TOWARDS NET ZERO CARBON: THE ROLE OF URBAN BUILDINGS

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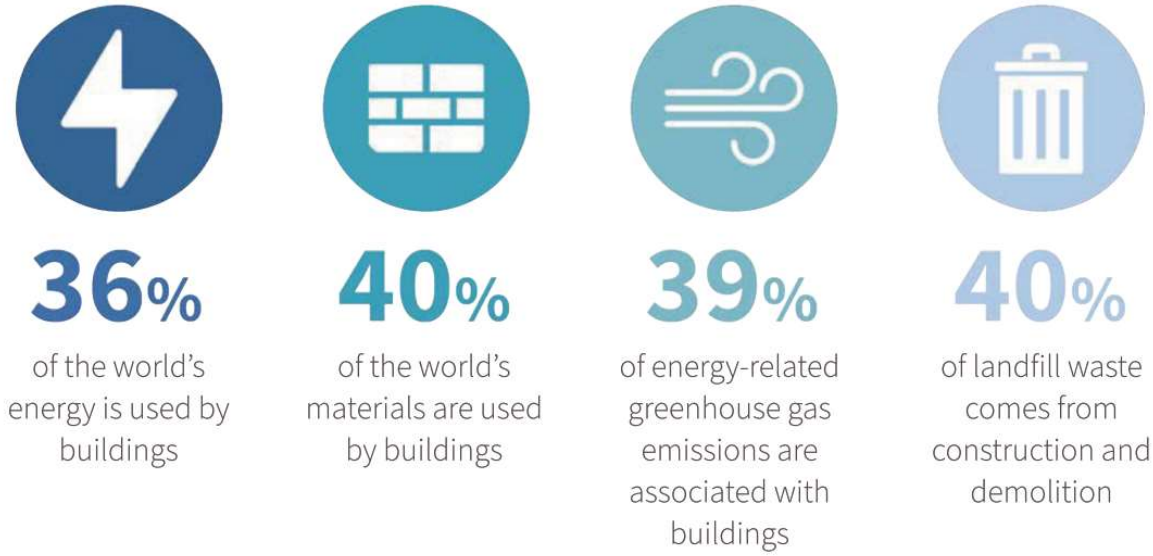
IMPACTS OF THE BUILDING SECTOR



Source: Global Alliance for Buildings and Construction, International Energy Agency and the United Nations Environment Programme (2019).

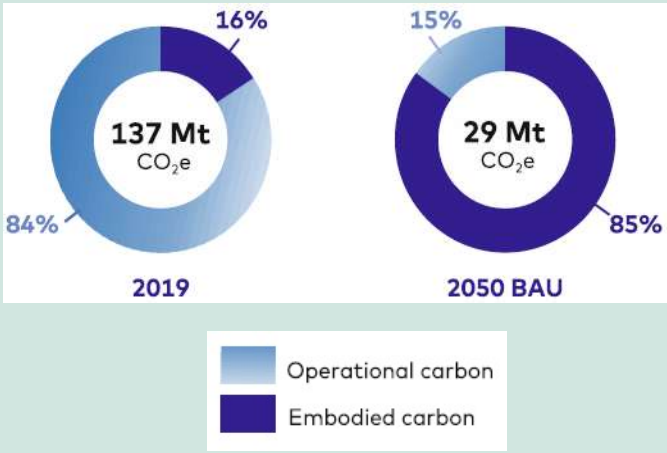
- Building materials have a large range of environmental impacts, from accounting for most waste to landfills to depleting natural resources.
- All the life cycle stages of buildings, generate environmental flows such as greenhouse gas emissions, waste and energy and water use.

SDGS RELATED TO BUILDINGS & THEIR ENVIRONMENTAL IMPACTS

- SDG 7: Renewable energy and Energy efficiency
- SDG 11: Solid waste management; Air pollution; Urban planning
- SDG 12: Material footprint; Recycling rate
- SDG 13: Greenhouse gas emission

OVERVIEW – BUILDINGS IN AUSTRALIA

- Buildings account for over 50% of electricity use in Australia and almost a quarter of its emissions (Property Council 2023).
- About 8.8 million buildings standing in 2016 accounted for 3.8 billion tonnes of material stocks. By 2060, the projected material demand for new buildings ranges from 4.3 to 7.5 billion tonnes.
- The upper range of the demand signals a two-fold increase in building materials and associated environmental impacts, including CO2e, energy and water consumption (Soonsawad et al., 2022).



