Renovating a house in **Morangis**

APPENDIX - Detailed report: Life cycle analysis

VELUX - LIVING PLACES - RENOVATION

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APPENDIX - Detailed report: Life cycle analysis Erreur ! Utilisez l'onglet Accueil pour appliquer CP_Type of assignment au texte que vous souhaitez faire apparaître ici.

VELUX

LIFE CYCLE ANALYSIS STUDY

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ARTELIA, BIDF, ENVIRONMENTAL TRANSITION & PERFORMANCE BRANCH 16, RUE SIMONE VEIL - 93400 SAINT-OUEN-SUR-SEINE - TEL : +33 (0)1 55 84 10 10			

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INTRODUCTION

Artelia has been commissioned as part of the "Living Places Renovation" project initiated by VELUX France. The aim of this project is to experiment with renovation concepts in real-life situations, in order to achieve better energy performance and interior comfort in existing homes, particularly in single-family homes with convertible attic space.

The renovation of a house in Morangis is part of this project, as a pilot.

The purpose of this study is to carry out a lifecycle analysis of the project to enable the Active House radar score to be calculated.

The calculation method used is based on the RE2020 - calculation of environmental impacts using the dynamic method.

LCA is an environmental assessment method that measures and quantifies different environmental impacts throughout all stages of a product's life cycle (from extraction of raw materials to end of life).

1. RE2020 REGULATIONS

The RE2020 methodology was used for this calculation. All emissions are calculated as dynamic emissions over 50 years.

It is made up of 3 main indicators:

- ***ic_construction***: greenhouse gas emissions linked to materials and the building site. The phases of manufacture and transport of materials, construction, maintenance and end of life of the building are taken into account.
- ***ic_energie***: greenhouse gas emissions linked to energy consumption over the lifetime of the building. This consumption is estimated by the thermal study.
- ***ic_batiment***: greenhouse gas emissions for buildings. They take into account materials and the building site (ic_construction), energy (ic_energy), as well as emissions linked to the water consumed during the life of the building.

Two regulatory thresholds for carbon emissions

- ***ic_construction_max***: emissions from materials and construction sites must be below a regulatory threshold to comply with the RE2020.
- ***ic_energie_max***: energy emissions must be below a regulatory threshold to comply with the RE2020.

NB: The RE2020 does not give the same weight to greenhouse gas emissions that take place on different dates. The regulations state that it is preferable to emit 1 kgCO2e in 50 years' time rather than today.

A weighting factor is therefore assigned to emissions:

- 1 for year 0
- 0.58 for year 50

2. STUDY PARAMETERS

2.1. SOFTWARE

The Vizcab tool was used to determine environmental impacts. The online tool is available at https://app.vizcab.io/. The database contains verified declaration sheets that are compatible with European standards, including the INIES database.

The calculation takes into account a number of environmental impact indicators defined in standard NF EN 15804:

> Global Warming Potential [kg CO2 eq.], referred to as Carbon Impacts for simplicity.
> Abiotic resource degradation potential for the elements [kg Sb eq], which for simplicity will be referred to as resource depletion
> Total use of non-renewable primary energy resources (primary energy and primary energy resources used as raw materials) [MJ], referred to as grey energy for simplicity.
> Net freshwater use [m^3]
> Hazardous waste used [kg]
> Non-hazardous waste used [kg].

2.2. ENVIRONMENTAL DATA

The LCA of the building was carried out using environmental data from construction products of the French EPD type, in compliance with standard NF EN 15804.

The environmental data containing all the indicators listed above comes mainly from the Environmental and Health Declaration Sheets available in the INIES database (EPD).

The Vizcab software mainly uses the FDES and EPD from this INIES database for its calculations.

Three types of data are and will be used in this study:

> **“Specific" data**, which defines the environmental impact of a specific product on the market. The impacts are then calculated directly by the manufacturer and represent the most "realistic" impacts of the products used in the building, if known.

> **“Collective" data**, which defines the environmental impact of a type of product on the basis of average input data. They are generally produced by industry associations.

> **“Default" data**. These data tend to be penalising compared with "specific" or "collective" data (ratio x 2 in general).

2.3. PERIMETER

The environmental data was selected from the INIES databases (EPD).

The impacts have been calculated over the entire life cycle of the building, taking into account the Typical Life of the products (X years) and the Planned Life of the building (50 years).

