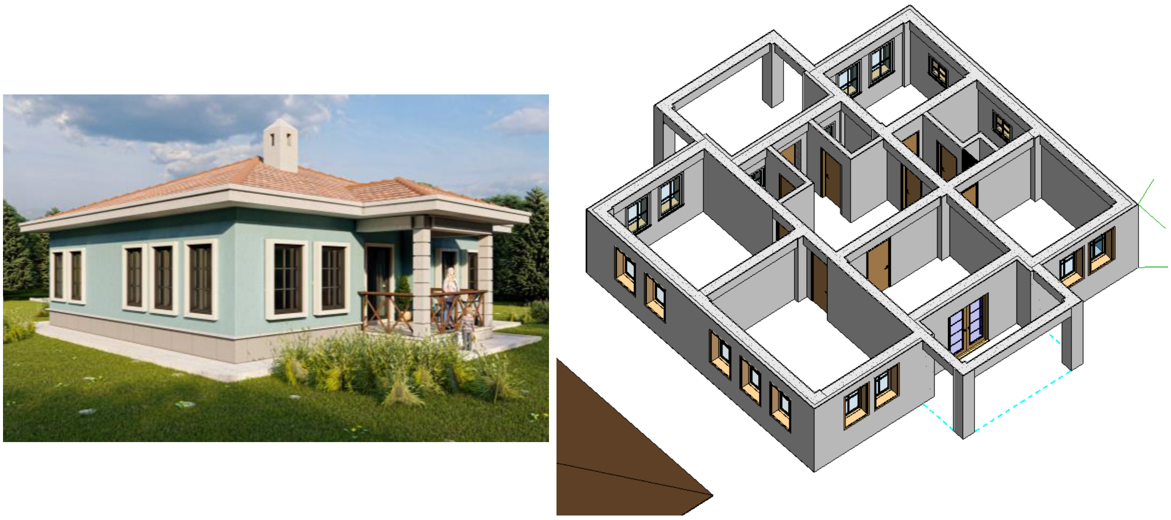

Figure 1. Reference building (left) as a case study (MoEUCC, n.d.) and a part of the created Revit model (right)

Two distinct scenarios were created to evaluate replacement-based embodied carbon emissions, accounting for conventional and low-carbon material use. A life cycle inventory analysis was conducted for replaceable building elements to reveal the embodied carbon emissions for each material type in the scenarios. The building service lifetime was assumed to be 50 years. In contrast, the service lifetimes of each material were determined through life-cycle inventory analysis by examining their environmental product declaration (EPD) documents. The One Click LCA, Ecoinvent, and GaBi databases, embodied in the One Click LCA tool, were mainly used to obtain EPD documents. In this scope, embodied carbon emissions of two different scenarios were assessed considering a partial cradle-to-grave approach in the scope of replacement-based LCA, including production (A1-A3 phases), transportation (A4 phase), replacement (B4 phase), transportation for disposal (C2 phase), and disposal process (C4 phase) (Figure 2).

