
11 SUSTAINABLE CITIES AND COMMUNITIES
Building With Purpose
Case Study Insights: Reducing the Carbon Footprint Of Your Home

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An Introduction to Building With Purpose

By 2050, the number of buildings globally is expected to double as the human population approaches 10 billion. Even before a building is occupied, its emissions will be responsible for half the entire carbon footprint of the new construction (World Green Building Council, 2019). Builders, as well as owners, play a crucial role in addressing this climate crisis by adapting to green, sustainable design and construction.

According to the United Nations (UN), CO_2 emissions from buildings and construction have reached a new high, putting the sector off track to decarbonise by 2050 (UNEP, 2022). While there has been a slight decrease in the level of emissions and energy use, the growth in the building sector is outpacing efforts to improve energy efficiency, making it an urgent area for action and investment. Using energy-efficient materials is just one aspect of green design. Sustainable design and construction involves the development of systems and products that minimise their carbon footprint throughout their entire life cycle.

Figure 1. The number of buildings is expected to double by 2050.
Source: Pexels

Background

As people become more concerned about the environment and climate change, there has been an increased emphasis on the process by which new structures are commissioned and constructed, particularly regarding the amount of energy and resources they consume (Hayles & Kooloos, 2005).

The fact that industries related to transportation, building, and construction are the biggest contributors to climate change is an undeniable and unchangeable reality. Buildings are responsible for:

- 35% of global energy consumption (UNEP, 2020)
- 40% of all raw materials (Bonoli et al, 2021)
- 50% of global greenhouse emissions (Bonoli et al, 2021)

Around one-third of all waste produced annually in the European Union (EU) comes from construction and demolition alone. Increased energy performance is one of the most appealing benefits of investing in sustainable construction. Florida's UTC Center for Intelligent Buildings is a prime example; they have removed 988 tons of greenhouse gases annually by using 60% less energy (Dodge Data & Analytics, 2018).

What is Green Building?

A green building is a built environmental space that considers its impact on both the environment and the people who use it. This means that the building's operation, design, and construction will generally place a strong emphasis on minimising its environmental impact through the use of sustainable building materials, high-efficiency energy and water use, reduced waste, and various other measures. The entire life cycle of a building is taken into account in this green construction method, including siting, design, construction, operation, maintenance, renovation, and demolition.

Comprehensive rating systems that certify green buildings, such as LEED, Living Building Challenge, and the Green Building Initiative (GBI), measure the building's energy efficiency and sustainability according to a number of criteria that define what makes a building green.

However, measuring the greenness of a building is a complex process. While none of the above rating systems are necessarily a perfect assessment of a building's performance, some measurement is certainly better than none, and moving to a higher performance rating is essential.

Figure 2. Green buildings consider its impact on both people and the environment. Source: Pexels

Why Building With Purpose Matters

Energy efficiency has recently become more and more critical to professionals across numerous industries. Studies show that the long-term growth of larger communities has had a profound effect on the environment. As a result, experts are starting to focus on the creation of green buildings which could offer people a more responsible way to use natural resources. The widespread use of green buildings not only enhances a neighbourhood's environmental conditions, but those who work and live there can also benefit from healthier environments free of unnecessary pollution and waste.

Environmental Benefits

With green buildings, building planners are able to improve and protect local ecosystems and foster biodiversity. This is crucial, as urbanisation is often responsible for endangering local species and ecosystems. In addition to conserving and restoring natural resources, greener building practices can also aid in enhancing the water and air quality in the surrounding area.

Economic Benefits

Greener practices may also be extremely helpful to company owners. Some economic benefits include lower overall operating expenses and increased tenant productivity. Studies have shown that greener buildings may help increase asset values while also maximising a company's economic performance across its whole life cycle. Such practices support long-term corporate success, improve occupant comfort, and improve health and overall well-being.

Environmental Issues in Construction

Some only consider the evaluation of product waste disposal without taking the environmental impact of construction and product life cycles into account. This view is too narrow. As much as 90% of a product's environmental impact is attributable to its use phase (American Chemistry Council, 2011).

A host of factors should be evaluated and contrasted with the product's performance. It is important to consider how the substitution of materials impacts on the overall functionality, aesthetics, cost, and health of people using them (American Chemistry Council, n.d.) .

A systems approach enables the assessment of a product at each stage of its life cycle, starting at the point where raw materials are removed from the earth, moving through to processing, manufacturing, fabrication, materials transportation, "use", and ending with disposal or reuse.

The American Chemistry Council (n.d.) provides guidelines for building designs, systems, and products to support this "systems approach" to sustainable and green building design:

- Design and purchasing criteria should take into account energy efficiency and the environment. This is properly weighed against other crucial factors like product safety, cost, performance, and accessibility.
- A systems approach should be used, focusing on the interactions

between individual building components and identifying options with the best chance of increasing energy efficiency and lowering overall environmental effects.
- Any procedure for establishing "sustainable" building/product standards must be science-based, open to all parties involved, transparent, and take into account any relevant new information.

Building With Purpose: Sustainable Construction

The construction sector is critical to a country's economic success. It contributes to the improvement of its residents' quality of life by providing vital socio-economic infrastructure like roads, hospitals, schools, and other basic and expanded facilities (Hussin et al., 2013).

During the First International Conference on Sustainable Construction held in Tampa, Florida, USA, the conference convener, Kibert, defined sustainable construction as, "creating a healthy built environment using resource-efficient, ecologically-based principles".

The OECD sustainable building project identifies five objectives for sustainable buildings: resource efficiency; energy efficiency (including greenhouse gas emissions reduction); pollution prevention (including indoor air quality and noise abatement); harmonisation with environment; and integrated and systemic approaches (John et al., 2005)

According to Hussin et al., (2023), sustainable construction involves a commitment to:

- Economic sustainability – increasing profitability by using labour, materials, water, and energy more efficiently.
- Environmental sustainability – preventing negative and potentially irreversible effects on the environment through careful use of natural resources, minimising waste, protecting, and where possible enhancing the natural environment.
- Social sustainability – attending to people's needs at every stage of involvement in the construction process.

Challenges in Sustainable Construction

Humans resist change for several reasons. Trying anything new in the cause of a more sustainable future is no exception; it is not impossible, but there are always challenges to overcome.

The construction industry has always been plagued by severe and persistent challenges such as (Hussin et al., 2013):
- capital cost
- waste generation
- negative environmental impacts
- excessive resource consumption

The hurdles faced in the adoption of sustainable or green building also include materials and technology selection, lack of cohesive information and knowledge relating to sustainable construction, design processes, and construction processes (Hayles & Kooloos, 2005).

A study conducted by du Plessis (2002) identified the following obstacles to sustainable construction in developing countries: insufficient capacity of the construction sector; an uncertain economic environment; a lack of accurate data; poverty and low urban investment; stakeholders' lack of interest in the issue of sustainability; technological inertia and dependence; a lack of integrated research; and entrenched colonial codes and standards. In accordance with the experiences of the developed world, the dearth of knowledge and information regarding sustainable construction issues and appropriate, cost-effective solutions is a significant obstacle that must be surmounted (Hayles & Kooloos, 2005).

