Wonga Street House
Whole Life Carbon Account

Introduction

This report accounts the amount of greenhouse gasses that are emitted through the complete life of the building project, Wonga Street House. The assessment is a “Cradle to Grave” life cycle assessment, accounting with the Global Warming Potential (GWP) indicator which is measured in tons of CO2 equivalent gasses. It accounts for all EN 15978 modules, excluding B1 and B2. We have also included demolition, site preparation, services, landscaping, and other Ancillary works where possible.

It uses The Footprint Company, TFC, Calculator, which follows a hybrid approach, where specific Process information and Input Output, I/O, costing data have been used to provide a complete picture of the building.

The quantity data is sourced from Construction Drawings, Engineering Documents, Trade Breakdowns, Quotes, and the Contract. The GWP coefficients are taken from TFC and supplemented with available Environmental Product Declarations. The operational portion uses the National Greenhouse Gas Accounts and the energy efficiency rating tool BersPro.

The report follows the current methodology of DIN EN 15804 and does not account for Biogenic carbon. The Static approach, 0/0, is used.

Australia’s understanding of Whole Life Carbon is in its infancy, and liable to change. This assessment follows best of practice as it appears at the time of assessment.

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Reporting system

The whole life carbon account will be broken down into four sections:

- Embodied Carbon: A1 – A5
- Operational Carbon: B3 – B5
- End of Life Carbon: C1 – C4

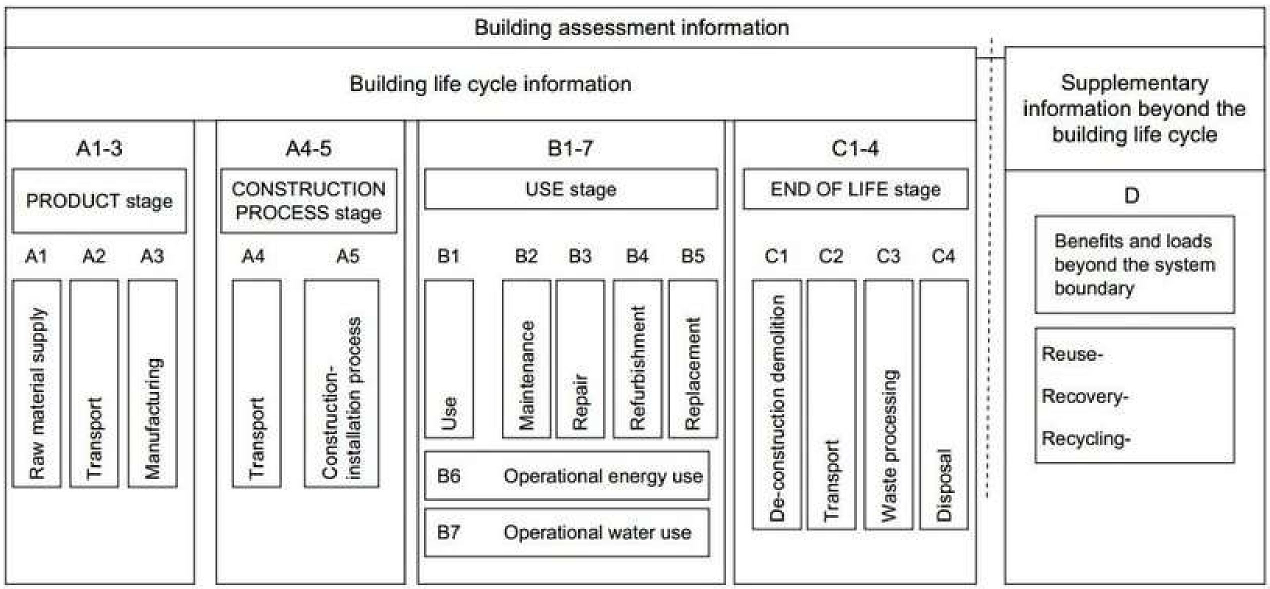


Figure 1 EN 15978 Modules

Each section is reported independently then brought together at the end of the report. This is done as each section uses different tools to calculate and helps to split the lifecycle of the building into a chronological timeframe.

Modules B1: Use, and B2: Maintenance have been excluded, as they mainly include concrete carbonisation and cleaning impacts. They are cumulatively well below one percent of the Whole Life Carbon, justifying their exclusion.

Modules B3 and B5 have been included into a single replacement scenario, as the process of repair often involves significant replacement of materials in the residential building context. B4: Refurbishment, is in scope, and is to be included if a renovation of significance occurs.