During this phase, an LCA was carried out to calculate the house's various environmental impacts.

The product families studied are divided into several Allotments:

> Allotment 1: Roads and miscellaneous networks

> Allotment 2: Foundations and infrastructure

> Allotment 3: Superstructure - Masonry

> Allotment 4: Roofing - Waterproofing - Framework - Zinc works

> Allotment 5: Partitioning - Lining - Suspended ceilings - Interior joinery

> Allotment 6: Façade and external joinery

> Allotment 7: Floor, wall and ceiling coverings - Screed - Paintwork - Decoration products

> Allotment 8: HVAC (Heating - Ventilation - Cooling - Hot water)

> Allotment 9: Sanitary installations

> Allotment 10: Energy networks (heavy current)

> Allotment 11: Communication networks (low voltage)

> Allotment 12: Lifts and other indoor transport equipment

> Allotment 13: Local electricity production equipment

It is possible to model the technical packages (8.1, 10 and 11) with **generic allotment values** provided by the reference systems. These are approximate models, based on the project's floor area and dimensioned by the CSTB.

In accordance with the ISO 14040, ISO 14044 and ISO 21930 standards, the LCA of a building is carried out over its entire life cycle: from cradle to grave (Cradle-to-Grave). The data used in this study show environmental impacts calculated over their entire life cycle.

2.4. INDICATORS TAKEN INTO ACCOUNT IN THE STUDY

The calculation of **carbon performance** according to the RE2020 standard is based on **two indicators**:

> A level of greenhouse gas emissions relating to Construction Products and Equipment and to the carbon footprint of the construction phase: **Ic construction.**

> A level of greenhouse gas emissions related to energy consumption: **Ic energy**

PI: The translation of EGES in the RE 2020 regulations is IC building = IC Construction + IC Water + IC Energy, which is not a regulatory indicator.

In addition, as part of the Active House radar, we also looked at the environmental impact of the following elements:

- Global Warming Potential (GWP)
- Ozone depletion potential (ODP)
- Photochemical Ozone Creation Potential (POCP)
- Acidification potential (AP)
- Eutrophication potential (EP)

3. INPUT DATA

3.1. QUANTITATIVE DATA AND ASSUMPTIONS

In order to model the elements of the project as accurately as possible, we used the quantities from the various estimates, in particular those for the roof, plumbing/heating, stairs, electricity, masonry, ITE and joinery.

In addition, a number of assumptions concerning materials and calculation methodology have been taken into account:

- Estimated surface area of new walls in the attic, including paintwork
- Estimation of measurements for electrical and plumbing ducts

3.2. REFERENCE AREAS TAKEN INTO ACCOUNT

The living area taken into account is 81 m² for the LCA calculation.

Floor area: approximately 57 m²
Attic space: 25 m² (floor area)