Carbon emissions from Australian building stock in 2019 and 2050

Source: Green Building Council of Australia & thinkstep-anz, 2021

Toward net zero – the role of urban buildings

3D building footprint

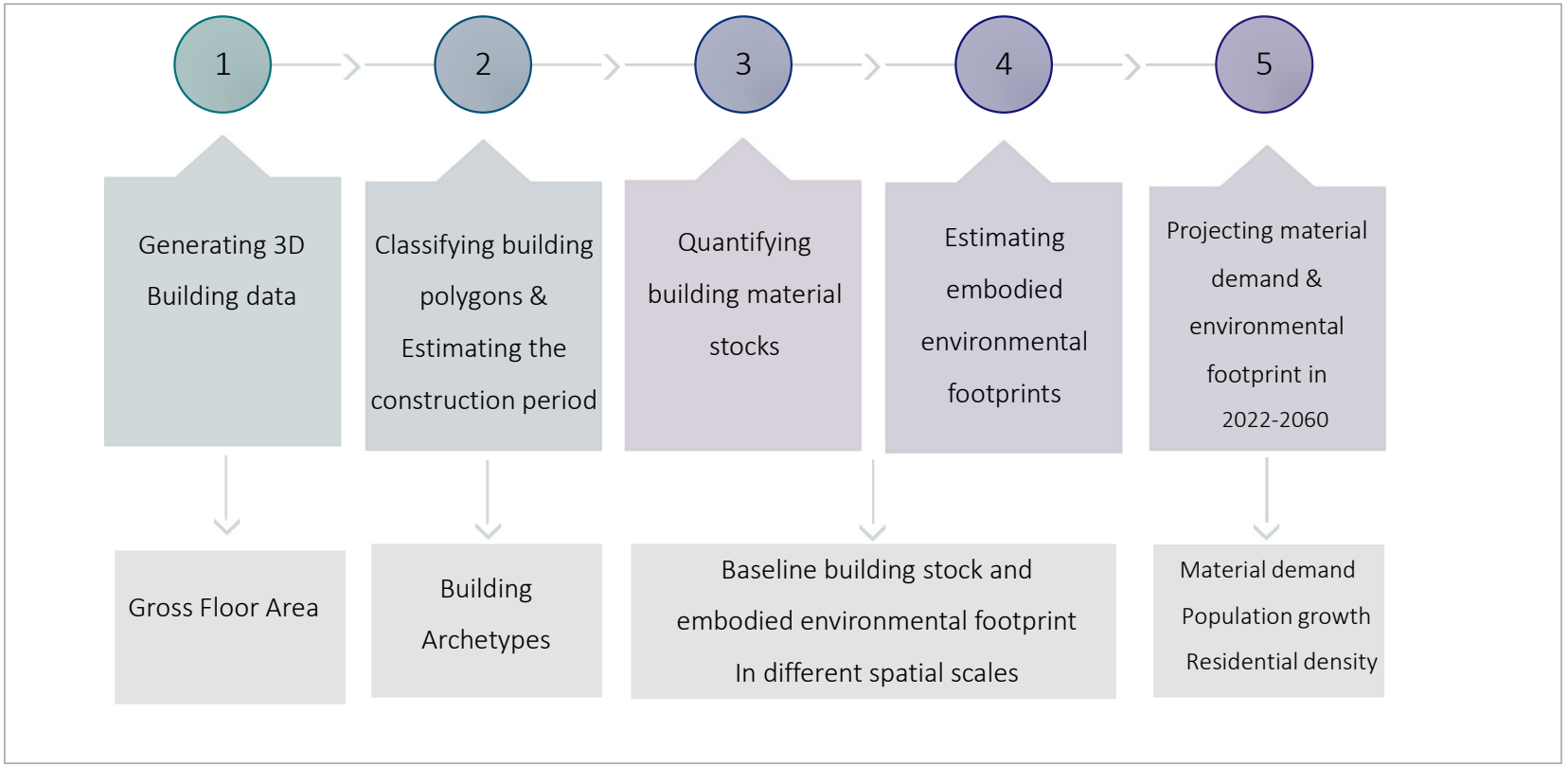
Modelling embodied environmental impacts of buildings