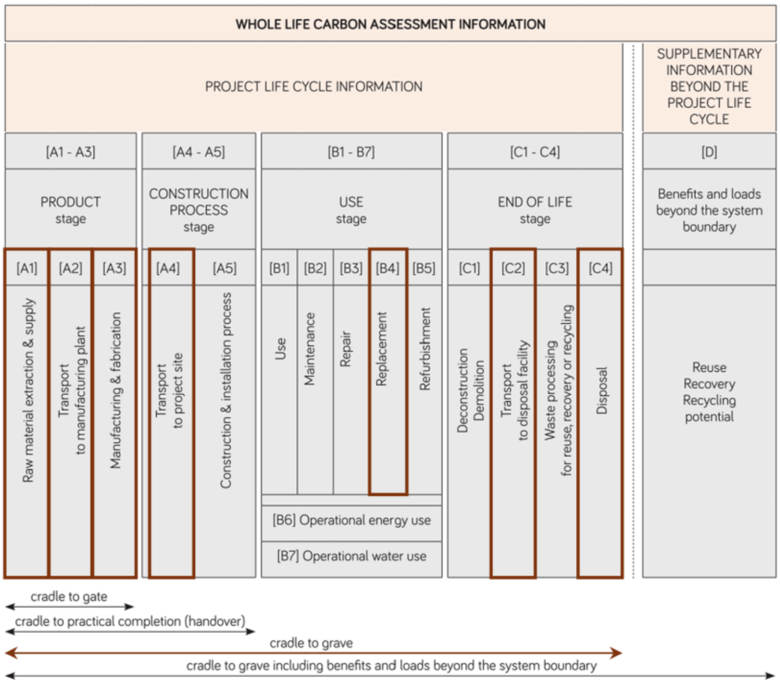

Figure 2. LCA stages with phases (derived from Sturgis, 2017)

The replaceable building elements during the use phase were included in the LCA calculations. These elements include ground tiles and flooring, roofing tiles and the waterproofing membrane, windows, doors, and exterior and interior painting due to their higher replacement frequency. The embodied carbon emissions were manually calculated in accordance with EN 15978 (BRE Global, 2018) based on a replacement-based LCA approach, by considering A1-A3, A4, B4, C2, and C4 phases calculations.

The A1-A4 phases in A modul and the B4 phase in B modul were considered in this study due to the replacement-based approach. In contrast, the A5 phase in A modul and the C1 and C3 phases in C modul were excluded to focus on the impact of different materials rather than on assembly and disassembly effects. In this regard, the following equations in Figure 3 were used in this study for embodied carbon assessments.

$$GWP_{A1-A3} = \sum_{i=1}^{n} (Q_i \; x \; GWP_{A1-A3,i})$$

$$GWP_{A4} = \sum_{i=1}^{n} (Q_i \; x \; D_i \; x \; EF_{A4-transport,i})$$

$$GWP_{B4} = \sum_{i=1}^{n} N_{replace,i} \; x \; (GWP_{A1-A3,i} + GWP_{A4-A5,i} + GWP_{C1-C4,i})$$

$$GWP_{C2} = \sum_{i=1}^{n} (Q_i \; x \; D_i \; x \; EF_{C2-transport,i})$$

$$GWP_{C4} = \sum_{i=1}^{n} (Q_i \; x \; GWP_{C4,i})$$

GWP: $Global\ warming\ potential$

Q: $Quantity\ of\ the\ material$

D: $Distance$

EF: $Related\ emission\ factor$

$N_{replace}$: $Number\ of\ replacements$

Figure 3. Replacement-based LCA equations[1] used in this study (derived from BRE Global 2018; Z. Chen et al. 2025)

3. Results and Discussion

The life cycle inventory analysis and embodied carbon emission results in the scope of the replacement-based LCA approach were provided to discuss the results. Life cycle inventory analysis was conducted for two distinct scenarios, considering different material selections. While the first scenario was created conventionally using typical building elements such as PVC-framed windows, the second scenario was created using materials with lower embodied carbon emissions, such as wooden-framed windows and doors, and water- and emulsion-based wall finishes. As summarized in Table 1, nine material-related parameters varied between two distinct scenarios: ceramic tiles and laminate flooring on the ground, roof membranes, windows, interior doors and an exterior door, exterior and interior wall paintings, and roofing tiles. The required futures of the materials, such as embodied carbon emissions and mass per the mentioned functional unit, were extracted from their environmental product declaration (EPD) documents. These documents were obtained from databases such as One Click LCA, Ecoinvent, and GaBi, accessed through the One Click LCA tool (One Click LCA, n.d.). Embodied carbon emissions for A1-A3 phases were given as kgCO2e/kg instead of kgCO2e/m^2 for some of the materials in their

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[1] A5, C1, and C3 phases were excluded from this study due to insufficient data. Hence, A module was represented by A4, while the C module was represented by C2 and C4 phases in this study. The impact of the A5, C1, and C3 phases embedded in the B4 equation was assumed to be zero due to a lack of data.