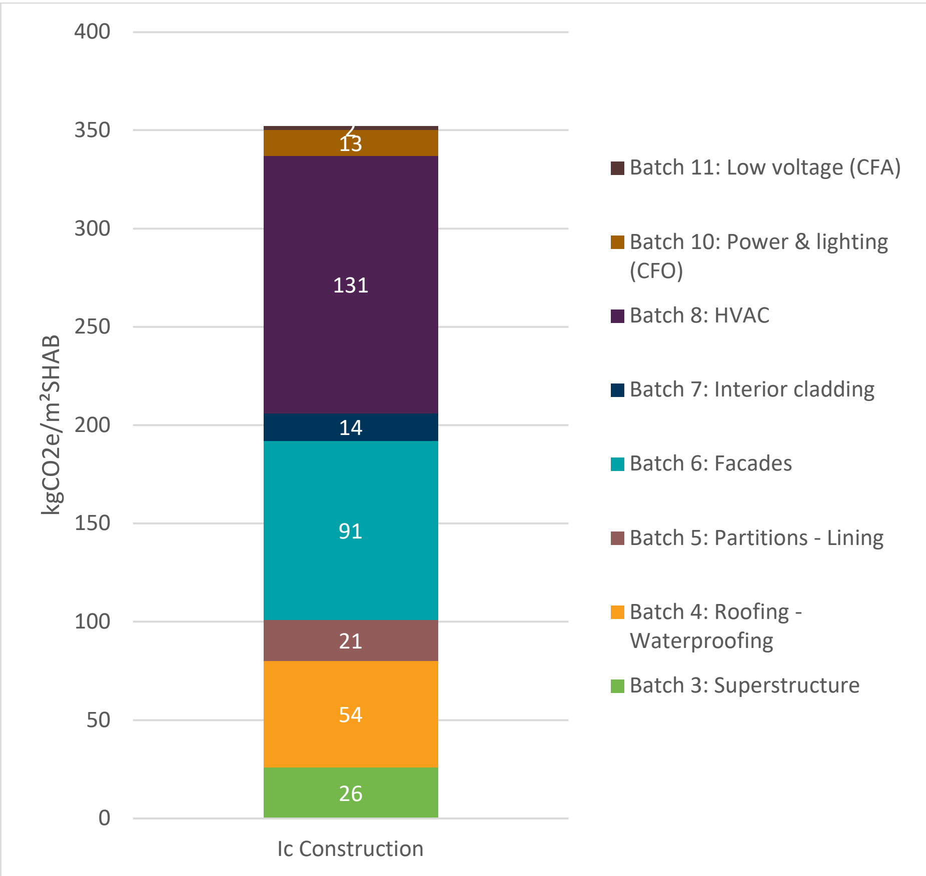
4. MODELLING RESULTS

4.1. SUMMARY OF RE2020 RESULTS

In this section, we focus on the carbon indicator taken into account in the RE 2020 certification: global warming potential, represented by the Production of kg.CO2.equivalent indicator.

RE2020 indicators	Carbon impact kgCO2e/m²SHAB
Ic_component	351
Ic_construction site	0,3
Ic_construction *(Ic_component + Ic_site)*	**352**
Ic_eau	56,2
Ic_energy	**176**

4.1.1. Details of contributor Ic_ construction



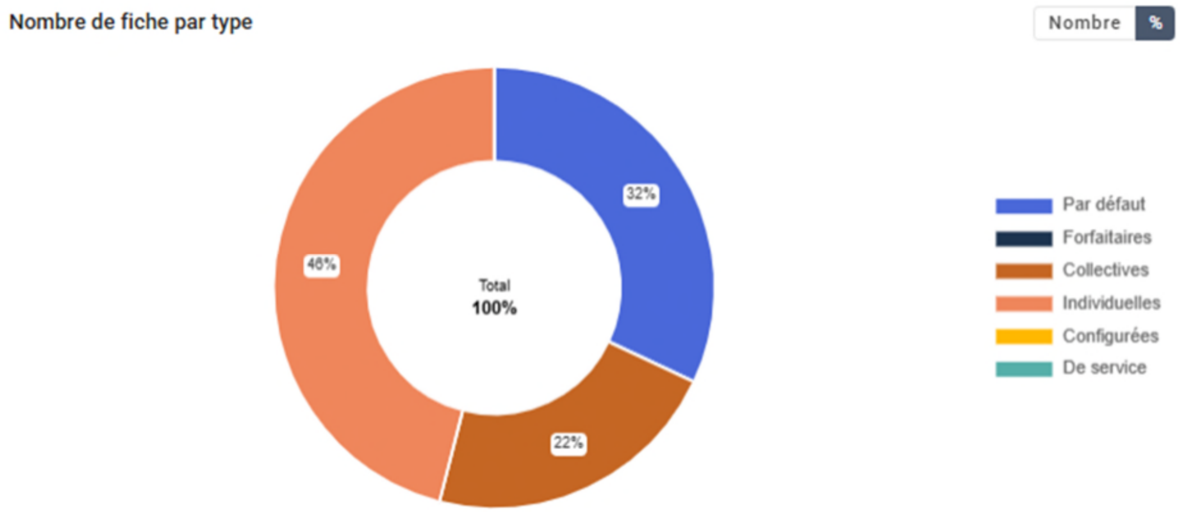
	Dynamic LCA RE2020 (kg CO2 eq/m² SHAB)	
	Allotment 1: External works	0
	Allotment 2: Infrastructure	0
	Allotment 3: Superstructure	26
	Allotment 4: Roofing - Waterproofing	54
	Allotment 5: Partitions - Lining	21
	Allotment 6: Facades	91
	Allotment 7: Cladding	14
	Allotment 8: HVAC (including refrigerant fluids)	131
	Allotment 9: Sanitary installations	0
	Allotment 10: Energy networks (CFO)	13
	Allotment 11: Communication networks (CFA)	2
	Allotment 12: Lifting equipment	0
	Allotment 13: Local electrical production equipment	0
	Ic_construction site	0,3
	Ic_construction project	**352**
Ic_Construction ***max***	*Threshold 2025*	*633*
	Threshold 2028	*567*
	2031 threshold	*495*