Using the high-resolution images from the CSIRO-Urban Monitor, we have generated 3D modelling of buildings by photogrammetry and quantified the followings:

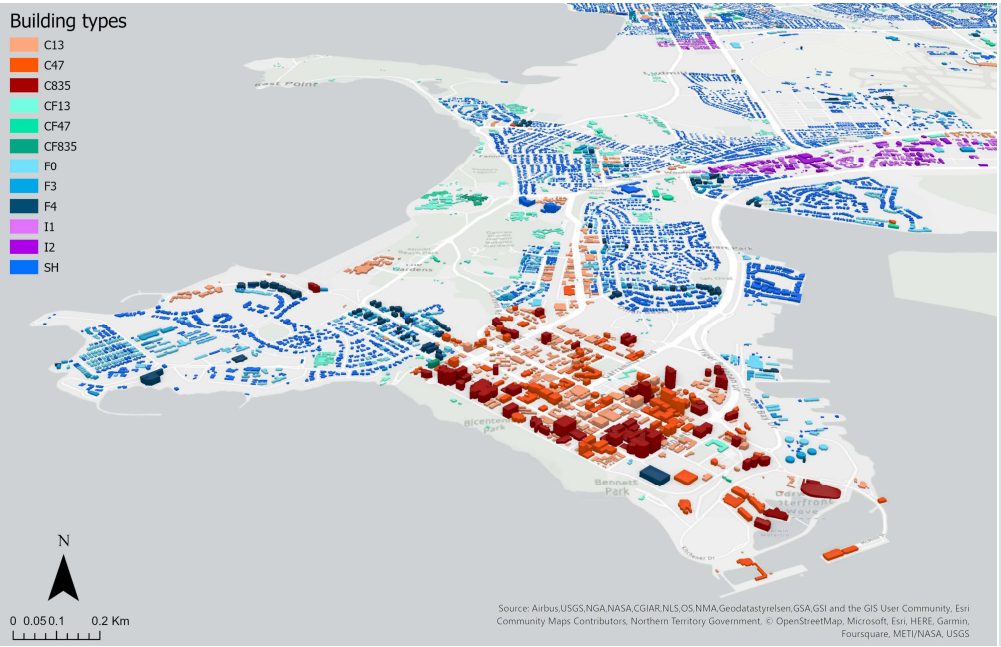
- Building material stocks by material type
- Embodied carbon emission
- Embodied energy
- Embodied water

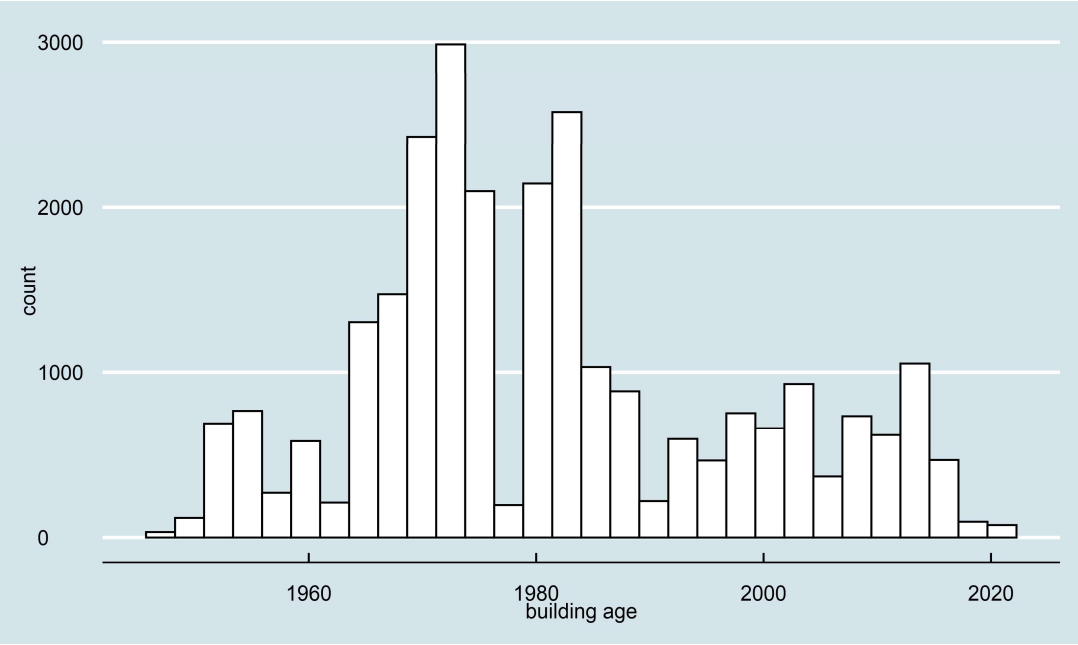
We have analysed buildings standing in 2021 as a baseline study. We are projecting results for up to the year 2060 in different urban setting scenarios.

