Net Zero Carbon Report

for

Irota EcoLodge

IROTA ECOLODGE

August 2022

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1. Introduction

At the UN conference in Paris in 2015, an agreement was reached to keep the rise in global temperature well below 2 °C above pre-industrial levels, and preferably limit the increase to 1.5 °C (UNFCCC). This goal requires a drastic reduction of greenhouse gas emissions by 55% by 2030 and to net zero emissions by 2050. Several initiatives have been developed since Paris to reach this goal. The World Green Building Council (WGBC), a network of professionals in the building industry who are committed to the environment, has set a similar target in the Advancing Net Zero Project: by 2030 all new buildings should operate at net zero carbon emissions and by 2050 all existing and new buildings should operate at net zero (WGBC[1]). Moreover, WGBC also emphasises the importance of taking not only the operational emissions into account, but accounting for the embodied carbon in the buildings as well (WGBC[2]).

Life Cycle Assessment (LCA) is a useful tool to analyse an asset's environmental impact throughout its entire life cycle. Therefore, it enables accounting for a building's embodied carbon, operational and deconstruction impacts. Reaching carbon transparency through LCA helps to reduce cost, greenhouse gas emissions and material use in construction. Moreover, it is a useful aid to optimize building designs.

Building properties

Irota EcoLodge is a small-scale sustainable holiday resort in Northern Hungary, consisting of three holiday homes. The three houses are similar in sizes and features. In this report, we provided data and results for one holiday home only. However, considering that the other two homes are nearly identical, the result is valid for all the Irota EcoLodge buildings.

The resort opened on the 7th of July 2016. Both the design and construction were executed with an environmentally conscious mindset. Annual carbon footprint reports of the operational emissions are released each year – the 2021 report can be accessed via https://www.irotaecolodge.com/en/pdf/PDF_CarbonFootprint_EN.pdf. The latest reports show that the EcoLodge's annual operations are carbon neutral, however, the embodied carbon impacts have not been taken into account thus far.

2. Purpose of the Study

This LCA was carried out to determine the life cycle environmental impacts of the Irota EcoLodge building. We set out to prove that the building achieves net zero carbon emissions over its lifetime – even with considering the embodied carbon impacts. This study's results will support Irota EcoLodge's case in the submission for the WGBC's Case Study Library.

3. Life Cycle Assessment (LCA) – Framework

The framework for general LCAs (ISO, 2006a, 2006b) consists of four elements, which are shown in figure 1 and are explained shortly in the following. Firstly, in the goal and scope definition, the subject and general lines of the study are identified. The second step in the LCA framework is the inventory analysis, in which environmental inputs (e.g., extraction of resources, energy use) and outputs (e.g., emissions) are gathered for the previously defined scope. This is followed by the impact assessment (LCIA), in which the positive or negative contributions of the inventory elements to a number of problems are determined. Finally, in the interpretation (or improvement assessment) the possibilities to reduce the assessed product's or system's impact on the considered problems are identified.

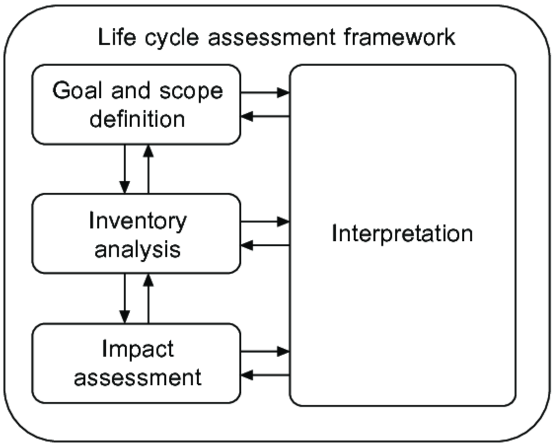

Figure 1: LCA framework (Hellweg et al., 2004)

The LCA framework is established by the following International Standards:

- **ISO 14040** - Environmental management. Life cycle assessment. Principles and framework (ISO, 2006a)
- **ISO 14044** - Environmental management – Life cycle assessment – Requirements and guidelines (ISO, 2006b)
- **ISO 21930** - Sustainability in buildings and civil engineering works – Core rules for environmental product declarations of construction products and services (ISO, 2017)

4. Methodology

4.1. Software

One Click LCA from Bionova Ltd. was the applied software for this study. The tool supports CML methodology and all assessed impact categories, and it is verified by Building Research Establishment (BRE). The inventory database for One Click is ecoinvent, which is updated yearly with expanded sectorial and geographical coverage. The latest released update is ecoinvent v3.8.