EPD documents, such as exterior and interior paintings. Hence, the quantities were also calculated in kilograms by multiplying the area (square meters) by the mass per functional unit. The quantities in kilograms were calculated for the conventional scenario (CS) and the low-carbon scenario (LCS) by multiplying the quantities in square meters by mass per unit values reported in EPD documents for distinct selected materials (Table 1).

Table 1. Life cycle inventory analysis for the case study, quantities

Building parts group	Building elements	Item	Project Quantity (m²)	CS - Project Quantity as kg	LCS - Project Quantity as kg
Superstructure	**Floors**	Ceramic tiles as coverings on the ground (CS: conventional tiles, LCS: alternative tiles with lower embodied carbon)	59	777.0	1362.9
		Laminate flooring on the ground (CS: conventional wood boards, LCS: wood fibres)	62	433.4	678.9
	Roof	Waterproofing membrane (CS: synthetic rubber membrane, LCS: water-based membrane)	203.9	397.6	422.1
	Windows	Windows (CS: PVC framed, LCS: Wooden framed)	20.2	868.6	808.0
	Doors	Interior wooden doors (CS: conventional wooden doors, LCS: wooden doors with lower embodied carbon)	18	648.0	795.6
		Exterior steel door	2	117.8	117.8
		Exterior door, double-glazed (CS: PVC framed, LCS: Wooden framed)	4	142.4	147.2
External Finishes	**Wall finishes**	Exterior painting (CS: water-based, LCS: acrylic emulsion-based)	119.3	20.3	8.6
	Roof finishes	Roofing tiles from clay (CS: conventional roofing tiles, LCS: alternative roofing tiles with lower embodied carbon)	203.9	8767.7	7136.5
Internal Finishes	**Wall finishes**	Interior painting (CS: top coat paint, LCS: acrylic water-based)	295.6	23.6	17.4

The embodied carbon emissions for each material were examined under two distinct scenarios using EPD documents in databases such as One Click LCA, Ecoinvent, and GaBi, which were accessed through the One Click LCA tool (One Click LCA, n.d.). The detailed EPD information was provided in Annex, Table 4. Additionally, the service lifetimes of the materials were redefined in accordance with national documents (Resmi Gazete, n.d.) and used in B4-replacement phase calculations. The replacement numbers for each material were considered for the B4 phase by dividing the building service lifetime by the service lifetime of the material (Table 2).

Table 2. Life cycle inventory analysis for the case study, service life, and carbon emissions (A1-A3 phases)

Building parts group	**Building elements**	**Item**	**Service Life**	**Functional Unit (FU) for A1-A3**	**CS - kgCO2e/ <u>FU</u> (A1-A3)**	**LCS - kgCO2e/ <u>FU</u> (A1-A3)**
Superstructure	**Floors**	Ceramic tiles as coverings on the ground	20	m²	7.22	6.36
		Laminate flooring (CS: conventional wood boards, LCS: wood fibres)	20	m²	4.73	0.0159
	Roof	Waterproofing membrane	10	m²	6.85	2.37
	Windows	Windows (CS: PVC framed, LCS: Wooden framed)	25	m²	99.65	74.51
	Doors	Interior wooden doors	20	m²	57.83	50.7
		Exterior steel door	25	m²	191.66	191.66
		Exterior door, double-glazed (CS: PVC framed, LCS: Wooden framed)	25	m²	109	49.4
External Finishes	**Wall finishes**	Exterior painting (CS: water-based, LCS: acrylic emulsion-based)	10	<u>kg</u>	<u>5.58</u>	<u>2.16</u>
	Roof finishes	Roofing tiles from clay	10	m²	7.26	5.91
Internal Finishes	**Wall finishes**	Interior painting (CS: top coat paint, LCS: acrylic water-based)	5	<u>kg</u>	<u>5.58</u>	<u>2.57</u>

The worst-case scenarios were adopted for the transportation of materials to the sites for the A4 phase and for their disposal at the end of the lifetime for the C2 phase. The distances from cities were derived from Google Maps, using the shortest driving route

(Google Maps n.d.). In this regard, the transportation distance for the A4 phase was assumed to be 377 km, with material supply from Ankara, Türkiye's capital, to Tokat, as a conservative approach to account for possible variations in the supply chain, pandemic, or post-disaster conditions. On the other hand, the transportation distance for the C2 phase was assumed to be 107 km for disposal in case of potential unavailability for disposal of building elements and components.