Embodied Carbon

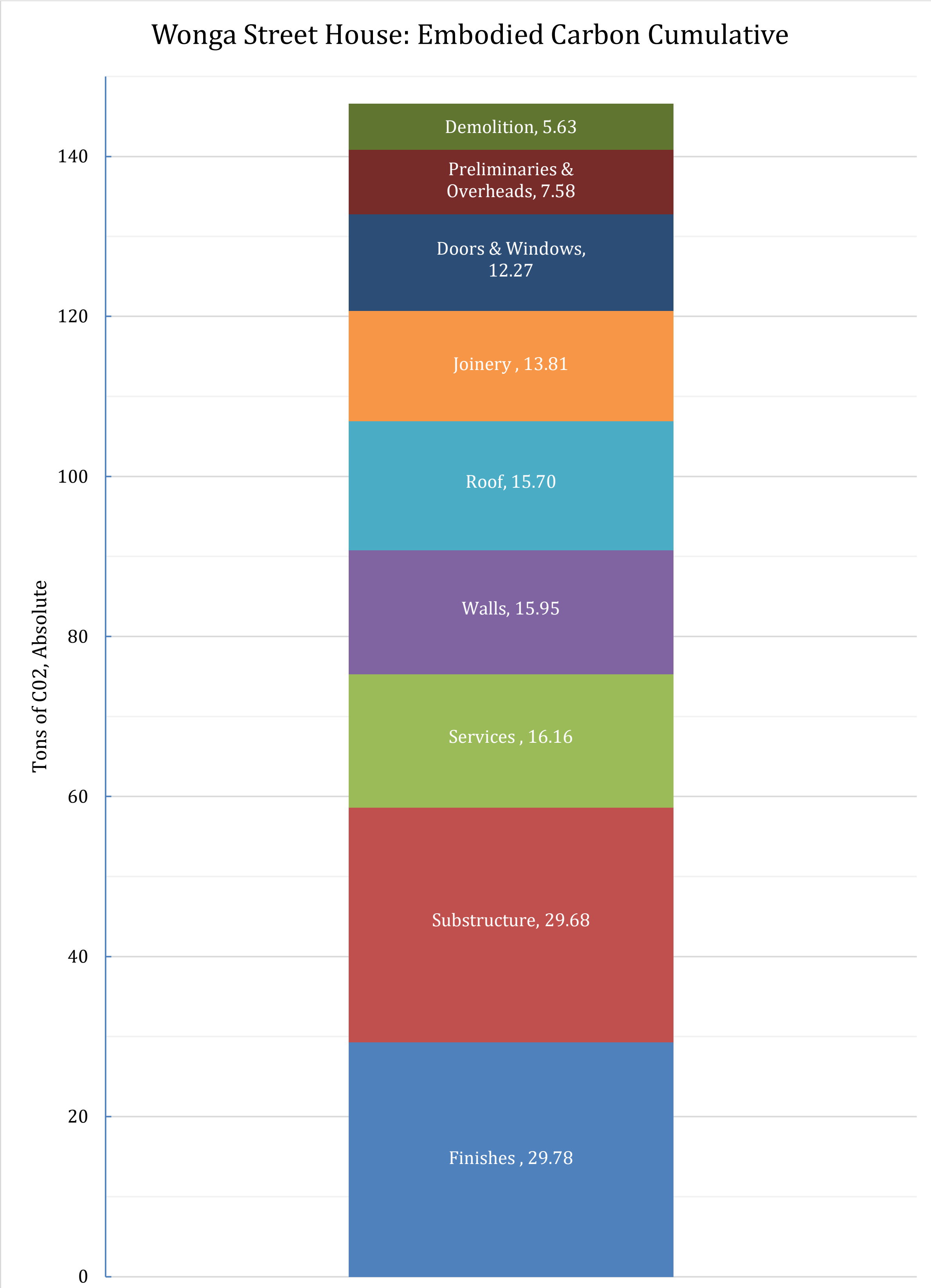
The embodied carbon assessment was completed using TFC calculator tool, with slight modifications where a specific environmental product declaration was available. A1 – A3 are accounted for totally, with both A4, transport, and A5, construction, emissions in part through I/O information.

Modelling Notes:

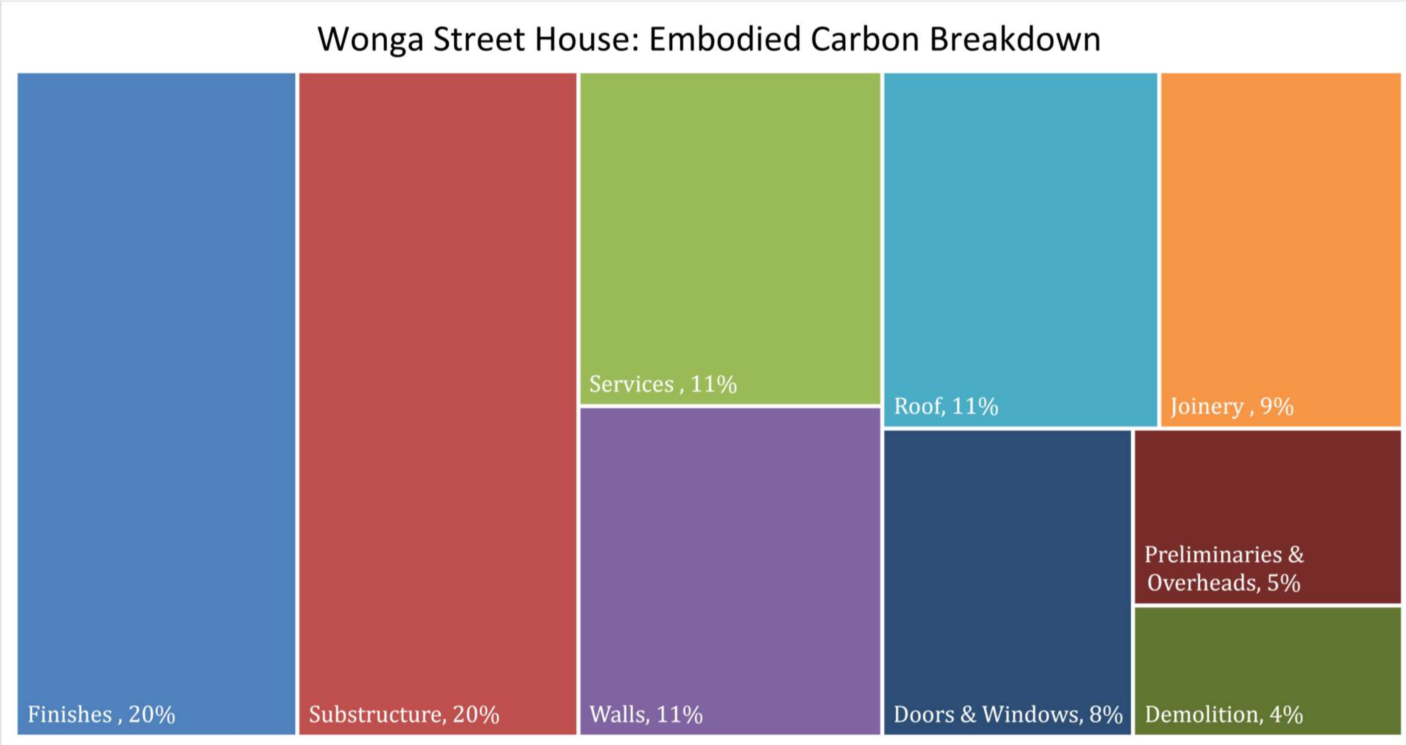
- Carport, Shed, Driveway, and further post completion Landscaping were excluded as they were not included in Lighthouses services.
- All doors modelled as solid timber leaf, due to technical restrictions.
- All input output data is inaccurate as this is a build from 2013. They have been inflation adjusted, but prices for all building works have increased significantly.
- Decking doesn't include structural timber, as there is no detail drawing of it.
- Demolition Waste includes Module C disposal emissions.
- Includes Onsite Wastage

Footprint Aspects	T CO2 e Absolute	TCO2e/m2 NFA	Percents
Finishes	29.78	0.19	20%
Substructure	29.68	0.19	20%
Services	16.16	0.10	11%
Walls	15.95	0.10	11%
Roof	15.70	0.10	11%
Joinery	13.81	0.09	9%
Doors & Windows	12.27	0.08	8%
Preliminaries & Overheads	7.58	0.05	5%
Demolition	5.63	0.04	4%
Total	**146.56**	**0.92**	**100%**

Table 1: Embodied Carbon Breakdown



Graph 1: Embodied Carbon Cumulative



Graph 2: Embodied Carbon Percentage Breakdown

Embodied Carbon: A1 – A5 analysis

This project is comparable but higher emitting than recent LightHouse Homes with notable hotspots. Given that the house was completed in 2013, the costs used for I/O entries, though correct, are no longer reliable, as the I/O coefficients use 2022 economic data. It is likely that these I/O segments are underestimated.

The largest emitter is the Vitrified Porcelain tiles in the wet areas. Across all wet areas, 50 m² of tiling have been used. This accounts for 24.6 T CO2 e on its own and will have more significant impacts in the replacement modules.

Aside from this, the substructure maintains the norm of being the largest carbon sink in a residential home. Waffle pod slab systems are effective in many ways, but still need innovation and development in their sustainability performance.

Interestingly, the accounting for various services, preliminaries, and other detailed I/O inputs have not made as significant an impact as expected, but this may well be due to my first point of analysis.

The inclusions of the Carport, Shed, and Driveway will significantly increase materiality of the project, and bring the account closer to the real emissions.

Additional Information

Pre-Construction CDW	m3	EoL Scenario
Asbestos Tiles, 7.5 mm	0.9	Landfill
Bricks	8.4	Recycled
Concrete	21.17	Recycled
Timber, 90 x 45	0.7	Landfill
Plaster Board, 10 mm	3.4	Landfill
Total	**34.6**	

Table 2: Site Preparation Construction Demolition Waste, CDW

GWP of Module A0 Demolition	m3	T CO2 e
Landfill	5.0	1.00
Recycling	29.57	0.26
Total		**1.26**

Table 3: Site Preparation CDW Carbon Impacts

These demolition waste quantities and end of life scenarios come from the buildings Waste Management document. Transport impacts are counted in TFC I/O costings, however this stage 3, module C, emissions are not. The figures come from the EPiC database [5] for Recycled Aggregate, and the National Greenhouse Gas Accounts [1] for Landfill. Their impact is small, but nevertheless important.