Traditional design and construction focuses on cost, performance, and quality objectives but sustainable design and construction considers minimising resource depletion and environmental degradation, and the creation of a healthy built environment to these criteria (Kibert, 1994b). The shift to sustainability can be seen as a new paradigm (Vanegas et al., 1996) where sustainable objectives are within building design and construction. It is considered for decision-making at all stages of the life cycle of the facility. *Figure 3* outlines the evolution and challenges of the sustainable construction concept in a global context.

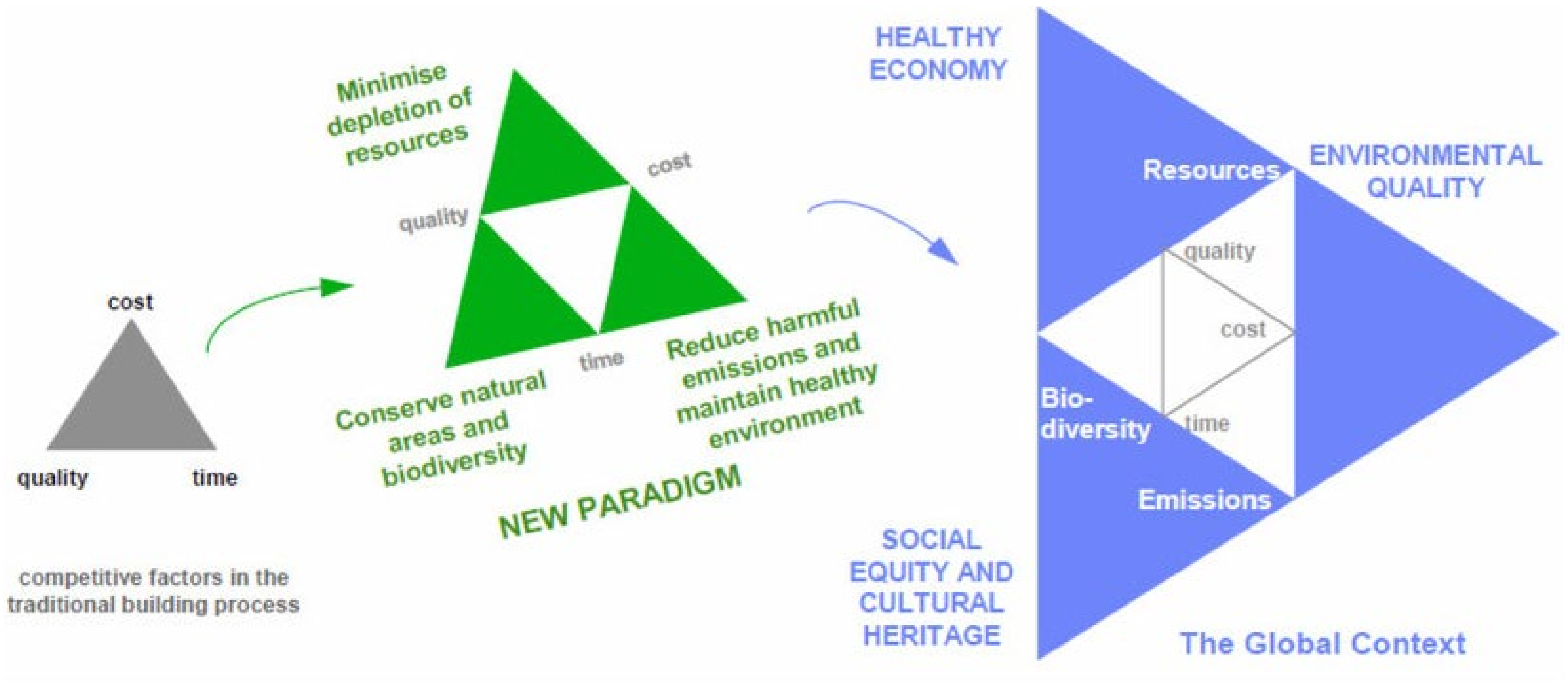

Figure 3. Challenges of sustainable construction in a global context.
Source: Huovila & Koskela (1998)

Sustainable construction considers every stage, from design to construction to ongoing maintenance. It's crucial to keep in mind that sustainable building processes don't only start once the contractors get to the job site; they continue thereafter. Making sustainable and "best practice" decisions at every stage of the process is the goal.

THRIVE Case Study: Life Cycle Analysis of a Single Residential Dwelling

Research Method

How do we apply the principles of decarbonisation, sustainability, and green building design to limit our impact as homeowners? We looked at two important end results to measure impact based on the home's carbon emissions: embodied carbon and energy efficiency which is also known as operational carbon.

Two Types of Carbon Emissions

Embodied Carbon

The embodied carbon of a material is the total carbon dioxide associated with its life cycle. This includes extraction, manufacturing, and transport. To put it simply, embodied carbon is the carbon emissions associated with the materials used to make the home.

A four-step framework is outlined by the Singapore Green Building Council (2015) to reduce embodied carbon emissions: prevent, reduce, and optimise, future-proof, and offset. Design choices should prioritise low or zero-carbon materials, responsible sourcing, and low lifecycle impact in other aspects. Future use and end-of-life considerations should also be taken into account by ensuring flexibility and potential for maintenance, repair, renovation, deconstruction, and future material reuse and recycling.

Operational Carbon

On the other hand, operational carbon is used to calculate the long-term impact after the building materials are installed. It refers to the carbon emissions that are generated from day-to-day energy use. This includes the emissions from electricity used to power lighting, heating, cooling, and other appliances on a daily basis. These emissions can be reduced by using energy-efficient appliances and systems, such as LED lighting and high-efficiency HVAC systems, or by using renewable energy sources, such as solar panels. By increasing energy efficiency, we can reduce our impact and achieve net-zero homes (ANSI, 2022).

Both embodied carbon and operational carbon are important considerations in the construction of a sustainable home. Embodied carbon emissions account for 30% of a building's carbon emissions, with the remaining 70% coming from building operations.

Building With Purpose: Conventional vs. Sustainable House Models

The construction of a conventional home typically involves the use of standard building materials such as brick veneers for external walls, plasterboard ceilings and partitions, concrete slabs, and ceramic tile flooring.

THRIVE modelled a typical 167 sqm., four-bedroom, single-story house based in Sydney, Australia (see *Figure 4).*

In the study, the embodied carbon of a conventional house model was measured with a systems approach through the life cycle analysis of building materials using the [OneClick LCA] tool. This measures the carbon footprint during the building phase and helps us identify the largest contributors to carbon emissions.

The operational carbon of the two models was measured using Australia's energy rating system, [NatHERS]. We analysed and compared the results of two models: the conventional (baseline) and sustainable house models. Below are the proposed sustainable materials and systems used as replacements for conventional building materials (see *Figure 5, next page*).