The embodied carbon emissions for the A4, C2, and C4 phases were also extracted from the EPD information summary provided by the One Click LCA tool for each material in both scenarios. In this regard, it was observed that the embodied carbon emissions for these phases were similar, with slight variation. In the A4 phase for transportation by truck or trailer combination, the embodied carbon emissions of interior and exterior paintings were equal to 0.0928 kg CO2e / tonkm (approximately 0.00009 kg CO2e / kgkm), while those of the rest were 0.0383 kg CO2e / tonkm (approximately 0.00004 kg CO2e / kgkm) in both scenarios (Table 3).

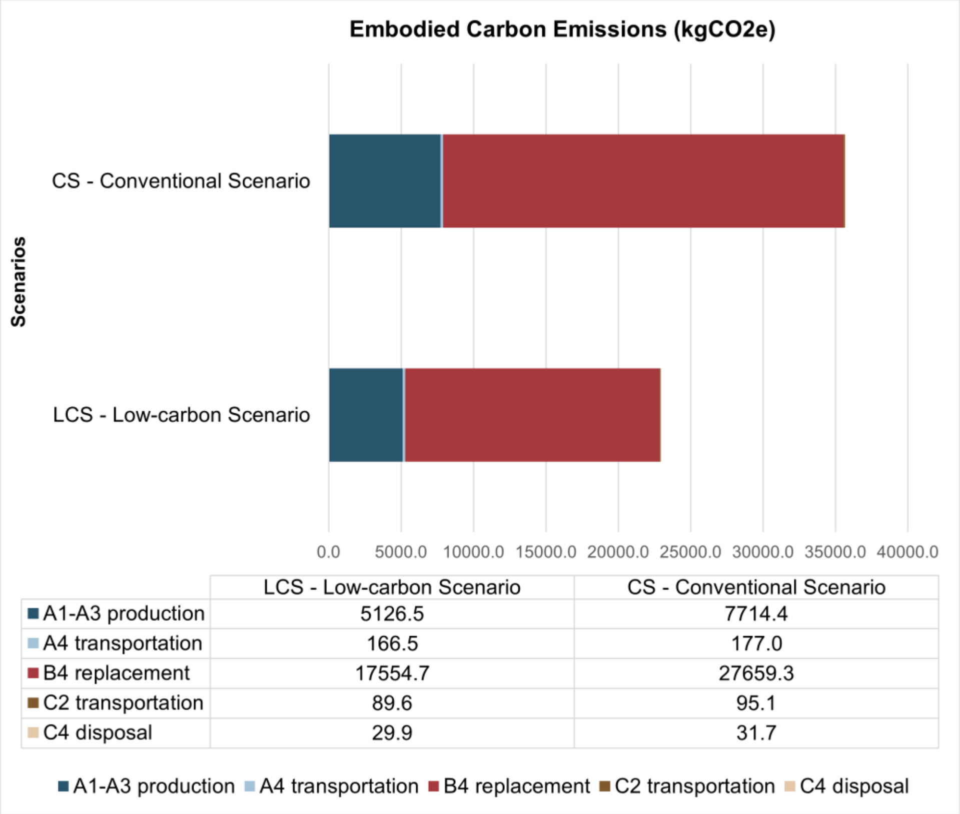
Table 3. Life cycle inventory analysis for the case study, carbon emissions (A4, C2, and C4 phases)

Phases	**Building elements and components**	**Carbon emissions kgCO2e/ kgkm**
A4 phase - transportation	Ceramic tiles and laminate flooring on the ground, waterproofing membrane, windows, interior wooden doors, exterior steel door, double glazed exterior door, roofing tiles from clay	0.00004
	Interior and exterior paintings	0.00009
C2 phase - transportation for disposal	Ceramic tiles and laminate flooring on the ground, waterproofing membrane, windows, interior wooden doors, double glazed exterior door, roofing tiles from clay, interior and exterior paintings	0.00007
	Exterior steel door	0.00004
C4 phase - disposal	Ceramic tiles and laminate flooring on the ground, waterproofing membrane, windows, interior wooden doors, exterior steel door, double glazed exterior door, roofing tiles from clay, interior and exterior paintings	0.0026