Onsite Wastage	% wastage	Amount Wasted
Bricks	5	617.39 kg
Concrete	4	1.17 m3
Plasterboard	23	171.76 m2
Tile	10	5 m2
Carpet	10	2.2 m2
Fibre Cement	18	14.04 m2

Table 4: Onsite Wastage

Onsite wastage is already counted but the information is worth separating to show which materials have impactful wastage rates. The waste percentages are taken from a BRANZ [3], a New Zealand based sustainability company, datasheet. These impacts make up most of Module A5 and are included in *Table 1*.

Operational Carbon

The assumed service life of the building is set at 60 years, as this is both a conservative estimate, and attested by other LCA specialists. This means that the operational emissions will be shown across a 60 year timeframe. These emissions happen slowly over the building's life cycle and are shown cumulatively. It It is assumed that after this period, there will either be significant renovation works or a demolition.

The Operational Carbon is split into three parts, firstly the replacement and repair of materials, secondly, the impact of operational energy use, and lastly, operational water use.

Repair and Replacement: B3 & B5

The replacement of materials is based on their estimated service life. There are many different datasets for this and none that apply directly to the Australian residential context. The service lives of these materials are taken from another BRANZ data set, and supplemented with in house experience, in the hopes of adapting it to the Australian setting.

Only a few materials would be replaced within the 60 years. These are listed below with their service lives, and number of times replaced. It is assumed that all the material present in the house is replaced.

Material or Assembly	Service Life in Years	Replacement Cycles
Vitrified Porcelain Tile System	20	2
Plasterboard	30	1
Paint	10	5
Carpet	15	3
Kitchen Joinery	20	2
Wet area Fixtures	30	1

Table 2: Service life and Replacement Cycles of Materials and Assemblies

The impacts of replacement across the service life of the building are counted by using the impacts of these materials and assemblies, as they are already accounted in TFC Calculator, and multiplying them by their replacement cycles. These figures also include the wastage from each installation.

Material or Assembly	Embodied, T CO2 e	Replacement Cycles	T CO2 e
Vitrified Tiles	24.6	2	49.2
Plasterboard	6.72	1	6.72
Paint	2.24	5	11.2
Carpets	2.13	3	6.39
Kitchen Joinery	1.7	2	3.4
Wet area Fixtures	1.26	1	1.26
Total			**78.5**

Table 3: Total Replacement Impacts

It is worth noting that, even before replacement, the Tiles were the highest emitter of CO2 e, and replacement emissions extend this by a dramatic margin. It just about doubles the impact of the entire substructure. Apart from the tiles, the rest of the replacement impacts are within expected ranges, and all together have a low impact on the Whole Life Carbon of the structure.

Operational Energy Use: B6

This excludes the impacts of tenancy but includes controllable building efficiency. We have modelled the house using BERSPro which uses the Chenath Engine, and a tool used to provide EER Star ratings. The building has been designed for energy efficiency and thus performs far better than a standard home.

House Energy Rating software	BERS Pro Plus		Version	4.2 (Run 1 dated 2/8/13)	
Star Rating	Floor Area (m^2)		Loads (area adjusted MJ/m^2/annum)		
	Conditioned	Unconditioned	Heat	Cool	Total
7.5	123	26	64	17	81

Figure 1: Excerpt from Energy Efficiency Rating Certificate

For its set 60-year lifespan, the building will hypothetically use 597,780 MJ or 166,049 kWh to control the temperature of the home. This number is for direct energy put into the home and changes based on the Coefficient of Power, CoP, of the chosen heating and cooling systems. This home uses electric resistive panels and a fireplace to cover the heating. As the Bers file is unavailable, the house cannot be broken down into its rooms and so we cannot account for the various heating systems. It is assumed that Electric resistive panels are used for all the heating loads. As there is no cooling system this is assumed as zero.

As the Coefficient of Power for electric resistive panels is 1:1, more realistic estimate for the Electricity consumption of the home's heating system is 131,200 kWh across the 60-year lifespan. This is an expected figure and will have a major impact on the Carbon Account.

The greenhouse gas impacts of electricity are modelled through the National Greenhouse Gas Accounts 2022, with our most current energy mix. The emission factor for electricity consumed in the ACT and NSW is 0.79 kg CO2 e / kWh. This is a conservative estimate and would be significantly lower with the use of a Heat pump, split cycle AC system.

Operational Electricity Consumption		
Electricity Consumption	131200	kWh
Greenhouse Gas Emitted	103648	kg CO2 e
Greenhouse Gas Emitted, in Tons	**103.65**	**T CO2 e**

Table 4: Operational Electricity Impact

The house has no gas fitting, generators, or other forms of fuel consumption, and so only electricity is included in this module. The impact of refrigerant leakage would also be here, if better information had been recorded at the time of construction.