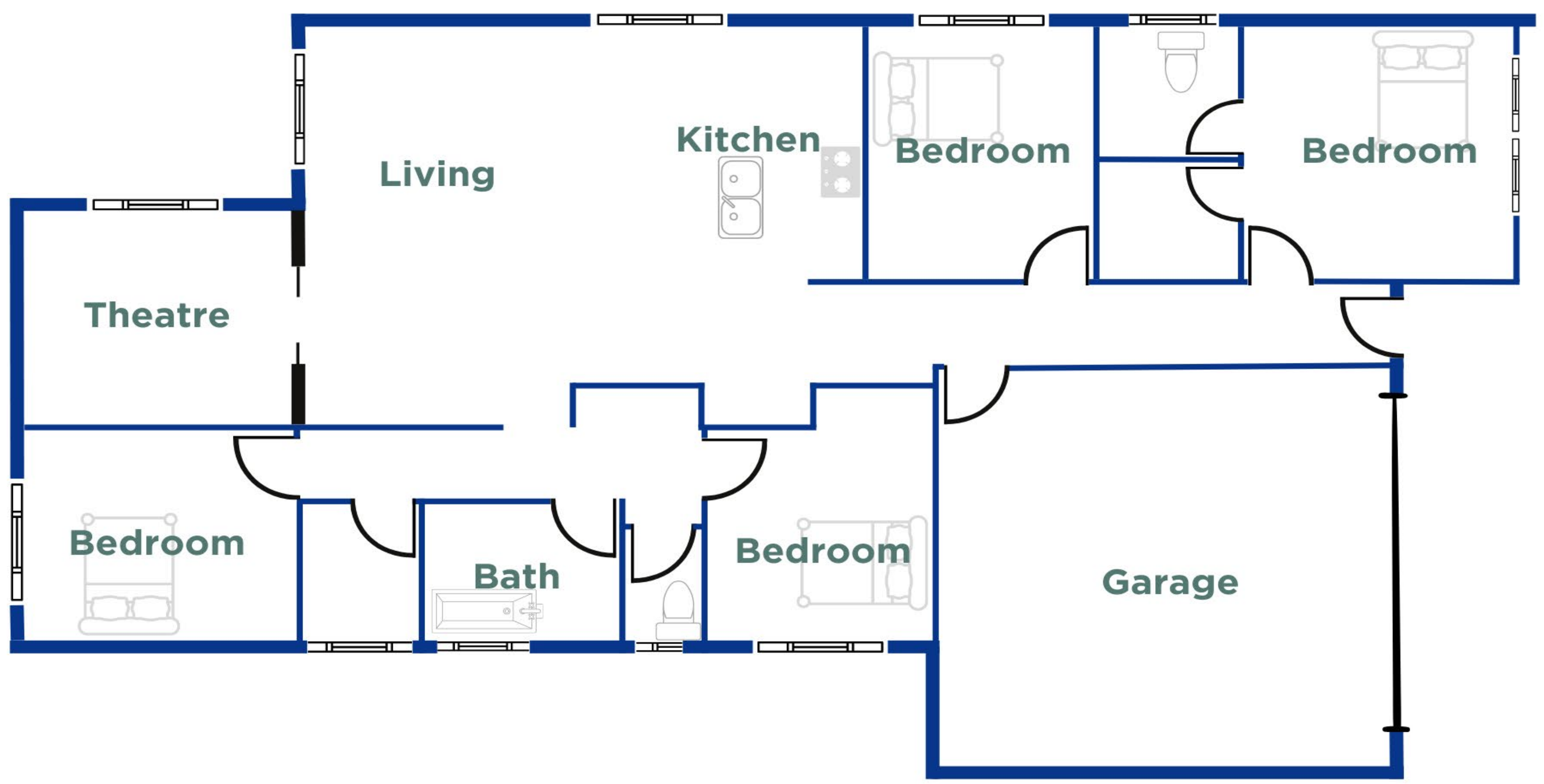

Figure 4. Floor plan for the LCA model.

The Conventional House Model

The life cycle analysis of the original house model shows that the three largest contributors to carbon emissions are concrete, metal, and brick, with 12.28, 7.46, and 5.19 tons of CO_2 emissions, respectively (see *Figure 6, next page*). Most of the concrete and metal were used as structural flooring. The external walls and facades are made of brick veneer. Concrete, metal, and brick all have relatively high embodied carbon compared to other building materials because of the energy-intensive processes involved in their production, transportation, and installation.

Concrete is made from a mixture of cement, sand, and aggregates. These materials are mined and transported from different locations before mixing. The production of cement, in particular, is a highly energy-intensive process involving very high temperatures and carbon dioxide emissions. The largest source of embodied carbon in the built environment and the source of about 7% of the world's CO_2 emissions is cement production. Sand, which makes up roughly 30% of concrete, is the second-most extracted earth resource, second to water. The extraction of sand and its demand, which is growing at an unsustainable rate of 6% annually (UNEP, 2022), has caused river pollution, flooding, shrinking aquifers, and deepening droughts (UNEP, 2019).