Apart from the aforementioned LCA framework standards, the program and related datasets are also compliant with:

- **EN 15978** - Sustainability of construction works – Assessment of environmental performance of buildings - Calculation method (BS EN, 2011)
- **EN 15804+A2** - Sustainability of construction works - Environmental product declarations (EN, 2019)

4.2. Scope and Boundaries

For the LCA, we considered results for all the cradle-to-grave life cycle stages according to the European Standard EN 15804:2012, as shown in Table 1. This framework excludes life stage "D" (benefits) from the total life cycle impact results. Therefore, in this report we presented the LCA results as required according to the relevant standard.

However, in the net carbon balance calculation, two items of "D" (benefits) were included: *B4-B5 – Material replacement* and *D – Exported energy*. B4-B5 was included, because the "B" life stage is part of the LCA framework. Exported energy was included because input data was based on real life values, therefore, the uncertainty of those results is small.

Table 1: Considered life cycle stages for building and construction works

A1-A3 Product Stage			A4-A5 Construction Process Stage		B1-7 Use Stage							C1-C4 End-of-Life Stage				D Benefits and loads beyond the system boundary		
Raw material supply	Transport	Manufacturing	Transport to building site	Installation into building	Use/application	Maintenance	Repair	Replacement	Refurbishment	Operational energy use	Operational water use	Deconstruction/demolition	Transport	Waste processing	Disposal	Reuse	Recovery	Recycling

Table 2: Description of the life cycle stages and analysis scope

Life-Cycle Stage	Description
A1-A3 Construction Materials	Raw material supply (A1) includes emissions generated when raw materials are taken from nature, transported to industrial units for processing and processed. Loss of raw material and energy are also considered. Transport impacts (A2) include exhaust emissions resulting from the transport of all raw materials from suppliers to the manufacturer's production plant as well as impacts of production of fuels. Production impacts (A3) cover the manufacturing of the production materials and fuels used by machines, as well as handling of waste formed in the production processes at the manufacturer's production plants until end-of-waste state.

Life-Cycle Stage	Description
A4 Transportation to site	A4 includes exhaust emissions resulting from the transport of building products from manufacturer's production plant to building site as well as the environmental impacts of production of the used fuel.
A5 Construction/installation process	A5 covers the exhaust emissions resulting from using energy during the site operations, the environmental impacts of production processes of fuel and energy and water as well as handling of waste until the end-of-waste state.
B1-B5 Maintenance and material replacement	The environmental impacts of maintenance and material replacements (B1-B5) include environmental impacts from replacing building products after they reach the end of their service life. The emissions cover impacts from raw material supply, transportation and production of the replacing new material as well as the impacts from manufacturing the replacing material as well as handling of waste until the end-of-waste state.
B6 Energy use	The considered use phase energy consumption (B6) impacts include exhaust emissions from any building level energy production as well as the environmental impacts of production processes of fuel and externally produced energy. Energy transmission losses are also considered.
B7 Water use	The considered use phase water consumption (B7) impacts include the environmental impacts of production processes of fresh water and the impacts from wastewater treatment.
C1-C4 Deconstruction	The impacts of deconstruction include impacts for processing recyclable construction waste flows for recycling (C3) until the end-of-waste stage or the impacts of pre-processing and landfilling for waste streams that cannot be recycled (C4) based on type of material. Additionally, deconstruction impacts include emissions caused by waste energy recovery.
D; B4-B5 External impacts/end-of-life benefits	The external benefits include emission benefits from recycling recyclable building waste. Benefits for re-used or recycled material types include positive impact of replacing virgin-based material with recycled material and benefits for materials that can be recovered for energy cover positive impact for replacing other energy streams based on average impacts of energy production.

4.3. Inventory – Data collection

The inventory data was acquired directly from the designers, contractors and material supply responsibles. Where precise data was not available, average data associated with the building's type and location were used to find the closest match. A complete list of data sources is presented in the attachment (Appendix B).

Table 3: Data sources for each assessed life stage

Area of analysis	Data sources
Material quantities (A1-A3)	As-built data supplied by the contractors.
Building material transport distances (A4)	Transport distances were based on the delivery note information. Where not available, values were estimated based on material type or typical average and provided by the LCA tool.
Construction and installation process (A5)	LCA tool average construction process emissions based on project size were used in the analysis.
Material service life (B1-B5)	The service life information for materials were checked and project specific values were used when available. Otherwise, default values from One Click LCA database were used.