STEP OF METHODOLOGY



BUILDING CLASSIFICATION

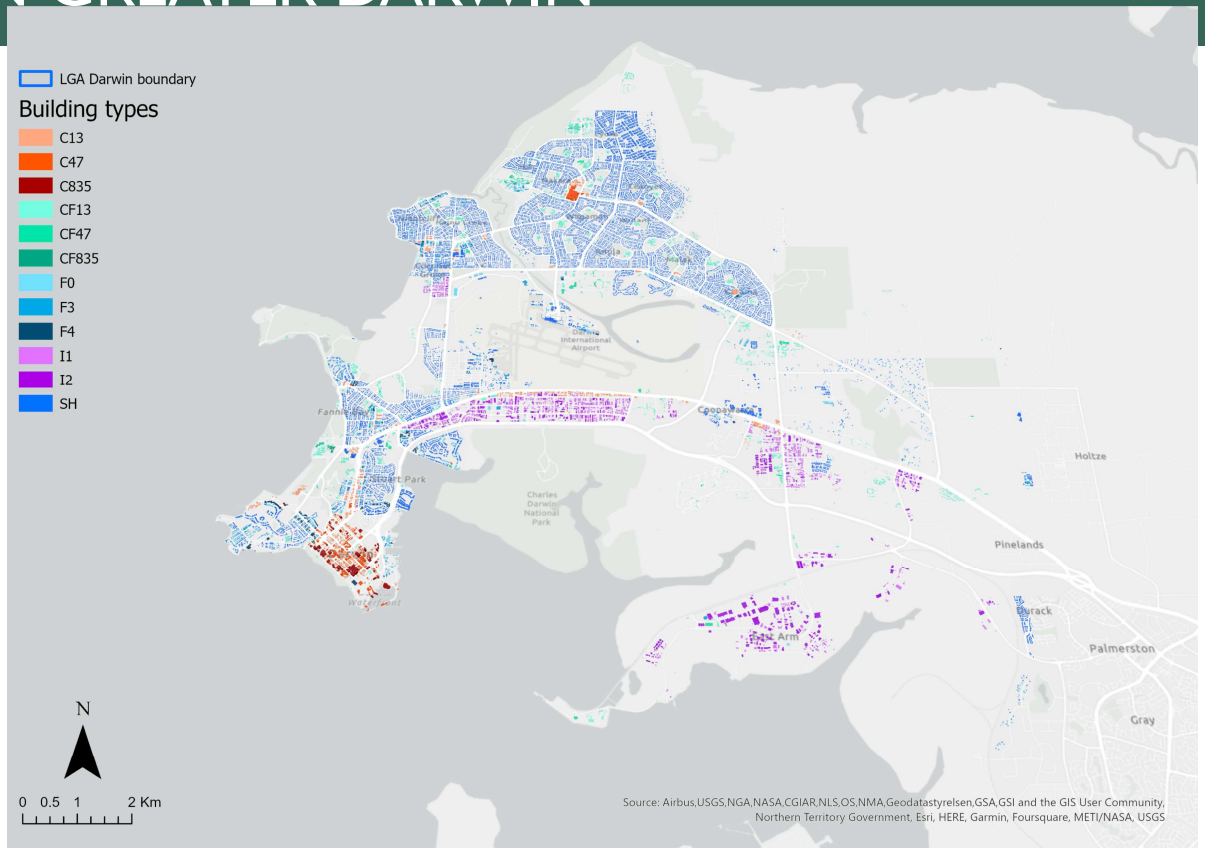




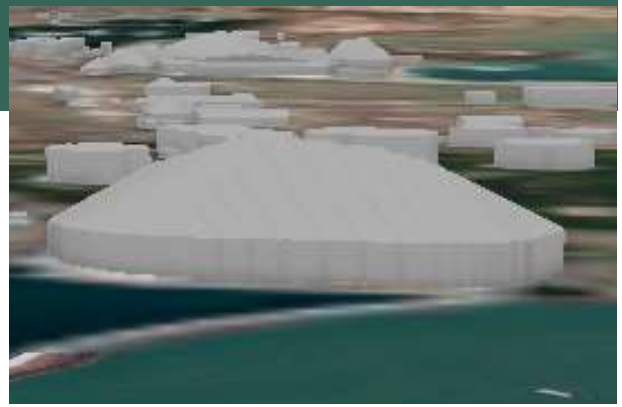
Building type

Building age