In the scope of the C2 phase for transportation of disposals, the embodied carbon emissions of the exterior steel door were 0.0383 kg CO2e / tonkm (approximately 0.00004 kg CO2e / kgkm), whereas those of the rest were 0.0732 kg CO2e / tonkm (approximately 0.00007 kg CO2e / kgkm) in both scenarios. In the C4 phase for the disposal of materials through landfilling, the embodied carbon emissions were 0.0026 kg CO2e/kg for each material in both scenarios (Table 3). EPD numbers and database information were provided in Annex

(Table 4) to verify embodied carbon emissions, and this information can be verified in the related databases embedded in the One Click LCA tool.

The replacement-based LCA results were calculated by estimating embodied carbon emissions for each scenario, considering their distribution across LCA phases and building elements and components. The most embodied carbon emissions occurred during the B4 phase due to replacements, while the A1-A3 phases were the second contributors to carbon emissions in both scenarios. On the other hand, the A4, C2, and C4 phases contributed remarkably lower amounts of carbon emissions in both scenarios. In total, the embodied carbon emissions of the conventional scenario (CS) were 35.7 t CO2e, whereas those of the low-carbon scenario (LCS) were 23 t CO2e. In this way, a 36% decrease in total embodied carbon emissions was achieved through the low-carbon scenario compared to the conventional scenario (Figure 4).



	LCS - Low-carbon Scenario	CS - Conventional Scenario
■ A1-A3 production	5126.5	7714.4
■ A4 transportation	166.5	177.0
■ B4 replacement	17554.7	27659.3
■ C2 transportation	89.6	95.1
■ C4 disposal	29.9	31.7

Figure 4. Embodied carbon emissions of each scenario, considering LCA phases

Considering LCA phases, the 37% decrease in carbon emissions was achieved in the B4 phase due to replacements, while a 34% decrease was obtained in the A1-A3 phases due to production. Although there were slight decreases in embodied carbon emissions for the A4, C2, and C4 phases (10, 5, and 2 kg CO2e, respectively), the reductions were 6% in each phase between the two scenarios (Figure 4).

The embodied carbon emissions results were also analyzed by building element and component classification, considering the replacements in the scenarios. In the low-carbon scenario, building elements and components having lower carbon emissions than those in the conventional scenario were selected, such as emulsion-based and wooden-based products. In the conventional scenario, the clay roofing tiles, the waterproofing membrane, and the PVC-framed windows had higher embodied carbon emissions (10.2, 8.4, and 6.1 t CO2e, respectively) than the other replaced building elements and components. Meanwhile, in the low-carbon scenario, clay roofing tiles, wooden-framed windows, and interior wooden doors resulted in higher embodied carbon emissions (8.3, 4.6, and 3.3 t CO2e, respectively) than the rest (Figure 5).