Area of analysis	Data sources
Building use phase energy consumption (B6)	The operational energy use was based on real life data from the last years of operation. Moreover, exported energy was also noted.
Building use phase water consumption (B7)	Water consumption values were based on real life data from the last years of operation.

For each material, a certain service life is assumed to calculate its impact for replacement and disposal (B4-B5 category). Default values for each material are included in the inventory dataset (ecoinvent). In the technical service life, it is assumed that the same type of materials has the same service life setting. This service life setting is the usual choice and recommended default. The building lifetime was assumed to be 60 years. It is the default value in the LCA software, according to the relevant standard.

4.4. Assessed Impact Categories

The results of life cycle assessments carried out in One Click LCA are described with mid-point impact categories. In this study, the only analysed impact category was the global warming potential (GWP). The evaluation of the global warming impact category enables the assessment of greenhouse gas (GHG) emissions. Therefore, it was suitable for the evaluation of the overall carbon footprint of the Irota EcoLodge.

Table 4: Relevant impact categories and their description

Impact category	Unit	Description
Global warming potential (greenhouse gases)	$kgCO_2$ eq	Global warming potential is a relative measure of how much heat a greenhouse gas traps in the atmosphere. The global warming potential is calculated in carbon dioxide equivalents meaning that the greenhouse potential of an emission is given in relation to CO_2. Since the residence time of gases in the atmosphere is incorporated into the calculation, a time range for the assessment is defined to be 100 years.

4.5. Net Carbon Balance calculation

The LCA results are presented according to standard, without taking any benefits into account. However, for the net carbon balance calculation we used the following formula:

$$\boldsymbol{Net\ Carbon\ Balance = Total\ life\ cycle\ impacts - Biogenic\ carbon\ storage - Avoided\ emissions}$$

where:

Total life cycle impacts: LCA results (A1-C4)

Biogenic carbon storage: amount of stored carbon in timber products

Avoided emissions: B4-B5 – material replacement benefits + D – exported energy benefits

4.6. Limitations and Assumptions

4.6.1. Handling biogenic carbon

There is as of yet no international consensus about the way of valuing stored biogenic CO_2 in the building. Majority of relevant studies simply disregard any effect from biogenic storage and exclude it from the scope. Other studies, however, show the impacts of biogenic carbon storage separately from the LCA results (according to EN 15804:A2) – and then they are subtracted from the A-C module total impacts (Areart et al., 2021). A fundamental requirement for accounting for positive carbon impacts from timber products is that they must be harvested sustainably – certified by FSC, PEFC, or equivalent (Andersen et al, 2021). Some institutes, such as RICS, GRESB and the Dutch Green Building Council allow the accounting of positive impacts related to in-built timber, as they value the effort for choosing sustainable building materials.

Based on literature and the industry-leading institutes' stand, we considered the positive effect of biogenic carbon storage in this study. First, LCA results will be showcase separately to comply with the relevant EN standards. Then, for the net carbon balance we subtracted the effect of biogenic carbon storage. The requirement of legal timber use was examined as well.

4.6.2. Avoided emissions

Irota EcoLodge is equipped with an on-site solar photovoltaics (PV) system. On an annual basis, the generated energy exceeds the on-site energy demand. This surplus energy is then loaded onto the local electricity grid, ending up as an indirect benefit. The WorldGBC's guidelines say that avoided emissions from renewables and offsets may be subtracted from overall emissions (WorldGBC[3], 2019). In this study we followed the provided calculation method for this item. Moreover, emission benefits stemming from B4-B5 – Material replacement were also included, because the "B" life stage is part of the LCA framework.

4.6.3. External developments

Global initiatives and commitments imply that the electricity mix's renewable share will grow overtime. Thus, its emission factor is expected to decrease as well as the overall environmental impact. However, no modelling of the greening electricity mix is taken into account in the used LCA software. To avoid further assumptions and increasing the uncertainty of the study, we relied on constant input data from the software sourced from the International Energy Agency (IEA).

A potential improvement in the current study could be taking the prospective changes of the electricity mix into account. By assuming that by 2050 the emission factors of the mix will be zero, the different emission factors could be obtained with interpolation for the coming years.

This method would also limit the benefits from exported energy by gradually reducing the amount that may be uploaded to the grid.

4.6.4. EPD database coverage

The inventory database for One Click LCA is ecoinvent, which is updated yearly with expanded sectorial and geographical coverage. Unfortunately, not all products were available in the database. Mainly because of the lack of local (Hungarian) products. To gather a comprehensive inventory, we considered the most similar products available and the adjusted the transported distances.