BUILDING TYPES IN GREATER DARWIN



Material stock and embodied environmental impacts



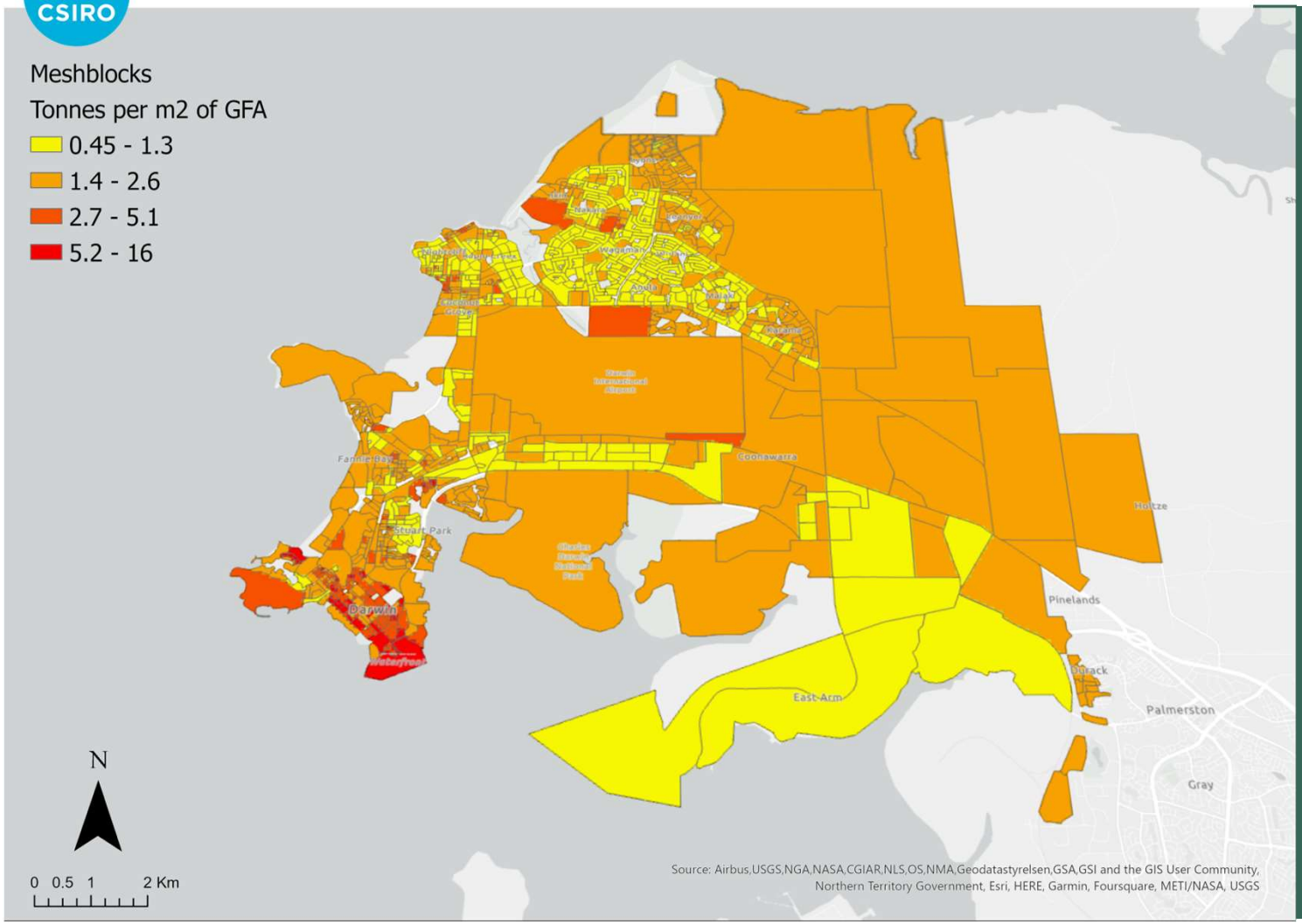
Building profile - Darwin Convention Centre