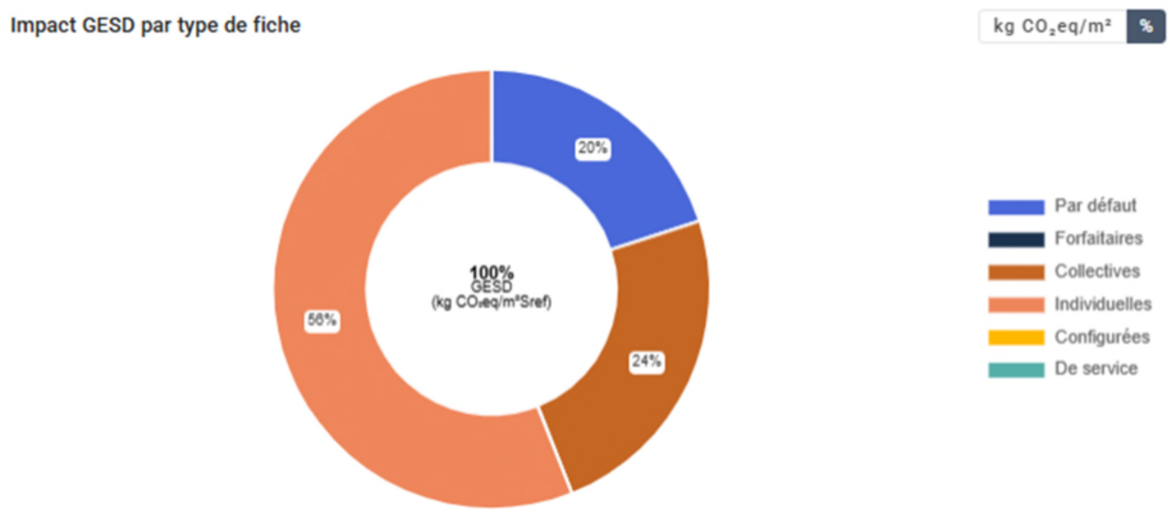
The carbon impact of the materials used in the renovation totalled 352 kgCO2e/m²SHAB.

The HVAC package accounts for more than a third of the total impact, due to the installation of a new heat pump and thermodynamic tank. The façades also represent a significant carbon footprint (25%), due to the replacement of all the joinery and the addition of windows in the attic.

Finally, allotment 4 accounts for 15% of the total carbon weight, due to the re-roofing and the addition of insulation.

4.1.2. Type of data used for materials





The graphs above show the percentage of file types by number and by carbon weight.