5. Results and Discussion

Table 5: Results summary of the life cycle impacts of the Irota EcoLodge over 60 years

	Global warming potential *kg CO_2eq*	Biogenic carbon storage *kg CO_2eq bio*
A1-A3 Construction Materials	5,11E+04	7,22E+04
A4 Transportation to site	3,13E+03	-
A5 Construction/installation process	5,30E+03	-
B1 Use Phase	0,00E+00	-
B4-5 Material replacement and refurbishment	4,08E+03	-
B6 Energy use	4,35E+03	-
B7 Water use	5,58E+02	-
C1-C4 Deconstruction	1,32E+04	-
Total life cycle impacts	**8,17E+04**	**7,22E+04**
B4-B5; D External impacts / benefits (Not included in totals)	-2,49E+04	-

We assessed the relative impacts of the building per m^2 internal floor area, to enable benchmarking against similar buildings in the area.

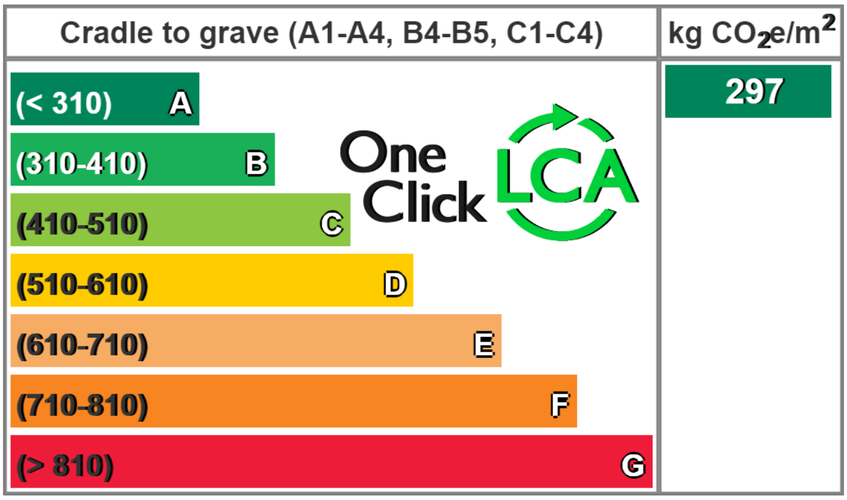

Figure 2: Benchmarking results against Eastern European apartments

The following figures present the major contributors for global warming potential. They show that the most carbon intensive life stage was A1, the materials. By considering the impacts of the construction as well (A5), the embodied carbon impacts take up over 70% of the overall life cycle impacts. The other figure shows a breakdown of the most impactful materials.

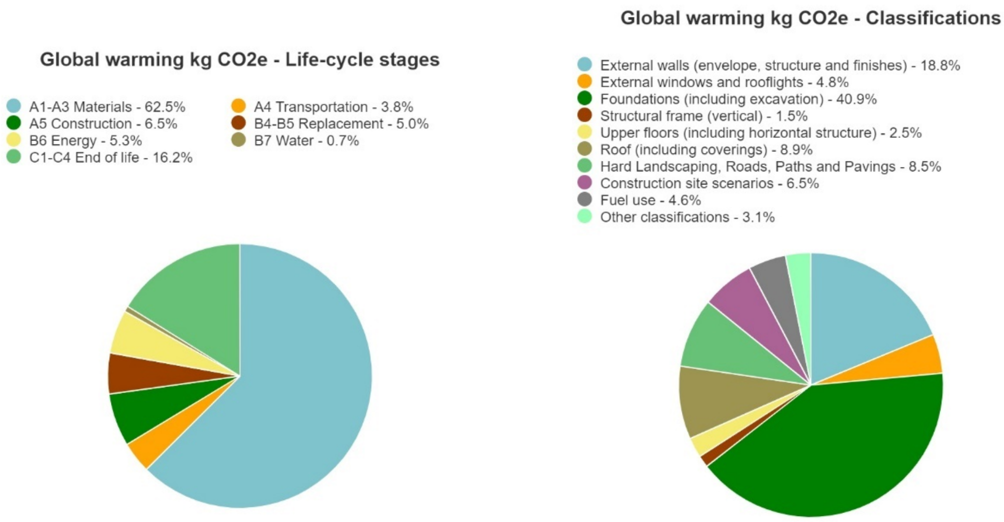

Figure 3: Main contributors to the global warming potential impact category

5.1. Embodied carbon impacts

The embodied carbon impacts comprise of the category A1-A5 impacts in the building life cycle. The GWP values are shown in Table 5. Altogether, 5,95E+04 kgCO_2eq carbon emissions can be associated with these stages. This makes up for precisely 73% of the overall life cycle impacts. As notable on the figure below, the most contributing materials were the foundation elements.