Operational Water Use: B7

While operational water is more obviously impactful as pure water consumption, it still has a measurable greenhouse gas emission. The average household water consumption figure was taken from the latest Water Account [2] from the Australian Bureau of Statistics and the impacts taken from the EPiC database. It uses a per Household consumption rate in place of a per person rate.

Operational Water Use		
Annual Household Consumption	0.18	ML / year
60 Year Consumption	10.8	ML
Greenhouse Gas Emissions	14040	kg CO2 e
Total	**14.04**	**T CO2 e**

Table 5: Operational Water Impact

End of Life Stage

The final stage in a building's lifecycle is it's end of life. As most of the buildings assessed in a LCA are either under construction or in use, the end of life stage is based on various scenarios, where possibilities are discussed and the most realistic is added to the Whole Life Carbon Account. Each scenario includes the impacts of Demolition: C1, Transport: C2, Waste Processing: C3, and Disposal: C4.

The module A0: Demolition refers to the impacts of clearing the site in preparation for the new building, while C1: Demolition is the impact of deconstructing the new building in the future. We can only assume that the future demolition impacts will be the same as they are now, so as we do not rely on the possibility of technological advancement.

Demolition: C1 and C2

The same method used to calculate the pre-construction demolition was used here. An estimate figure for the cost of demolition was put into TFC calculator. This estimate figure comes from in house experience and comparisons to recent projects of similar size. TFC Calculator uses a I/O emission factor that includes transport emissions. This is an inaccurate measure but the best available option.

C1 and C2 Emissions	Cost		T CO2 e
Demolition	**$**	**20,000**	**5.8**

Table 6: I/O Emissions of Modules C1 and C2

CDW Processing: C3

In Canberra, most building materials are given to Canberra Construction Recyclers, CCR, who recycle concrete and bricks into various new materials like road base or loose fill. They take truckloads of demolition waste and sort through them, taking what they can and landfilling what they can't. The usual EoL scenario for houses in Canberra involves all their bricks, concrete, and steel being recycled or reused.

The chosen EoL scenario for reporting has all brick and concrete being crushed into recycled aggregate, all steel and sand resold through CCR, and all glasswool insulation reused in new builds, while the remainder of the materials are taken to landfill.

Recycling	T	m^3
Concrete	63511.53	27.20
Bricks	12.35	7.66
Total Recycled	69.14	31.08

Table 7: EoL Recycling Quantity

Recycling Emissions	m^3	T CO2 e
Brick	7.66	0.09
Concrete	27.20	0.21
Total	**34.86**	**0.30**

Table 10: Impact of Recycling CDW into Recycled Aggregate

Bricks have the potential to be reused in their EoL state, by chipping off their mortar by hand. Steel is resold in a used state. Sand is sifted but reused in its EoL state. These processes have no environmental impact and are the best case scenario. Many other materials may be saved from landfill, and almost any alternative is preferable.

Reused	kg	m^3
Sand	26850	17.9
Glasswool Insulation	1691	67.6
Plywood	65	0.1
Steel	1980	0.25
Colorbond	600	0.076

Table 9: EoL Reuse Quantities

Disposal: C4

These emissions are calculated with the same process as A0: Demolition, by using the National Greenhouse Gas Accounts. Module A0: Demolition uses inaccurate data and thus is considerably lower impact than its C4 counterpart.

Landfill	T	m^3
Plasterboard	14.61	7.5
Radiata Pine	3.43	6.7
Windows	2.51	1.0
XPS	0.69	30.1
Fibre Cement Cladding	0.68	0.5
Eave Lining	0.36	0.0
LVL	0.08	0.2
Total Landfill	23.83	45.9