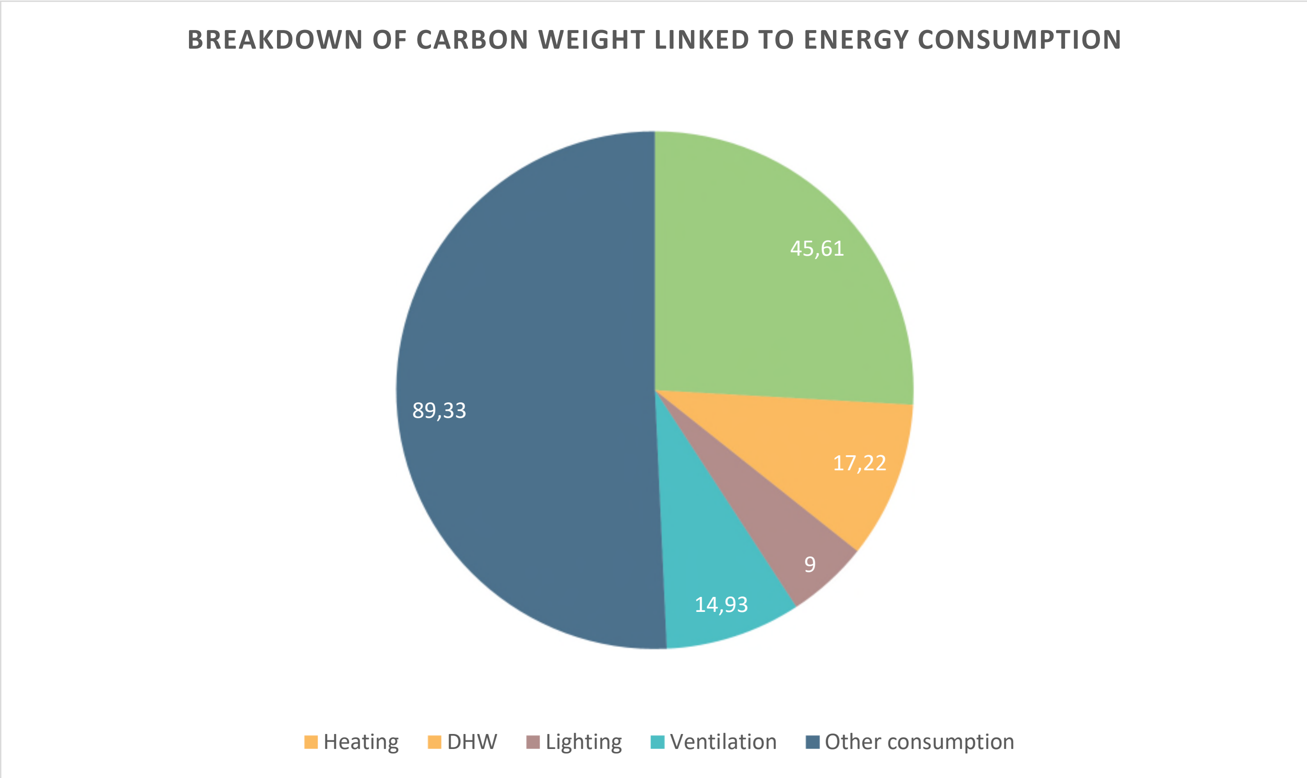
It can be seen that, despite the use of 32% default data, only 20% of CO2 emissions are attributed to these EPD even though they often have a penalising value.

The use of individual ESFs was maximised for this operation - even when there was no reference on INIES - in order to obtain a carbon weight closer to reality, as the project was not subject to certification.

The 5 ESDSs with the greatest impact on the project are:

- Heat pump: 73 kgCO2e/m².
- The thermodynamic tank: 30 kgCO2e/m².
- External rendering of the façade: 22 kgCO2e/m².
- Steel water radiators: 20 kgCO2e/m².
- UTHERM insulation: 16 kgCO2e/m².

4.1.3. Details of contributor Ic_energy



	Ic_energy	
	Ic_energy project	**176**
Ic_Energy max	Threshold 2025 to 2031	211

The RE2020 thresholds are met for the Ic_energy contributor for the house after renovation.

4.2. OTHER INDICATORS AND ACTIVE HOUSE RADAR

In addition to the global warming potential (often referred to as the carbon impact), the other indicators in the Active House reference framework have been calculated over the life cycle of the project.

The results are shown below:

Project data			Active House score
Global Warming Potential (GWP)	7,04	kg CFC 11 eq/m²Sref.year	2
Depletion of the ozone layer (ODP)	1,64E-05	kg ethylene eq/m²Sref.year	Out of scope
Photochemical Ozone Creation Potential (POCP)	5,32E-01	kg eq. SO_2/m²Sref.year	Out of scope
Acidification potential (AP)	2,24E-02	kg eq. $(PO4)^{3-}$/m²Sref.year	2
Eutrophication potential (EP)	7,18E-03	kg CFC 11 eq/m²Sref.year	3

		How to	
Recycled content	<5% by mass	Attic floor only	4
Recyclable or reusable content	10-30%	Estimate	3
Responsibly sourced wood	50 %	Information obtained	2
Declared origin (FDES)	40%	Individual and collective EHSFs	3

In terms of recycled content, the plan is to reuse the laminate flooring in the living room of the house to fit out the attic. As far as the other recycling indicators are concerned, recycling has been estimated based on the materials used - without being able to extract this data directly from the calculation.

The new timber elements on this project are the staircases and the framework - at this stage of the project, we have estimated that 50% of these elements are of responsible origin, pending further information from the companies.

5. COMPARISON OF PROJECT BEFORE AND AFTER VELUX INSTALLATION

5.1. FINAL RESULTS

In this section, we look at the difference between the 'Base' scenario of the initial works planned before Velux's involvement in the project, and the 'Velux modified works' section.