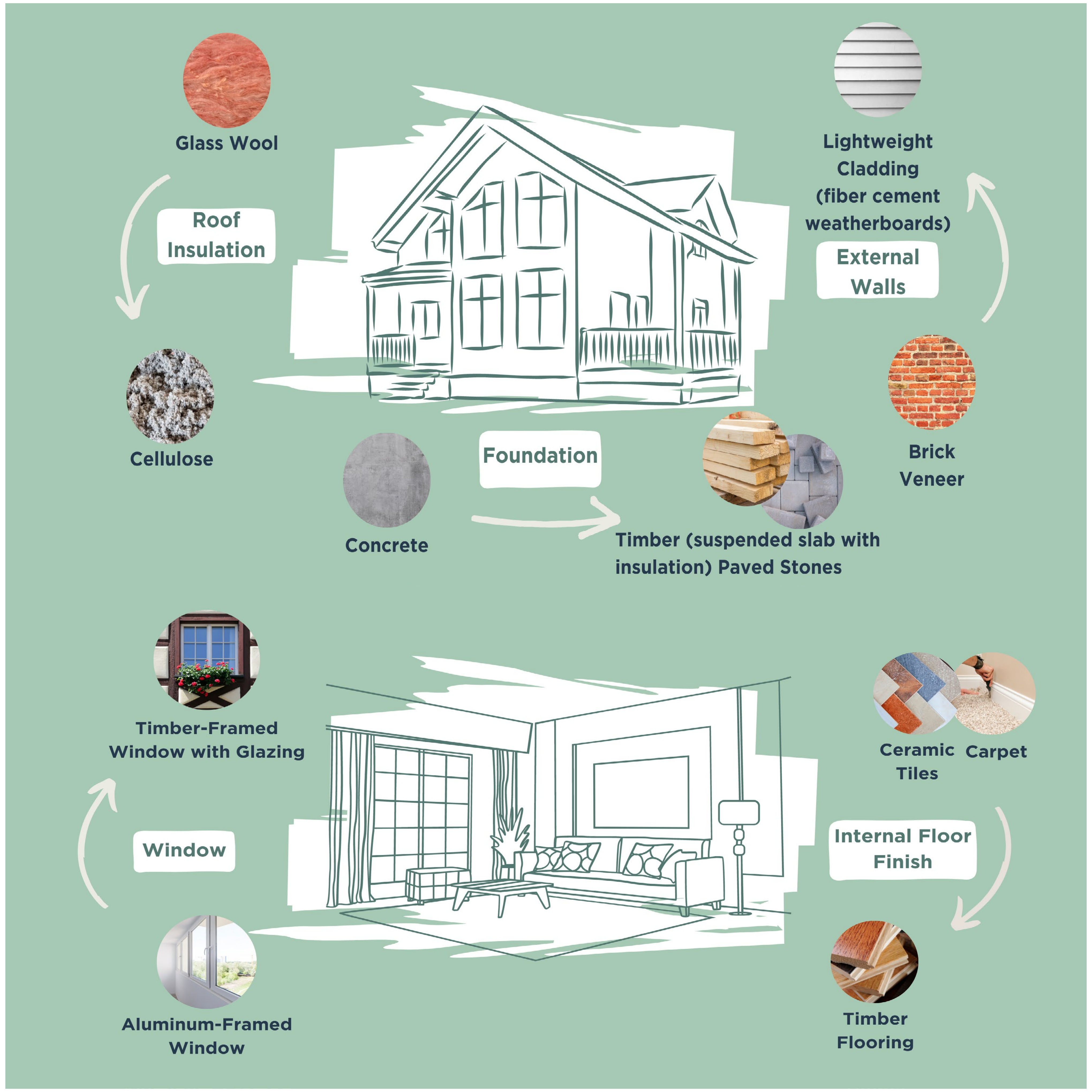

Figure 5. Sustainable material replacements in the THRIVE Case Study.

Metals commonly used in construction like steel, aluminium, and copper are also energy-intensive. These are extracted from ores using mining and undergo several processing techniques. Every year, metal production accounts for 40% of all industrial greenhouse gas emissions and 10% of energy consumption (Raabe, 2023). Similarly, brick production also uses large amounts of energy to fire clay in kilns at high temperatures. Brick manufacturing releases dust, greenhouse gases such as sulphur, nitrogen, carbon, organic compounds, and some hazardous air pollutants to the environment (US EPA, 1997).

Further CO_2 is emitted during the transportation and installation of these construction materials. For example, concrete typically uses heavy machinery for mixing and pouring on site, which runs on fossil fuels.

In this model, the estimated carbon emitted from building the home with conventional building materials is 270 kg per square metre. In total, it emits 45 tons of carbon, which is roughly equivalent to seven new cars or 78,900 loads of laundry (see *Figure 6*).

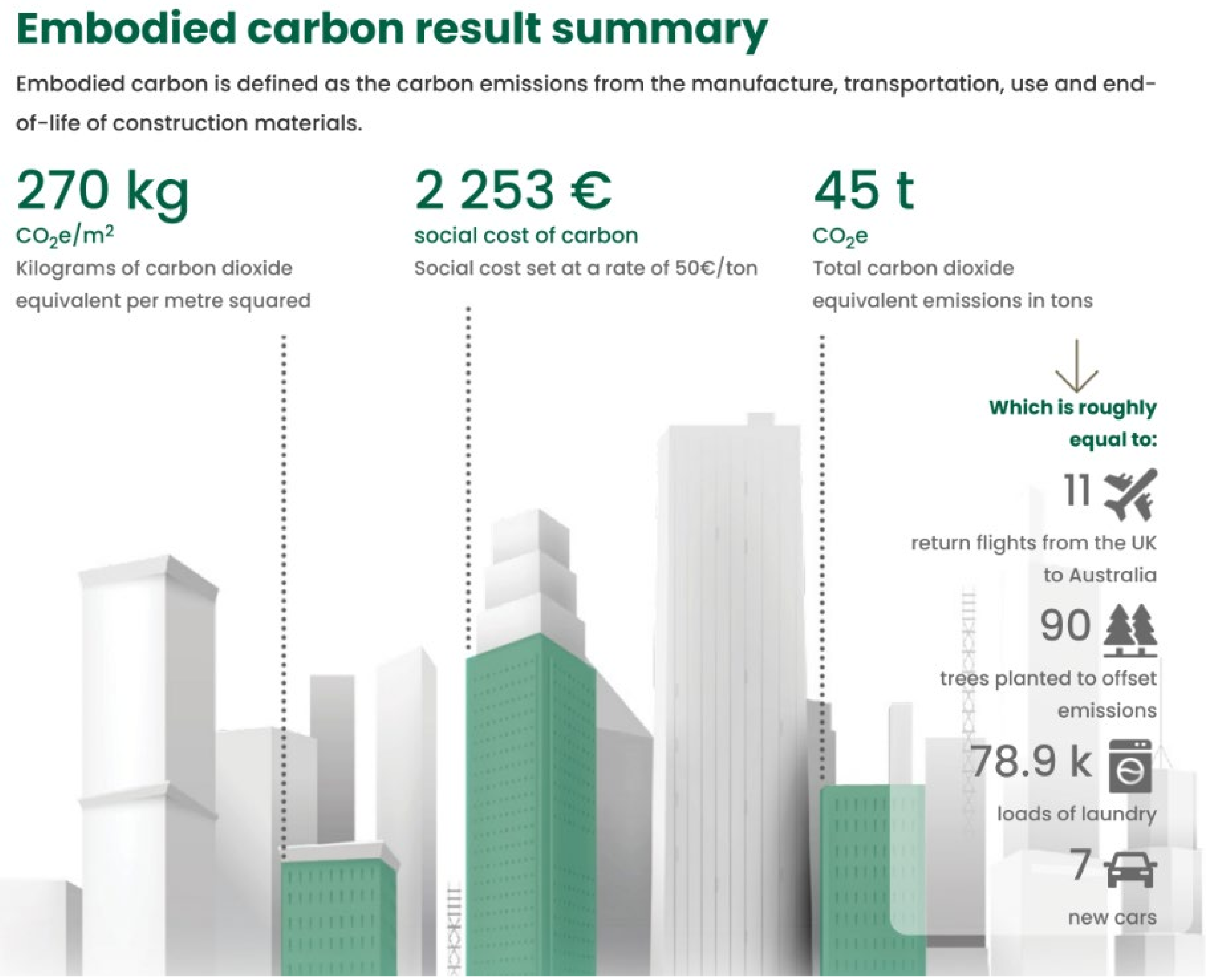

Figure 6. Embodied Carbon Summary - Conventional (Baseline).
Source: One Click LCA

In the sustainable materials house model, insulation generated the most carbon emissions with 6.41 tons, followed by steel and gypsum with 4.3 and 3.18 tons, respectively. The insulation was used mostly with the suspended timber flooring and ceiling, while steel was used mostly for the roof battens. Compared to the conventional model, the impact of concrete and metal was significantly reduced by shifting to suspended timber-framed flooring and by replacing bricks with lightweight cladding (see *Figure 7*).