Table 10: EoL Landfill Quantities

Landfill Emissions	m^3	T CO2 e
Landfill	**45.9**	**9.18**

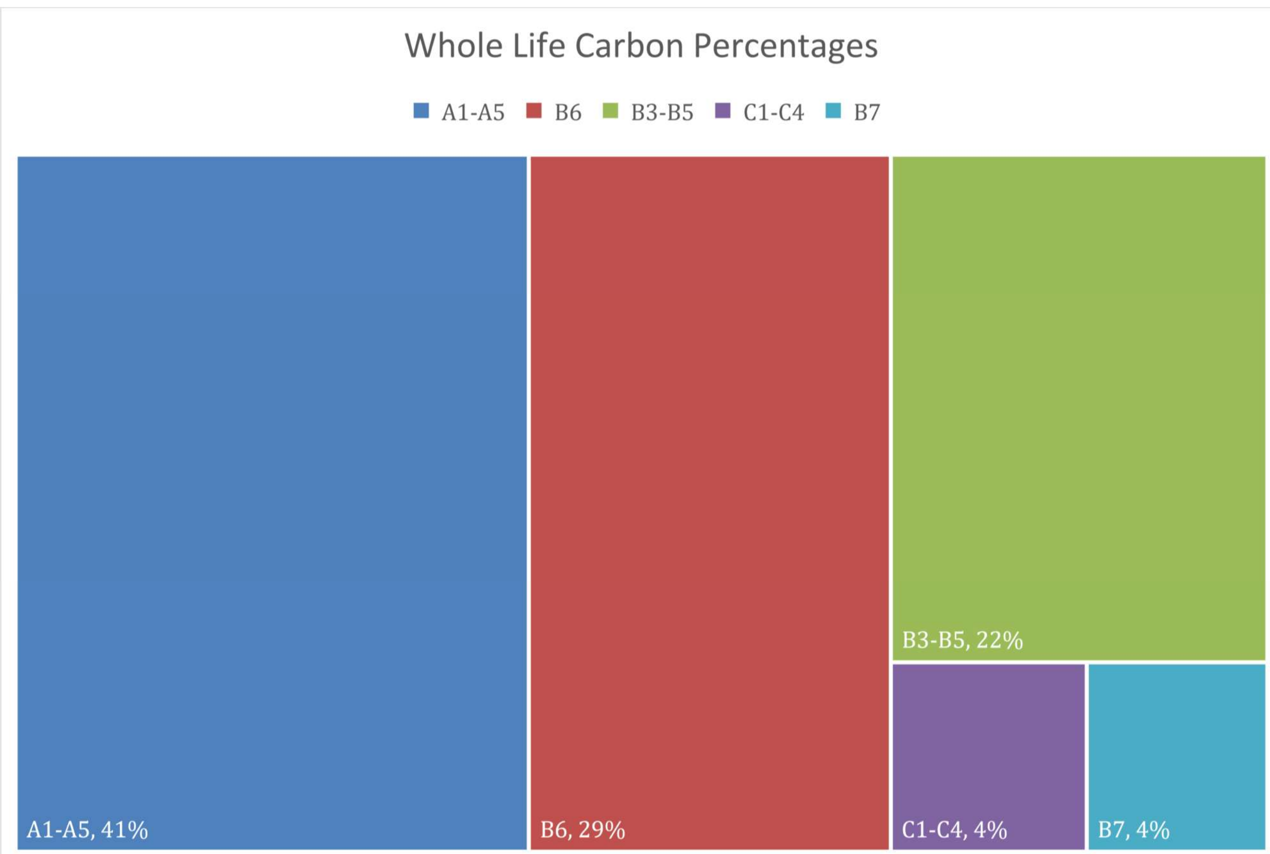
Table 11: EoL Landfill Emissions

Whole Life Carbon Account

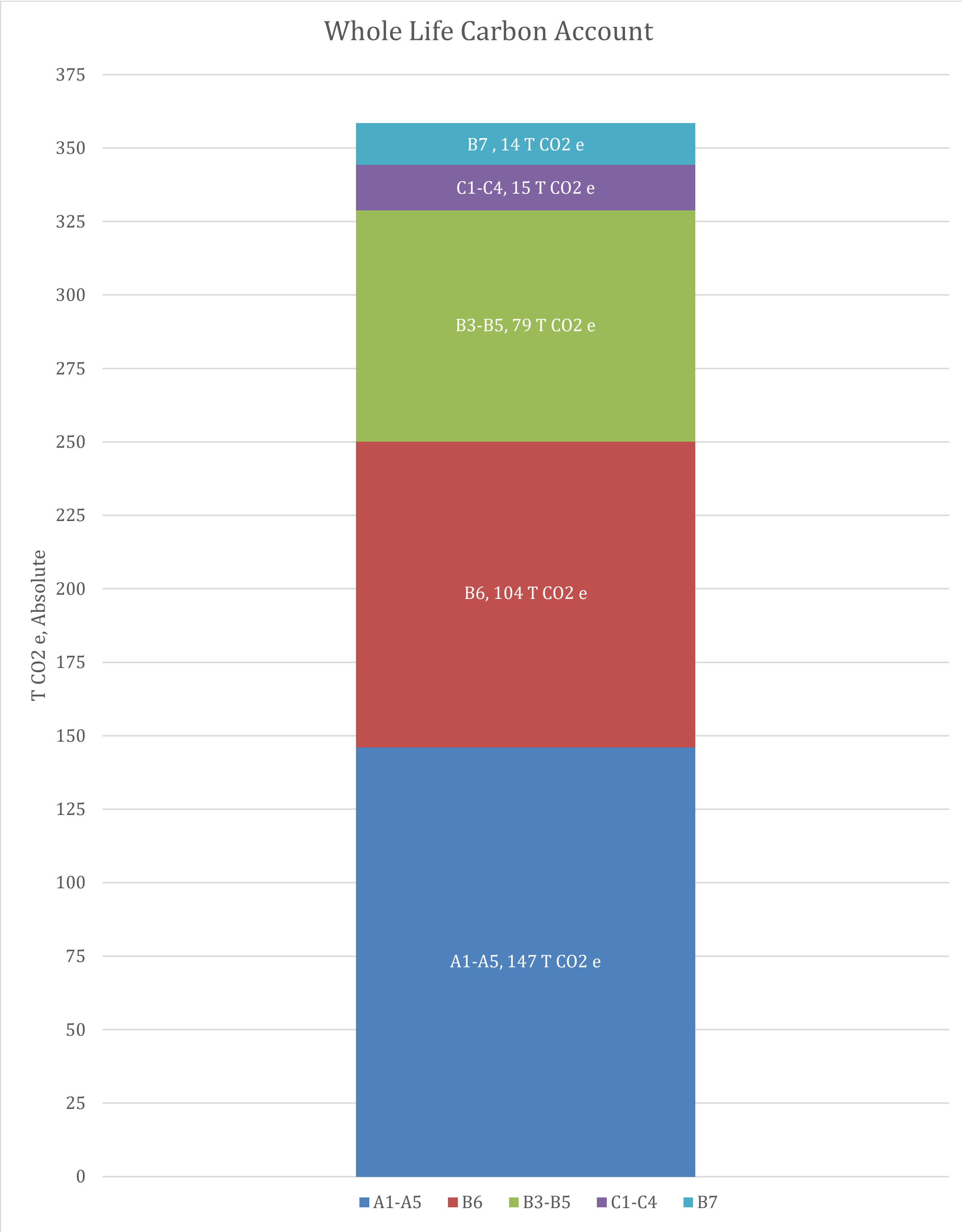
This account includes all previous Carbon emissions and represents the environmental impact of greenhouse gases emitted by or for the Wonga Street House across its entire life cycle. It is broken up into the main stages, with the Use Stage broken into its modules, as they are dramatically different from each other. The final Tons of Carbon emitted figure is higher than other reports, as the scope of this account is far larger than the built environment standard.