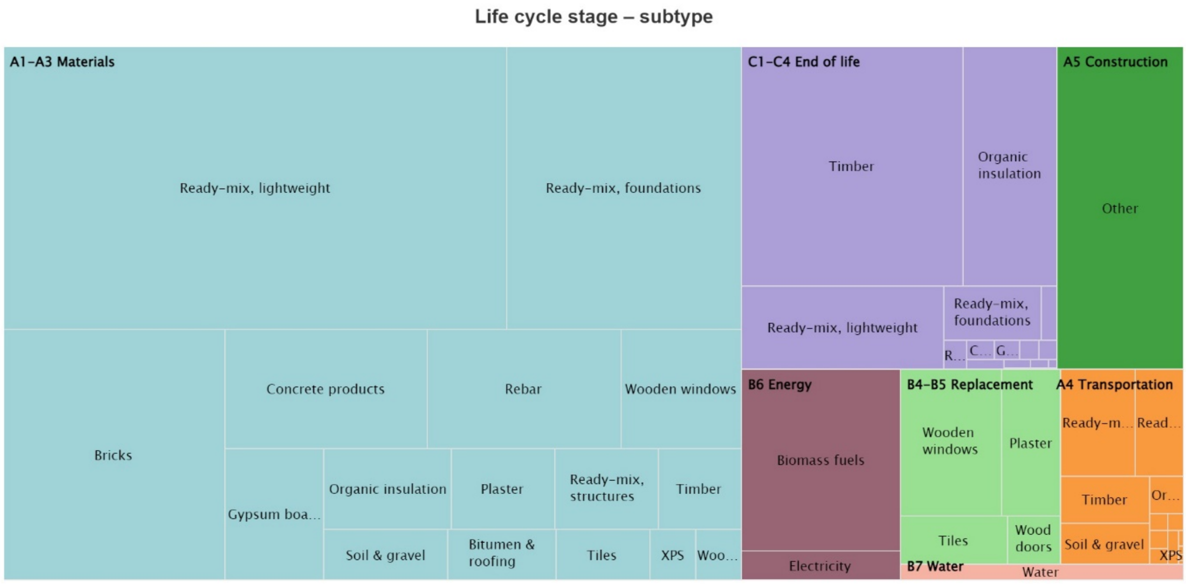

Figure 4: Main contributors for the embodied carbon impacts

The biogenic carbon storage is shown separately from the results in Table 5. The handling of this data was discussed in section 4.5.1 of this study. The value is only shown as additional information. This means that neither the negative emissions of storing the CO_2 from the atmosphere in A1 or the releasing of it in C3 are included in GWP results is the LCA, according to EN 15804:A2.

5.2. Operational phase impacts

As seen in Table 5, the main operational emissions (B1-B7) stem from the energy use in the buildings. Still, only accounting for 5.3% of the overall impacts (9,00E+03 kgCO_2eq). This is thanks to the solar photovoltaic (PV) panels places of the roofs. By ensuring access to clear energy, the energy use impacts are minimized. Moreover, Irota EcoLodge uses biomass for its heating which also keeps operational phase impacts to a minimum. “Use phase” B1 impacts are zero, as the software only accounts for refrigerant leakages within this category.

5.3. Offsets and avoided emissions (B4-B5; D)

Table 6: Balance of negative emissions and offsets

	Global warming potential *kg CO_2eq*	Biogenic carbon storage *kg CO_2eq bio*
A1-A3 **Construction Materials**		-7,22E+04
B4-B5-benefit **Material replacement - benefit**	-5,25E+02	
D **Exported energy**	-2,44E+04	
Total life cycle avoided emissions	**-2,49E+04**	**-7,22E+04**

External impacts and benefits (B4-B5; D in Table 5) are not considered in the overall life cycle impacts by default, according to EN 15804:A2. This is so that the carbon footprint results mirror the negative impacts of the buildings realistically. The benefits and "avoided emissions", however, may be accounted as negative emissions when calculating net emissions over an asset's lifetime (WorldGBC[3], 2019) – as discussed in more detail in section 4.6.2..