Why timber?

Timber is a versatile material and a renewable resource with a lower embodied carbon footprint than concrete and steel. Being more lightweight, it also requires less energy for transport and installation. Additionally, using timber as a building material offers the following benefits:

- Timber is easier to modify and repair for greater design flexibility.
- It can potentially reduce construction waste on-site as off-cuts can be reused or recycled for other purposes.
- It has natural insulating properties to improve comfort.
- It is easier and faster to install compared to heavier materials such as bricks. Unlike concrete, it does not require on-site mixing and curing.

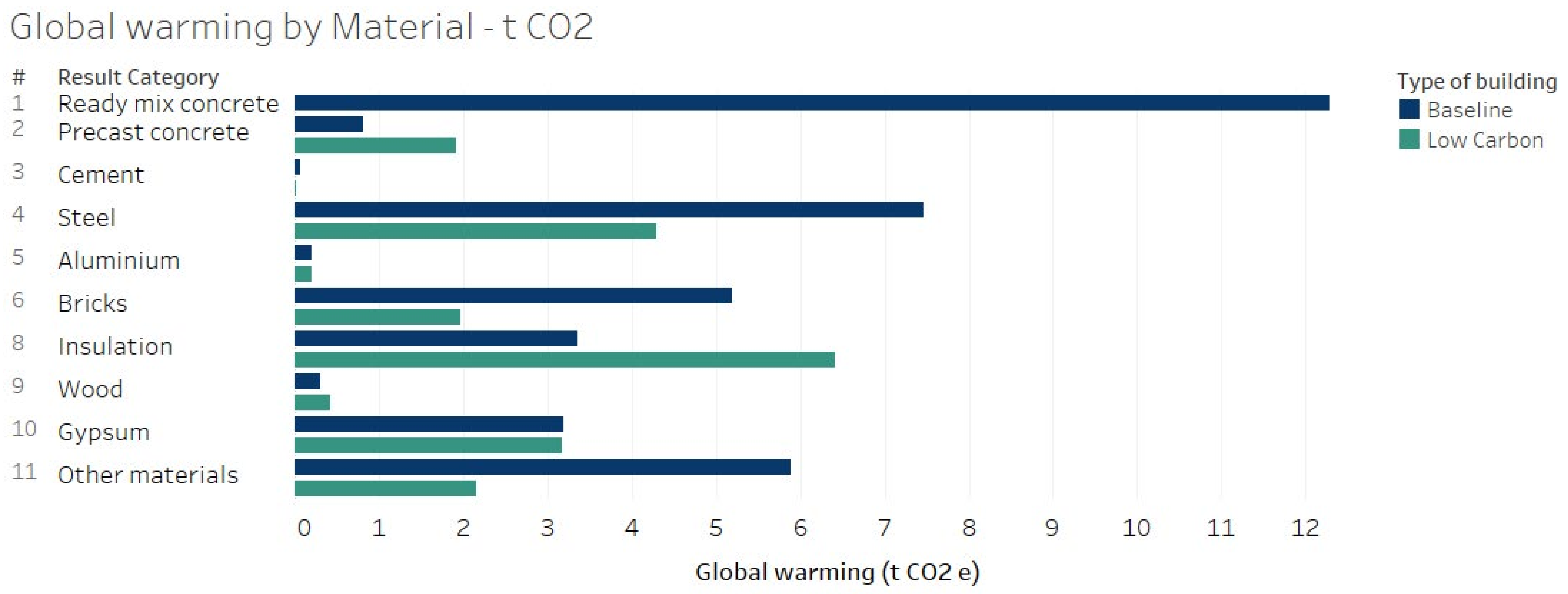

Figure 7. Baseline and Low Carbon model comparison of CO_2 emissions by material.

Using sustainable timber could potentially reduce emissions by 6% between 2017 and 2050 (University of Leeds et al., 2019).

Why lightweight cladding?

The embodied carbon was further reduced by replacing the brick veneer walls with lightweight cladding consisting of fibre cement and softwood frames.

In a lightweight cladding system, the materials used are lighter than traditional building materials. Fibre cement sheets, metal panels, vinyl siding, and composite materials are a few examples of cladding materials. In this model, fibre cement sheets fastened to timber frames were utilised (see *Figures 8 & 9*). Brick walls were replaced by lightweight cladding using fibre cement sheets - a mix of cement, sand, and cellulose fibres. These are highly durable, can withstand intense weather conditions, and are resistant to rot, termites, and fire, making them a low-maintenance and long-lasting option for external wall cladding. Additionally, fibre cement sheets are available in various textures and finishes to mimic the look of wood and stone without the maintenance requirements or installation challenges of using these materials.

Using a lightweight system offers the following advantages:

- The materials are typically pre-fabricated, making the installation process faster, and less labour-intensive.
- Lower weight reduces the need for structural supports and foundations, thus reducing the overall cost.

By shifting to these low-carbon and lightweight alternatives, we can cut back on the use of traditional materials that are energy-intensive and reduce waste. Eliminating waste during the design stage can reduce greenhouse gas emissions by 18% between 2017 and 2050 (University of Leeds et al., 2019).

Figure 8. Fiber cement for lightweight cladding. Source: Freepik

Figure 9. Timber frames for lightweight cladding. Source: Freepik.

The Bottom Line

With all materials in consideration, the estimated carbon emission for the sustainable model is 24 tons, a 47% drop in emissions compared to the original plan (see *Figures 10 & 11*). By implementing more sustainable building practices, we can achieve a substantial reduction in carbon emissions.