Whole Life Carbon Account	T CO2 e	T CO2 e / NFA	Percents
A1-A5: Embodied Carbon	147	0.94	41%
B6: Operational Energy	104	0.65	29%
B3-B5: Repair & Replacement	78.5	0.55	22%
C1-C4: End of Life Stage	15	0.10	4%
B7: Operational Water	14	0.09	4%
Total	**358**	**2.24**	**100%**

Table 12: Whole Life Carbon Account



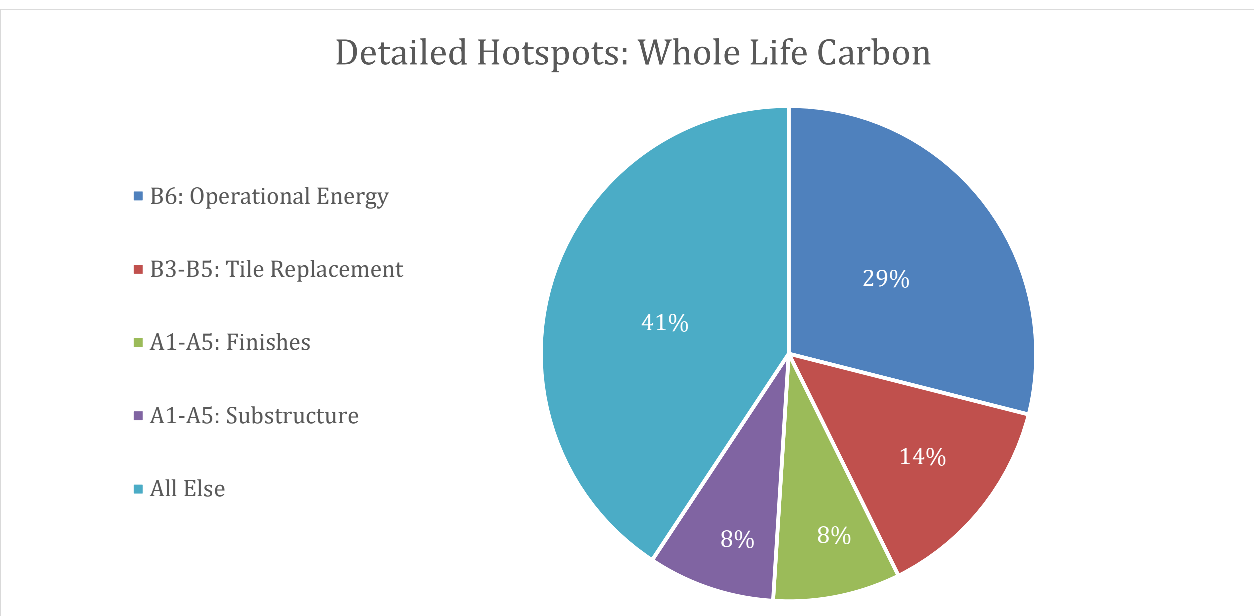
Graph 3: Whole Life Carbon Percentages



Graph 4: Whole Life Carbon Account

Detailed Breakdown Whole Life Carbon	T CO2 e Absolute	TCO2e/m2 NFA	Percents
B6: Operational Energy	103.6	0.65	28.9%
B3-B5: Tile Replacement	49.2	0.31	13.7%
A1-A5: Finishes	29.78	0.21	8.3%
A1-A5: Substructure	29.7	0.19	8.3%
Services	16.2	0.10	4.5%
Walls	16.0	0.10	4.5%
Roof	15.7	0.10	4.4%
Op. Water	14.0	0.09	3.9%
Joinery	13.8	0.09	3.9%
Doors & Windows	12.3	0.08	3.4%
Paint Replacement	11.2	0.07	3.1%
EoL Landfill	9.2	0.06	2.6%
Preliminaries & Overheads	7.6	0.05	2.1%
Plasterboard Replacement	7.1	0.04	2.0%
Carpets Replacement	6.4	0.04	1.8%
EoL Demolition	5.8	0.04	1.6%
Pre-Demolition	5.6	0.04	1.6%
Kitchen Joinery	3.4	0.02	0.9%
Wet area Fixture Replacement	1.3	0.01	0.4%
EoL Recycling	0.3	0.00	0.1%
Total	**358.03**	**2.27**	**100%**

Table 12: Detailed Breakdown of Whole Life Carbon



Graph 5: Largest Contribution Hotspots

Analysis and Reduction strategies

Graph 5 highlights the biggest contributors to the Whole Life Carbon Account, being Operational energy, Replacement of Tiles, Internal Finishes, and Substructure. By addressing these, the largest changes to total carbon can be made.

Firstly, changing the heating system of the home to a high efficiency reverse cycle air conditioner would dramatically lower the electricity consumption and thus B7: operational energy. Currently, the electric resistive panels heat at 1:1 output to input ratio where a high efficiency reverse cycle AC can heat at a 600:1 output to input ratio. Combining this with a Photovoltaic system and a personal battery could dramatically reduce operating emissions and costs.

Secondly, replacing the Vitrified Porcelain tiles with a more sustainable alternative. The Homogeneous Flooring Sheet by Armstrong Flooring needs replacing far less and has significantly less embodied carbon than most tiling. Given that there is 50 m2 of tiling across the home, this could save up to 60 T CO2 e with a minor design choice.

Other changes could be made, but at a high cost for less impact across the home's lifespan. If this were to be built today, updating the Waffle pod slab system, and using alternatives to gyprock, such as Durra Panels, would help limit embodied carbon.

Conclusion