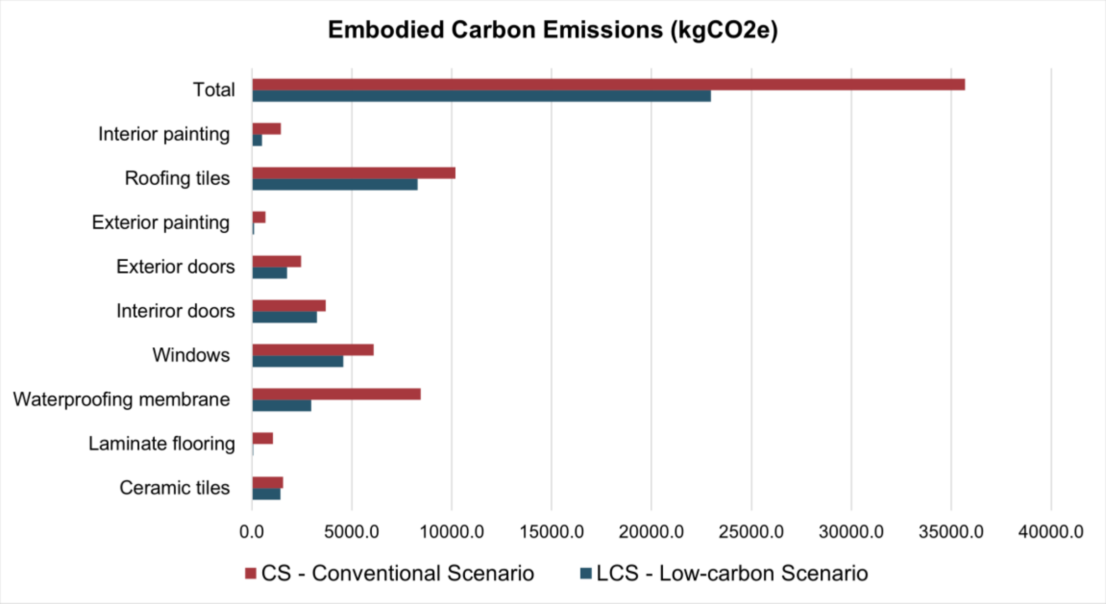


Figure 5. Embodied carbon emissions of each scenario, considering building elements

The most significant decrease in embodied carbon emissions, within the building element and component classification, occurred through the replacement of waterproofing membranes. A 5.5 t CO2e of the total 12.7 t CO2e reduction in carbon emissions was achieved by using a water-based waterproofing membrane instead of a synthetic rubber membrane (Figure 5). Roofing tile replacements contribute to a 1.9 t CO2e decrease, making them the second most crucial replacement in this study. On the other hand, using wooden-framed windows instead of PVC-framed types resulted in a 1.5 t CO2e reduction after the replacements (Figure 5).

4. Discussion

The literature highlights the importance of the material selection impacts on embodied carbon emissions (D. Chen et al., 2025; Jeleniewicz et al., 2025; UNEP, 2023). A module, especially the A1-A3 phases (production), has been widely studied (Cabeza et al., 2021). However, more studies are needed on the B4 phase for replacements, given its significant impact during the use phase (Z. Chen et al., 2025). Integration of related phases in the C stage (end-of-life stage) and the use of sustainable materials yield a more sustainable circular environment (Bacheva and Raposo Grau, 2025; Dsilva et al., 2023).

In this study, the embodied carbon results for the low-carbon (LCS) and conventional (CS) scenarios indicated that 36% of carbon emissions could be saved by reducing total carbon emissions by 12.7 t CO2e in LCS relative to CS. In both scenarios, the B4 and A1-A3 phases were the highest contributors to embodied carbon emissions, respectively. The embodied carbon emissions from the B4 phase were more than three times higher compared to the A1-A3 phases in both scenarios. This result showed the remarkable impact of replacement-based embodied carbon emissions across scenarios.

Additionally, the clay roofing tiles, the waterproofing membrane, and the PVC-framed windows were the major contributors to embodied carbon emissions (10.2, 8.4, and 6.1 t CO2e, respectively) in the CS scenario. In contrast, the main contributors to these emissions in the LCS scenario were clay roofing tiles, wooden-framed windows, and interior wooden doors (8.3, 4.6, and 3.3 t CO2e, respectively). Choosing water-based type waterproofing led to the most significant carbon savings compared to using a synthetic rubber membrane (a 5.5 t CO2e reduction out of a total of 12.7 t CO2e reduction).

Furthermore, differences in mass per square meter, which were affecting quantities in kilograms, also led to variations in embodied carbon emissions for the same types of materials. Although roofing tiles were clay-based in both scenarios, those in the low-carbon scenario were selected from low-carbon types. Additionally, the roofing tiles with low emissions in the LCS scenario had a lower mass per square meter, which affected their quantities in kilograms (Table 1). Hence, they reduced carbon emissions in the A1-A3 phases due to their lower emissions, and further decreased emissions in the remaining phases due to their lower quantities in kilograms.