IDs	Aluminium	Bitumen	Carpet	Ceramics	Concrete	Copper	Glass	Insulation	Paint	Plasterboard	Plastics	Sand and Stone	Steel	Timber	Total
Material stock	54.72	45.99	-	2,015.97	73,504.87	32.25	77.68	19.57	21.36	207.46	23.28	639.09	15,886.35	487.53	93,016.12
GHG Coefficient	26.70	0.20	7.80	1.30	0.24	10.10	2.00	3.80	6.30	0.79	7.70	0.03	2.10	1.19	
GHG (ton)	1,461.11	9.20	-	2,620.76	17,641.17	325.72	155.35	74.38	134.54	163.89	179.22	19.17	33,361.34	580.17	56,726.02
Water coefficient	0.16	0.00	0.29	0.02	0.00	0.29	0.03	0.06	0.20	0.01	0.44	0.00	0.04	0.03	
Water(ML)	8.76	0.13	-	30.64	271.97	9.32	2.50	1.22	4.21	2.48	10.31	1.20	703.77	13.00	1,059.49
Energy Coefficient	0.30	0.00	0.12	0.02	0.00	0.15	0.03	0.06	0.12	0.01	0.13	0.00	0.03	0.02	
Energy (TJ)	16.14	0.19	-	38.10	191.11	4.84	2.21	1.12	2.65	2.42	2.96	0.28	468.65	9.31	739.98

Material stock and embodied environmental impacts

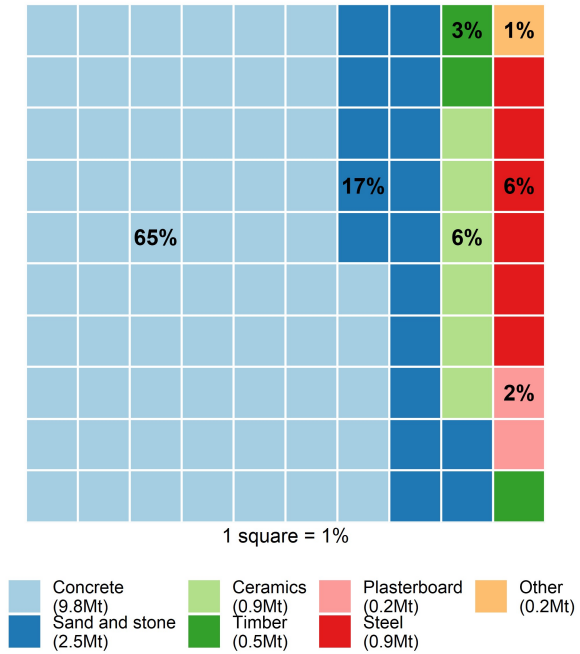
Comparison between three residential buildings

	Construction years		
	1977	2000	2007
Material stock (Tonnes)	131.51	131.38	131.7
GHG (Tonnes)	88.37	56.45	54.63
Water(ML)	1.54	1.02	0.99
Energy (TJ)	1.3	0.77	0.72