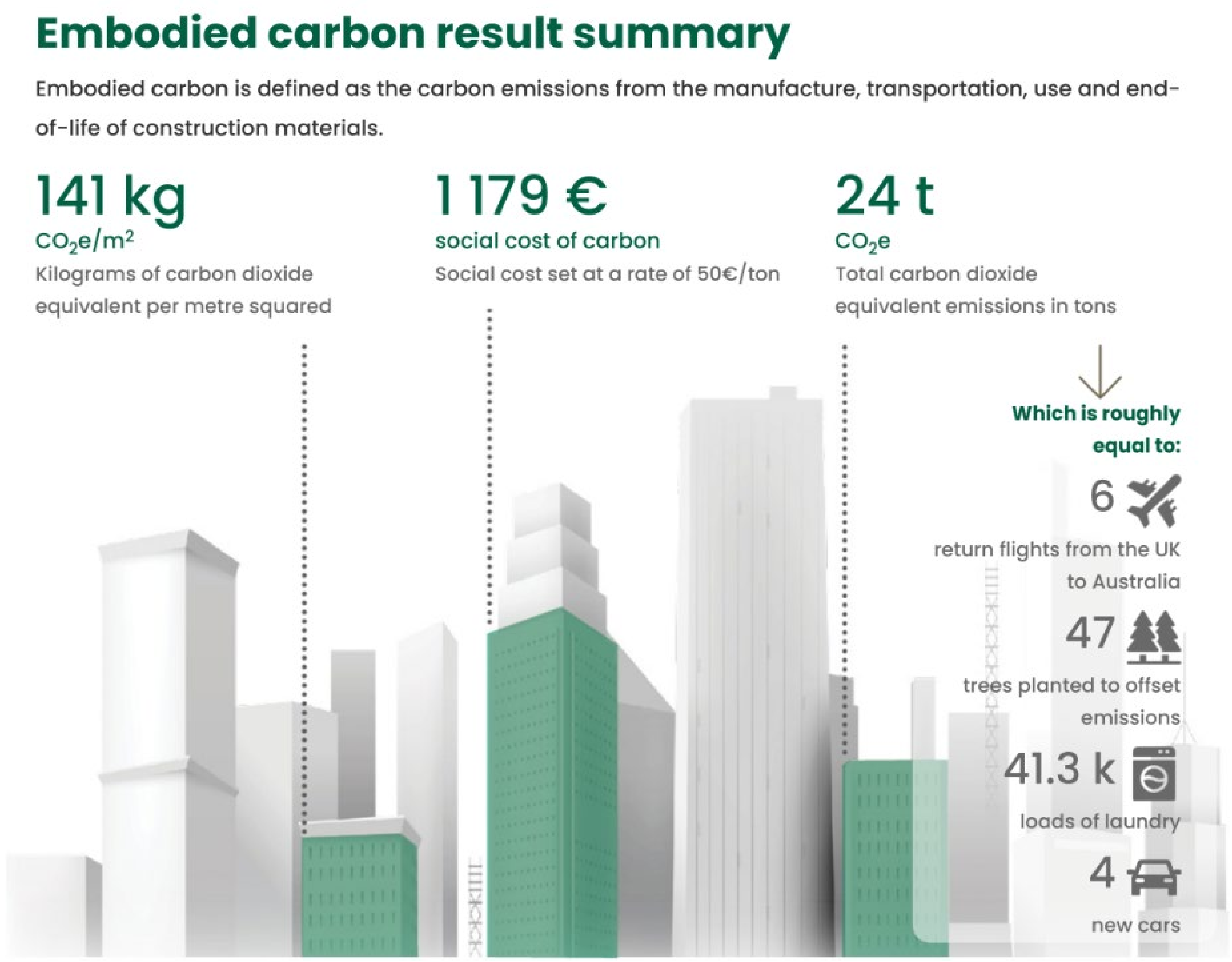

Figure 10. Embodied Carbon Summary - Sustainable (Low Carbon).
Source: [One Click LCA]

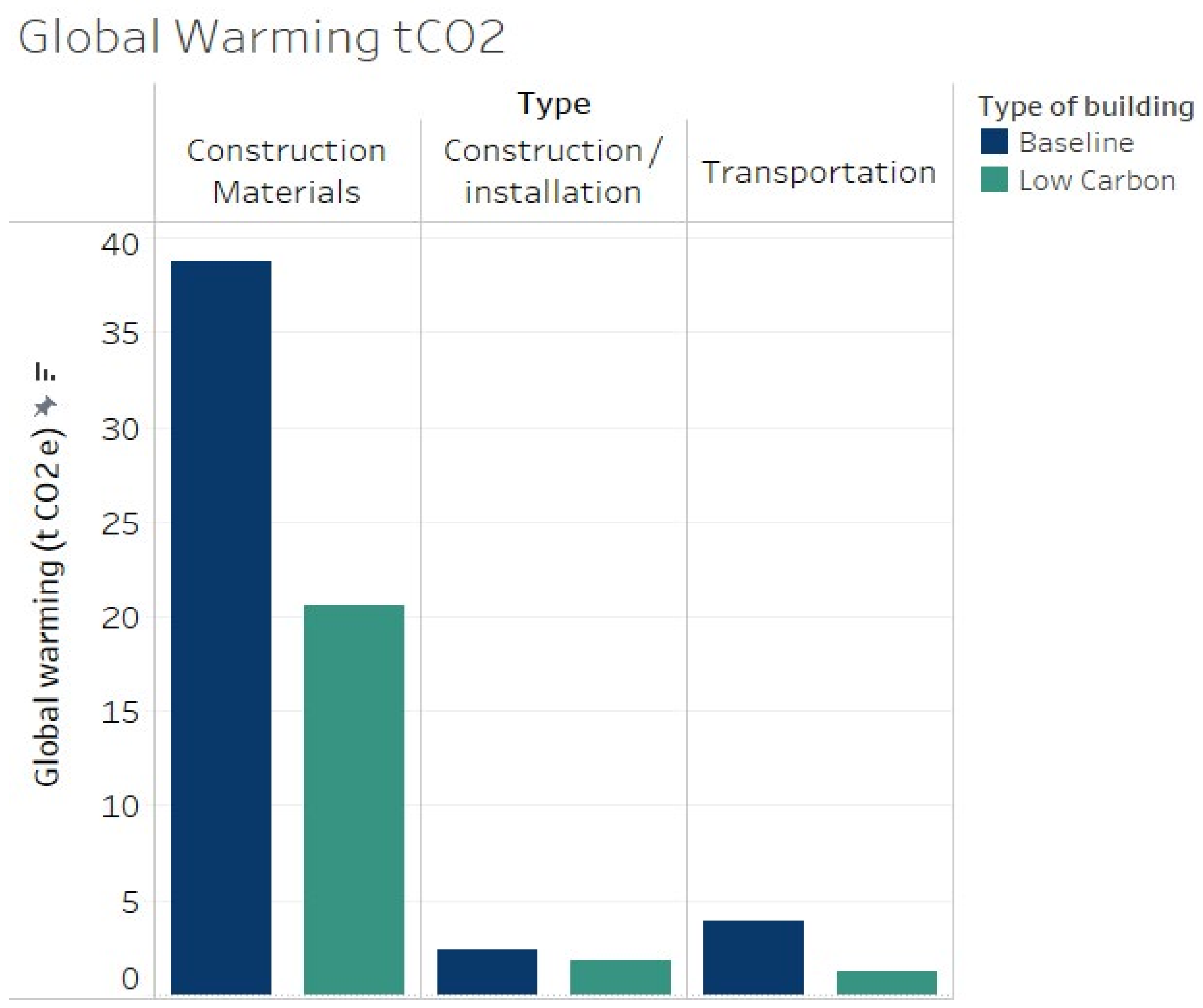

Figure 11. Baseline and Low Carbon comparison of CO_2 emissions by category.