Wonga Street House is an interesting house, well designed to limit operational energy consumption. It has specific hotspots of embodied carbon and may well serve as an example of common practice in embodied footprint accounting. It is likely that most homes built in Australia have similar hotspots, and significantly worse operational energy.

Other LCAs of Australian Homes include credit offsets from residential Solar Panels. This leads to findings that approach "Neutral" or even "Carbon Negative". This is an antiquated system of counting and allows for dramatic greenwashing. We have followed the international academic recommendation of not including Credit for PV systems.

"No benefits and loads beyond the system boundary (module D1) are shown [...] which in any case should not be combined and not used to "offset" emissions from other life cycle stages." (Röck et al., 2022) [7]

The findings of this report are within internationally recognised ranges. This is necessary to include, as there are insufficient studies of comparable scope within Australia. The study in reference is linked below [8].

Resources

1. *Australian National Greenhouse Accounts Factors 2022.* publication. Australian Department of Climate Change, Energy, The Environment and Water. Available at: https://www.dcceew.gov.au/climate-change/publications/national-greenhouse-accounts-factors-2022.

2. Australian Bureau of Statistics 2020-21, *Water Account, Australia*, ABS, viewed 17 March 2023, Available at: https://www.abs.gov.au/statistics/environment/environmental-management/water-account-australia/latest-release

3. *BRANZ*. Available at: https://www.branz.co.nz/environment-zero-carbon-research/framework/data/ (Accessed: March 17, 2023).

4. CEN (2011). *Sustainability of construction works - Methodology for the assessment of performance of buildings - Part 1: Environmental Performance* (prEN 15978-1:2011).

5. Crawford, R.H., Stephan, A. and Prideaux, F. (2019) Environmental Performance in Construction (EPiC) Database, The University of Melbourne, Melbourne. Available at: EPiC Database

6. *Net zero carbon calculation tools* (2022) The Footprint Company. Available at: https://footprintcompany.com (Accessed: March 17, 2023).

7. Röck, M. *et al.* (2022) "Towards indicative baseline and decarbonization pathways for Embodied Life Cycle GHG emissions of buildings across Europe," *IOP Conference Series: Earth and Environmental Science*, 1078(1), p. 012055. Available at: https://doi.org/10.1088/1755-1315/1078/1/012055.

8. Satola, D.; Röck, M.; Houlihan-Wiberg, A.; Gustavsen, A. (2021) *Life Cycle GHG Emissions of Residential Buildings in Humid Subtropical and Tropical Climates: Systematic Review and Analysis.* Buildings **2021**, 11, 6. https://dx.doi.org/10.3390/buildings11010006