EMBODIED MATERIAL PER GROSS FLOOR AREA

MATERIAL STOCK AND EMBODIED ENVIRONMENTAL IMPACTS 2021 BUILDINGS



Materials	Material Stock (Tonnes)	Percentage Material Stock	Energy (TJ)	Water (ML)	GHG (Tonnes of CO2e)	Percentage GHG
Aluminium	18,900	0.12	5,576	3,024	504,636	7%
Bitumen	11,022	0.07	46	32	2,204	0%
Carpet	9,381	0.06	1,091	2,695	73,174	1%
Ceramics	891,707	5.89	16,853	13,554	1,159,219	16%
Concrete	9,870,942	65.21	25,664	36,522	2,369,026	32%
Copper	5,237	0.03	786	1,513	52,890	1%
Glass	35,492	0.23	1,012	1,143	70,984	1%
Insulation	42,615	0.28	2,433	2,651	161,935	2%
Paint	18,948	0.13	2,350	3,733	119,375	2%
Plasterboard	231,057	1.53	2,696	2,759	182,535	2%
Plastics	13,847	0.09	1,759	6,134	106,625	1%
Sand & stone	2,541,084	16.79	1,118	4,752	76,233	1%
Steel	947,031	6.26	27,937	41,953	1,988,766	27%
Timber	498,943	3.3	9,525	13,302	593,742	8%
Total	15,136,206	100	98,845	133,767	7,461,344	100%

Total municipal emissions during 2020-21, were 1,682,000 tonnes

Embodied GHG from buildings was 4.4 times total municipal emissions.

POLICY IMPLICATIONS

- Material demand of building sectors could challenge Australia's ability to achieve a net-zero emission target by 2050.
- To achieve sustainability targets, more environmentally friendly construction materials and technologies are needed.
- Policies that enable reuse, repair and refurbishment of buildings, and a focus on green procurement of building materials and improving secondary material markets can all contribute to a circular economy of built infrastructure.

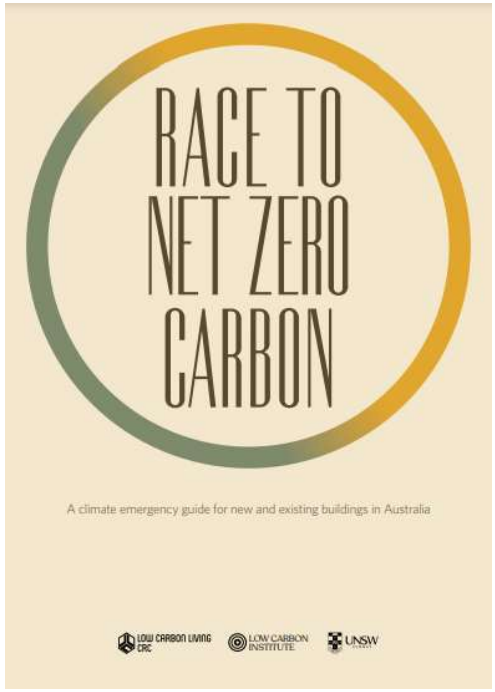
LIMITATIONS

- The model did not account for recurrent use of materials during the service life of buildings, e.g. non-structural materials such as flooring, ceramic tiles, and insulation and waste of construction materials.
- Our analysis did not account for differences in construction technologies or building codes in different Australian regions.

CONCLUSIONS AND FUTURE RESEARCH

- Most building stock comprises single houses, which collectively have a high material and environmental footprint.
- We are working towards projecting material demand and environmental requirements up to the year 2060 in different urban density scenarios.
- Improvements in resource use efficiency could help inform urban planning decisions, and changes in household preferences could reduce the demand for building materials
- This research can inform circular economy efforts to improve building materials management by helping estimate the implications of alternative configurations of the urban built environment.