On a global scale, the magnitude of the impact becomes evident. According to UN-Habitat (n.d.), 3 billion people will need access to housing by 2030. To meet this demand, the world needs to build 300 million new homes, according to the World Bank Group (2016). This will require a significant investment in materials and resources. The pressing global need for new homes presents an opportune moment to drive change and adopt sustainable approaches in construction. Simply shifting to more sustainable building materials in every home could have a significant impact on lowering carbon emissions throughout the industry.

Phase 2: Energy Ratings and Behaviours

Energy use accounts for a substantial amount of building emissions over the long term. Therefore, improving the thermal energy efficiency of buildings is a critical step in carbon reduction. Both house models have the same design, orientation, location, and climate, allowing for a direct comparison of the impact of the building materials on energy efficiency.

The two models were analysed using Australia's NatHERS energy star rating and modelled using the HERO software. NatHERS stands for Nationwide House Energy Rating Scheme. Accredited thermal modelling tools are used to calculate a performance-based star grade of energy use, taking into account a home's design and construction materials. The assessment tools are powered by Chenath engine, which was created by the Commonwealth Scientific and Industrial Research Organization (CSIRO) based on how homes function under Australian circumstances. It considers climate and average user behaviour to estimate homes' annual energy needs. The homes are rated on a scale of 0 to 10 stars. The higher the rating, the less energy is required to maintain indoor comfort through heating and cooling.

In Australia, older homes are likely to have low star ratings. In 2001, the minimum requirement was between 3 to 4 stars. Before they were required in 2003, the typical residence had a star rating of only about 1.8. Recently, the National Construction Code 2022 increased the energy efficiency requirements for new houses and apartments from 6 to 7 stars and increased the scope to include the energy performance rating of appliances to support net zero emissions targets by 2050.

For more information, please refer to NatHERS' top tips for building for 7 stars.

In our original house model, the conventional materials achieved a 6.6-star rating, while the sustainable model achieved a 6.8-star rating, with an equivalent of 6% annual potential energy savings. In both cases, the area with the highest energy demand is the kitchen/living space, which takes up one-third of the home's total floor area. Shifting from conventional materials to more sustainable alternatives had different effects on different parts (also known as "zones") of the home. For example, in the kitchen/living area, the energy requirement increased by 9%, while in the bedrooms, it was reduced by 23% on average. However, the kitchen/living area had a higher impact on the overall energy load due to its large area (see *Figure 12*).

Therefore, the energy requirements of the entire home depend on each zone's floor area and thermal performance. Various energy-reducing measures can be applied to low-performance zones to optimise their energy efficiency, such as by increasing insulation, changing orientation, using more energy-efficient lighting, etc.

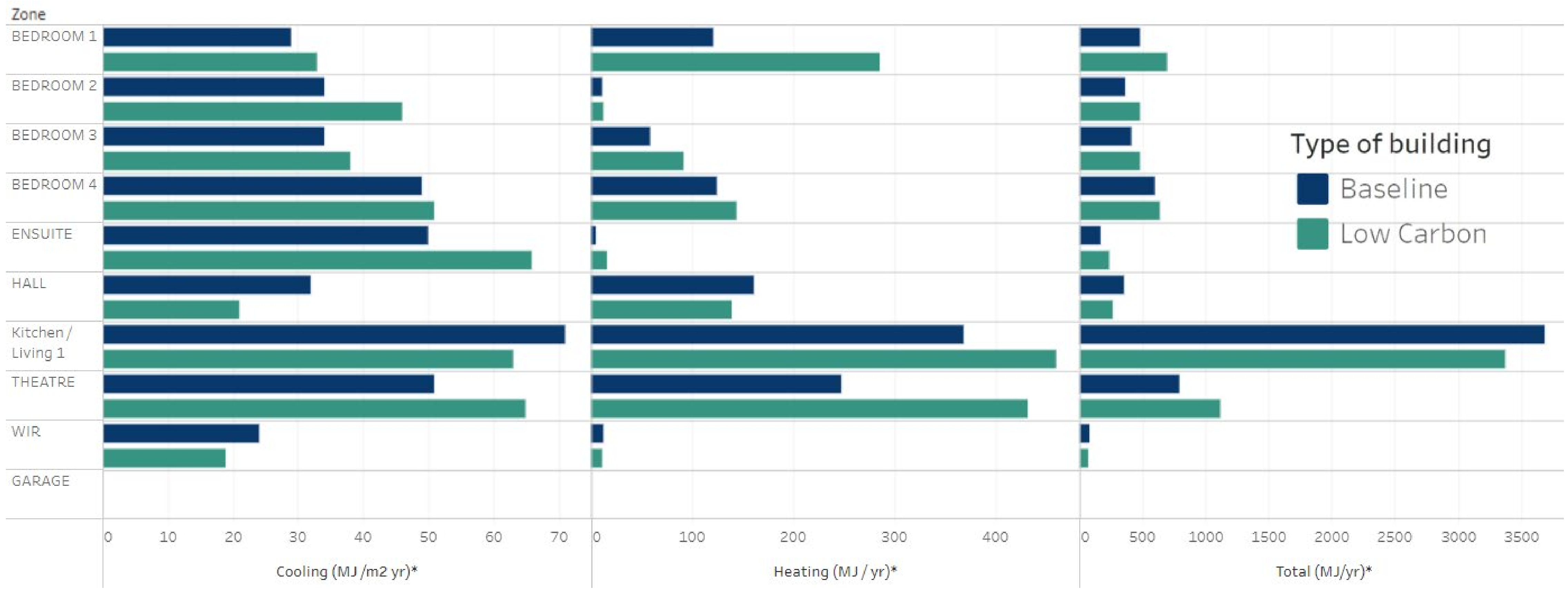

Figure 12. Baseline and Low Carbon Energy Requirement Comparison by Zone.

Location, home type, number of devices, and household size are all factors that affect how much energy is used in a household. According to the 2015 data from the US Energy Information Administration (2021), 51% of a household's energy consumption is for heating and air conditioning living spaces. Water heating, lighting, and refrigeration were also found to be significant, accounting for 27% of energy consumption.

Building more sustainably doesn't necessarily require a trade-off in energy performance. Understanding and utilising energy assessment tools helps homeowners, designers, and builders make better decisions on how a space can be transformed into a greener home and thereby reduce annual energy costs.
The adoption of sustainable building practices has shown significant success in reducing greenhouse gas emissions and saving energy and water. In Australia, low carbon buildings produce 62% fewer emissions than average buildings, while in India, sustainable buildings have resulted in energy savings of 40-50% and water savings of 20-30% (UN-Habitat, 2019). This highlights the potential for change in current building practices, particularly in the housing sector, to address the impacts of climate change.

Limitations of the Case Study

It is important to note that the tools utilised in the study have limitations. For example, it generalises assumptions about occupant behaviour . Modelling tools assume specific patterns that may not reflect the actual occupants' behaviour.