Beyond the embodied carbon emissions of the building elements and components per phase, their quantities also affected the case study's total carbon emissions (Tables 1, 2, and 3). Some of the replacements contributed less to total embodied carbon emissions because they were used in lower quantities in the case study. However, they indicated potential material-level emissions reductions, such as using laminate flooring with wood fibres instead of conventional wood boards (MDF/HDF/particle boards), water-based interior paints instead of conventional paints, and emulsion-based exterior paints instead of water-based versions. Nevertheless, their contributions to total carbon emissions were limited by the low flooring area and the low paint mass used in the study. Additionally, windows had a significant impact on total carbon emissions in each scenario, as they had higher embodied carbon despite their low square meterage (Figure 5).

5. Conclusion

This study assessed the impact of material selection on replacement-based embodied carbon emissions of a reference building in Tokat, considering material production, transportation (A1-A4 phases), replacement (B4 phase), waste transportation and disposal (C2 and C4 phases).

The results showed that the low-carbon scenario (LCS) featured strategic material choices, selecting more sustainable, low-carbon materials, such as emulsions, water, and wood-based materials, compared to the conventional scenario (CS). In respect of these two distinct scenarios, the replacement-based embodied carbon assessments were manually conducted in accordance with EN 15978. In total, 36% of embodied carbon emissions were saved through strategic material selection in LCS relative to CS. Moreover, the waterproofing membranes, roofing tiles, windows, and interior doors accounted for the highest share of total embodied carbon emissions.

The results demonstrated the importance of carbon awareness in material selection, resulting in remarkable reductions in embodied carbon emissions from cradle to grave for existing building replacements. The study highlighted the importance of material intensities and quantities beyond their embodied carbon emissions, the service life assignments, and transportation distances. In future studies, the D module could be integrated into existing buildings by considering reuse, recycling, and recovery potential through circular approaches. Additionally, distinct transportation scenarios, considering distances and modular approaches, could be conducted. Even though the service lifetimes of building elements and components were preferably obtained from national sources, those from international databases could also be compared. Since the case study is a typical building, this study could be scaled up to the national level in future studies.

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ANNEX

Table 4. Environmental Product Declaration (EPD) details for the used building elements in the scenarios

Building Elements	**CS Scenario**		**LCS Scenario**	
Item	**EPD Database**	**ID Number**	**EPD Database**	**ID Number**
Ceramic tiles as coverings on the grounds	ecoinvent	S-P-06839	ecoinvent	INIES_IESN20250124_165505, 43362
Laminate flooring on the ground	ecoinvent	S-P-06740	ecoinvent	EPD-IES-0008769:011
Waterproofing membrane	One Click LCA	Generic type in One Click LCA (Location: Turkey, EPD program: One Click LCA)	ecoinvent	BREG EN EPD000175, issue 03
Windows (CS: PVC framed, LCS: Wooden framed)	One Click LCA	Generic type in One Click LCA (Location: Europe, EPD program: One Click LCA)	One Click LCA	Generic type in One Click LCA (Location: Europe, EPD program: One Click LCA)
Interior wooden doors	One Click LCA	Generic type in One Click LCA (Location: Europe, EPD program: One Click LCA)	ecoinvent	INIES_IHHC20220716_001141, 30505
Exterior steel door	GaBi	M-EPD-TUE-1001	GaBi	M-EPD-TUE-1001
Exterior door, double-glazed (CS: PVC framed, LCS: Wooden framed)	ecoinvent	7210006	ecoinvent	10728
Exterior painting (CS: water-based, LCS: acrylic emulsion-based)	GaBi	EPD-IES-0015487:001	ecoinvent	NEPD-9529-9163
Roofing tiles from clay	One Click LCA	Generic type in One Click LCA (330 x 420 mm, Location: Turkey, EPD program: One Click LCA)	One Click LCA	Generic type in One Click LCA (285 x 475 mm, Location: Turkey, EPD program: One Click LCA)
Interior painting (CS: top coat paint, LCS: acrylic water-based)	GaBi	EPD-IES-0015488:001	ecoinvent	NEPD-2816-1513-EN