NATIONAL INITIATIVES



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THANK YOU

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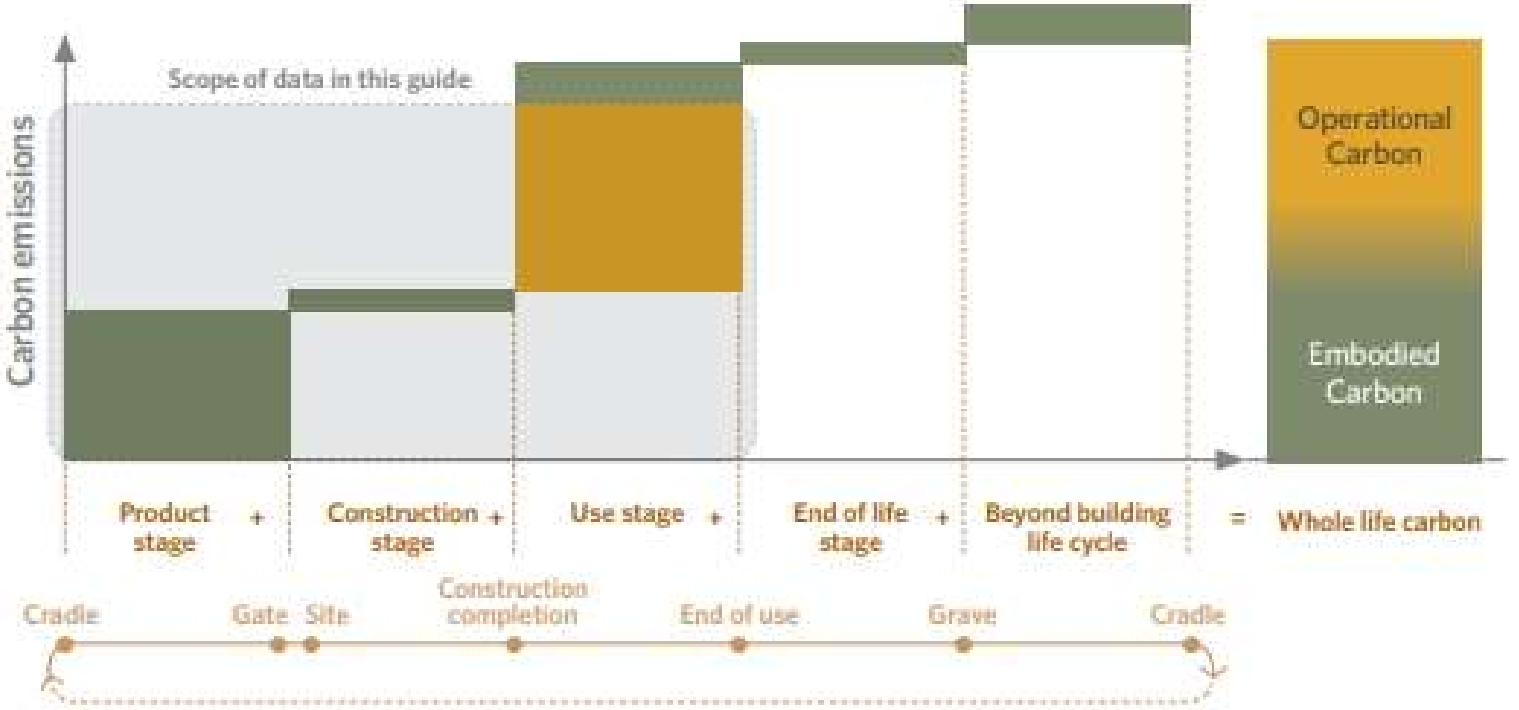

Figure 4: **Scope of carbon emissions across different stages of the building life cycle**

Prasad, D., Dave, M., Kuru, A., Oldfield, P., Ding, L., Noller, C., & He, B. (2021). *Race to Net Zero Carbon: A Climate Emergency Guide for New and Existing Buildings in Australia*.

DATA REQUIREMENTS

1. **<u>High-resolution imagery; building types; and building ages</u> – to calculate gross floor area by building archetype**

<u>2. Material intensities (kg/m²)</u> - adapted from Schandl et al. (2020) and Stephan and Athanassiadis (2017, 2018)

3. **Environmental impact coefficients** – adapted from Environmental Performance in Construction (EPiC) database developed by Crawford et al., 2019