CSIRO (2021) conducted validation studies that examined the software's ability to forecast actual results. They found a good link between anticipated and actual energy use in a study that tracked more than 200 homes for six years. The biggest differences found were in the occupant behaviour profiles and air conditioner energy use.

The difference between actual and calculated energy consumption, also known as the energy performance gap, is caused by various factors, including construction errors, simulation model simplification, and occupant behaviour. Theoretical energy calculations consider only the building characteristics and are therefore a simplified version of actual energy consumption.

The Impact of Human Behaviour

Despite knowing the benefits, social, cultural, and economic factors often prevent people from using energy efficiently. Even with energy-efficient technologies, 30% or more of potential energy savings are lost. Widespread change ultimately depends on the number of people engaged and empowered to use those technologies and redefine their energy use.

One study (Piao & Managi, 2023) across 37 countries found that household energy-saving behaviour has a positive impact on reducing emissions, but surprisingly, the purchase of energy-saving products has a limited effect on energy consumption.

According to sociologist Dr. Adua, human behaviour and attitudes have a profound effect on increasing emissions despite energy-saving technologies, as people become complacent and may get into the habit of using more energy-efficient equipment more frequently. Data indicates that increasing renewable energy by 1% reduced CO2 emissions across all sectors by 0.69%, but this trend was reversed in the residential sector, where every 1% increase in renewable energy led to a 0.36% increase in emissions.

Another study (Gill et al., 2010) highlights the need to address human factor issues in low-energy and low carbon design. A post-occupancy assessment of an 'excellent-rated' UK EcoHomes site found that energy-efficiency behaviours account for 51%, 37%, and 11% of the variance in heat, electricity, and water consumption, respectively.

Yet, evidence suggests that improving building efficiency can lower energy expenditure and emissions, even after accounting for this "rebound effect," but it depends on income group and energy efficiency levels. Research from the Cambridge Centre for Climate Change Mitigation Research (2013) shows an equivalent, opposite to the rebound effect, where energy use affects efficiency. People who consume more are motivated to use methods to increase energy efficiency to reduce their high energy bills. When measures to increase energy efficiency have been exhausted, the most effective way to reduce emissions is to change the energy-consuming behaviour of occupants.

To effectively reduce global energy consumption, we must recognise the significant role of household energy behaviour in driving meaningful, lasting change. People are more likely to engage in sustainable energy behaviour when they believe it has low individual costs and high individual benefits. Thus, by understanding that sustainable energy behaviour can yield individual benefits while imposing minimal costs, we can pave the way for a greener and more sustainable home.

Building Your First Home

When communicating with the builder, emphasisee your desire to build a sustainable home. By actively engaging with your builder and incorporating sustainable practices at each construction phase, you can lay the foundation for a low-impact, energy-efficient home.

- **Source Sustainable and Eco-Friendly Materials:** Ask your builder to use sustainable materials. Responsible materials sourcing for eco-friendly construction involves using durable and low-maintenance materials that are made from recycled content, natural or renewable sources, and do not contain highly toxic compounds. For example, swap traditional VOC emitting paint with safer alternatives. Prioritise obtaining building materials from local manufacturers to reduce transportation emissions.

- **Incorporate Energy-Efficient Design:** Request an energy-efficient design that maximises natural lighting, ventilation, use of energy-efficient windows and HVAC systems, and passive heating or cooling strategies. Insulation is crucial in colder climates, as most heat escapes through walls and roofs. It's important to consider the location and weather when designing for energy efficiency.

- **Consider Renewable Energy:** Inquire about the feasibility of incorporating renewable energy systems such as solar panels. There are mapping services and tools to determine your home's solar energy potential. These services can also provide information on estimated system size, costs, savings, and local contractors.

- **Water Management:** Discuss water-saving measures, such as rainwater harvesting systems, greywater recycling, and using low-flush toilets and low-flow shower heads. The largest source of wastewater in homes is greywater, which comes from showers, basins, and washing machines. This can be reused for gardens and toilets.

- **Waste Management:** Implement proper waste management practices, including recycling construction debris and reducing material use to minimise waste sent to landfills.

- **Regular Maintenance and Energy Audits:** Conduct routine maintenance and home energy audits to ensure the home continues to perform efficiently and identify areas for improvement.

For Home Renovators

There are various opportunities to incorporate sustainable building practices into home improvement projects. Focus on the following areas:

- **Improve Insulation and Zoning:** Improve the existing home's insulation by adding insulation to walls, roofs, and floors. You may also increase zoning by adding more internal doors to close off spaces that are not frequently used. This helps reduce heat loss or gain and improves energy efficiency.

- **Choose Windows and Doors Wisely:** Upgrade windows and doors to energy-efficient options, e.g. double-glazed windows, that provide better insulation and reduce air leakage.

- **Choose Energy-Efficient Lighting:** Replace traditional incandescent bulbs with energy-efficient LED lights to reduce electricity consumption. Other tips include installing automatic lighting as well as mirrors and reflective surfaces to maximise light

.

- **Choose Energy-Efficient Appliances:** Choose energy-efficient appliances to reduce energy consumption in renovated spaces. Become familiar with what energy ratings mean to help you make sustainable decisions and reduce utility bills.

- **Consider Renewable Energy:** Explore the possibility of incorporating renewable energy systems such as solar panels.

- **HVAC Upgrade:** Improve the energy efficiency of an existing heating, ventilation and air conditioning (HVAC) system when you replace and upgrade to a more energy-efficient model. Install programmable or smart thermostats to optimise heating and cooling schedules and reduce energy consumption.

- **Conserve Water and Fix Leaks:** Upgrade plumbing fixtures to low-flow options to conserve water. Fix any leaks or drips to prevent water waste.

Conclusion

The findings of this case study demonstrate the potential for significant carbon reduction by simply replacing conventional materials with more sustainable products and systems. Through material substitutions and without changes to other aspects such as building design or location, we estimated that carbon emissions from construction would be cut by 47%. Further studies indicate that building construction, building features and energy efficiency performance, and occupant behaviours are interconnected and crucial for long-term carbon reduction and sustainable energy transitions. This is a clear example of how systems thinking can guide our actions toward sustainability and a thriving society. Increased awareness, targeted actions, and favourable energy-reducing behaviours can significantly reduce impact by thinking about decarbonisation at every stage. Ultimately, people's choices and actions hold the key to transformative change.

THRIVE Framework and the Way Forward

Given the millions of homes that will need to be built to accommodate the growing world population, selecting sustainable building materials and systems thinking (using life cycle analysis and energy efficiency modelling tools) can help mitigate the impact of the building industry. Systems thinking is one of the key components of The Holistic Regenerative Innovation Value Enterprise (THRIVE) Framework, a blueprint developed based on several years of research that encompasses various sustainability measures and methodologies for predicting the sustainability performance of strategies and operations. THRIVE Project engages in impactful research and advocacies such as webinars, podcasts, and various publications.

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