To do this, the LCA was carried out twice, to enable a comparison - from a carbon impact point of view - of the project's evolution.

Ic Construction (kgCO2e/m²)	Base	Velux changes	Difference	Changes
Allotment 1: External works	*0*	*0*	*0*	
Allotment 2: Foundations and Infrastructure	*0*	*0*	*0*	
Allotment 3: Superstructure	22	26	+4	=> Addition of Fermacell, DRC insulation
Allotment 4: Roofing - Waterproofing	54	54	0	
Allotment 5: Partitions - Lining	12	21	+9	=> Add loft insulation
Allotment 6: Facades	103	91	-12	=> ITE modification
Allotment 7: Interior cladding	24	14	-10	=> Paint modification (recommended)
Allotment 8: HVAC	131	131	0	
Allotment 9: Sanitary installations	*0*	*0*	*0*	
Allotment 10: Power & lighting (CFO)	9	13	+4	=> Add a PAC meter
Allotment 11: Low voltage (CFA)	0	2	+2	=> Add Somfy module
Allotment 12: Lifts	0	0	0	
Allotment 13: Photovoltaics	0	0	0	
Total	**355**	**352**	-3	

> Velux's involvement in this renovation project has saved the equivalent of 3 kgCO2e/m² over 50 years, in particular through the use of materials with a lower carbon impact.

Note: these results do not take into account the changes made at the end of May 2025 regarding the installation of Fermacell.

5.2. VARIANTS CARRIED OUT DURING THE DESIGN PHASE

During the first phase of the project, various considerations were given to the choice of materials. Different variants were developed for this purpose and are presented below.

Element	Base	Variant	Difference in carbon impact (kgCO2e/m²)
Quantity and window sizes	4 skylights: skylight area 1.88*1.4 = 2.6 * 4 skylights = 10.5 m2	Removal of Velux windows to the west + reduction in staircases	-4,05
Addition of attic floor mass	-	Fermacell floor panels	+4,29
Adding roof weight	-	Fermacell panels for attic ceilings	+2,63
EXT roof insulation	ITE: 14 cm polyurethane R=4.5	ITE: 16 cm Wood wool R:7.4 (Unilin Utherm)	-5,45
EXT roof insulation	ITE: 14 cm polyurethane R=4.5	replacement ITE glass wool 160 mm R=5,3	-4,78
INT roof insulation	No ITI for the roof	Add 8 cm of wood wool	+3,24
INT roof insulation	No ITI for the roof	Addition of 8 cm of glass wool	+1,8
Risers	Wooden staircase	Risers	-0,71
		No risers	-0,95
Attic radiators	2 type 22 steel high-temperature hot-water radiators	2 electric radiators	-0,88
		Removal of a radiator in the attic	-5,7

These carbon impacts are directly linked to the choice of specific ESDSs for comparison.