In case of the EcoLodge, the biggest contributors to the benefits was the exported energy (surplus energy generated by the on-site solar PVs was loaded onto the grid). For this, a constant exported energy was considered, based on real-life data from the last operational years. Furthermore, a constant emission factor was considered for the electricity mix, as explained in detail in section 4.6.3. of the study.

Smaller benefits arise from the material replacement (B4-B5). This is due to the service life and recyclability-reusability of the built in materials. These mainly stem from the wooden windows and doors, as they contribute over 91% of the benefits here. This can be explained by the comparatively short life-time of the items and the relatively high recycling-possibility due to their material.

As the house was a wooden frame, we also considered the effects of biogenic carbon storage. In the results, these positive impacts are shown as a separate value according to EN 15804:A2. However, as explained in section 4.6.1., researchers and industry-leading institutes allow for the subtraction of the biogenic carbon impacts in the overall net balance accounting. Therefore, following this methodology, we showcased the balance of negative emissions and offsets from carbon storage in Table 6.

6. Conclusion – Net Balance

Table 7: Net emissions balance

	Global warming potential *kg CO_2eq*	Biogenic carbon storage *kg CO_2eq bio*
Total life cycle impacts	8,17E+04	
Total life cycle avoided emissions	-2,49E+04	-7,22E+04
Net carbon emissions	**-1,54E+04**	

Based on the calculations and assumptions explained in this study, the net carbon emissions equal -1.54E+04 kgCO_2eq. As the relevant standard does not grant negative net emissions for assets, we can say that the Irota EcoLodge building achieves net zero emissions over its lifetime – which was assumed to be 60 years for the study.

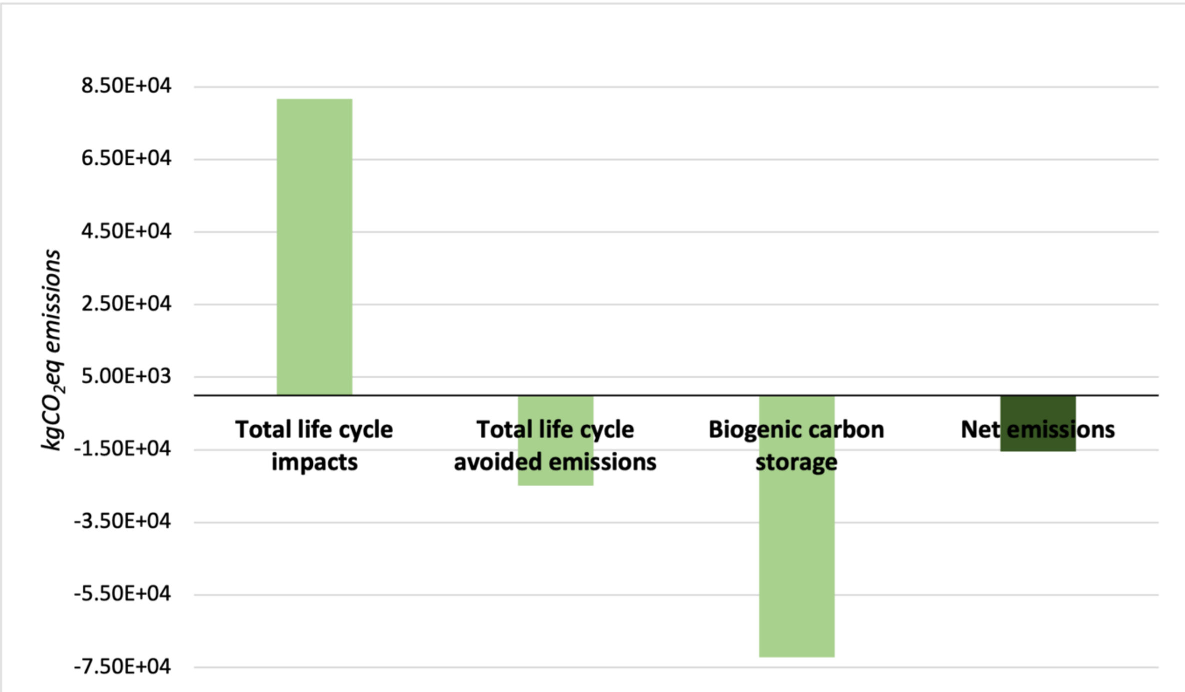

Figure 5: Net carbon balance

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WorldGBC[3], *"Net Zero Carbon Buildings Commitment – Detailed Guidance v1 January 2019"*, accessed on 31 August 2022.

Appendices

Appendix A – Statement of verification

Appendix B – Data Inventory