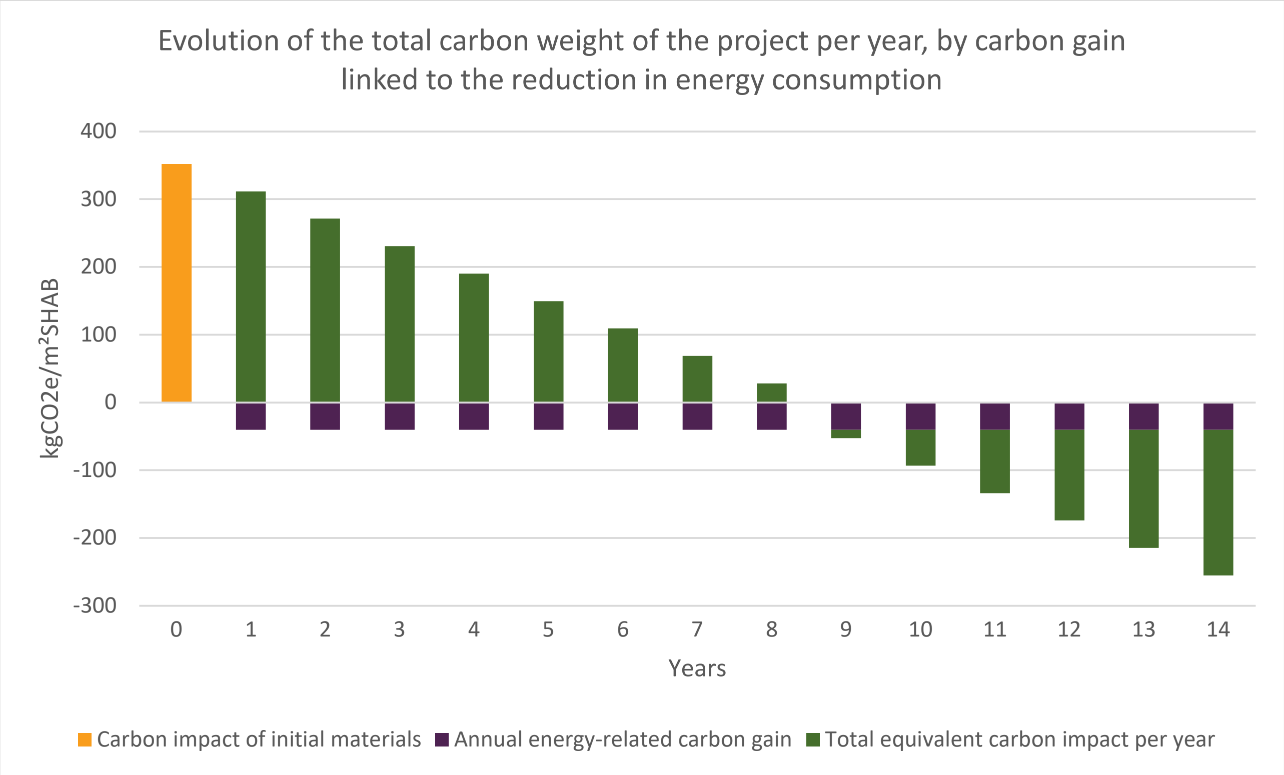
6. CARBON PAYBACK TIME

In this section, we look at the 'carbon payback time', i.e. the time required to offset the carbon emitted by the addition of new materials, compared with the benefits linked to the reduction in energy consumption.

To do this, we need to compare the energy-related carbon impact before and after the work.

Carbon impact of materials over 50 years ($kgCO_2e/m^2$)	Energy-related carbon impact - **before works** ($kgCO_2e/m^2$.**an**)	Energy-related carbon impact - **after works** ($kgCO_2e/m^2$.**an**)	Carbon gain on energy ($kgCO_2e/m^2$.**an**)	Carbon payback time
352	44	3,52	40,48	Calculation: 352/40.48 = **8.7 years**

This carbon payback time shows that the addition of new materials to the project is offset - in terms of carbon impact - after 8.7 years. Beyond this period, we can consider that we are 'gaining' carbon compared with the previous installation.



> The graph shows that each year the equivalent of 40 $kgCO_2e/m^2$ is saved following the energy renovation of the house, giving a carbon payback time of less than 9 years.
>
> Over 50 years, the estimated reduction in carbon weight is of - 1,672 $kgCO_2e/m^2$SHAB.

To simplify the calculations, the carbon weight of the materials over 50 years has been taken into account here at 100% in year 0 - theoretically these impacts could be spread over the 50 years depending on the renewal of the materials, but the calculation software does not allow us to differentiate the carbon weight by year at this stage.

These calculations also do not take into account changes in the French energy mix and the carbon impact per kWh.

7. ADDITIONAL INDICATOR: BIODIVERSITY

To go further, the biodiversity loss indicator has been calculated for the renovation project.

The tool used is that developed by Doughnut for Urban Development: a lifecycle biodiversity impact tool, based on a 50-year lifecycle.

This tool takes into account 3 aspects that can harm biodiversity:

- Impacts linked to the land (change of use, reduction in woodland, wetlands, etc.)
- The impact of new materials
- Energy-related impacts

Unit: species.year	Impact of land use	Impact related to operating energy	Impact of materials
Before work	-	1,5E-03	-
After works - Base	-	4,2 E-04	2,8 E-04
After work - Velux	-	4,2 E-04	2,7 E-04

The impact linked to land use is nil here, as there is no transformation of the type of use on the project (urban soil). In terms of energy, the impact before the works is lower because electricity has a greater impact than heat in this tool.

The differences between the Base and the Velux work are very slight when it comes to materials.

The materials with the greatest impact can be seen in the following graph: