THE CAMPAIGN FOR WOOL
Patron: HM King Charles III

THE LEVER ROOM

Wool in Architecture

A Sustainability Report for Architecture and Product Design Education

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About this Report

This report is the outcome of the Report Delivery phase of the Wool Dynamics architecture stream. It builds directly on the 2025 Discovery Resource, which compiled environmental data, lifecycle impacts, technical performance findings, and case studies on wool in the built environment.

The purpose of this document is to translate that research into a structured learning resource that architecture students can use in design projects, technical analysis, and material selection. As outlined in the Campaign for Wool project proposal, this stage is intended to provide clear, evidence-based material that fills the gap identified in the 2024 pilot: architecture students require more rigorous, quantitative sustainability information to support credible design work.

The report is organised into eight modules so it can be used flexibly within architectural studio workflows. Each module focuses on a key aspect of sustainability in relation to wool—performance, lifecycle impacts, embodied carbon, LCA tools, certification mapping, circularity, sourcing, and case studies, allowing educators and students to engage with the material at the depth and stage relevant to their project.

Figure 1: Image Credit - Stu Jackson Photography.[1]

[1] The Campaign for Wool New Zealand Trust

Introduction & Purpose

The built environment is shifting rapidly toward low-carbon, regenerative, and transparent material choices. Architecture students now need to understand not only how to design with materials, but how to evaluate their environmental performance, justify specification decisions, and work within emerging regulatory frameworks.

The Wool Dynamics pilot confirmed that while students recognise wool as a culturally significant and inherently low-toxicity material, they lacked access to the technical data required to assess it against conventional building products. The Discovery phase addressed this by compiling the necessary evidence base. This report now provides the applied, architectural version of that work.

The purpose of this document is to:

- Provide a clear, NZ-specific sustainability profile of wool across environmental, technical, and lifecycle dimensions;
- Enable students to compare wool meaningfully with alternative materials using recognised LCA tools and carbon methodologies;
- Support studio and research projects with worked examples, technical data, and certification-aligned guidance;
- Offer a practical reference for educators delivering sustainability-focused architectural teaching;
- Connect material decisions to contemporary standards such as Homestar, Green Star, WELL, the Living Building Challenge, and MBIE Building for Climate Change.

In essence, this report equips architecture students with the data, methods, and context required to integrate wool confidently and credibly into sustainable building design.

MODULE 1:

Why Wool in Architecture

Module 1: Why Wool in Architecture

The Role of Architects in Shaping a Low-Carbon, Regenerative Built Environment

THE GLOBAL CONTEXT

The built environment is now recognised as one of the most consequential leverage points for climate action. The global evidence base shows:

- Buildings account for ~37% of global energy-related greenhouse gas emissions, placing architects at the centre of climate mitigation responsibilities.[3]
- As countries decarbonise electricity grids and improve operational efficiency, the balance of emissions shifts. In high-performance buildings, embodied carbon[4] in materials becomes the dominant share of whole-of-life emissions, making early material choices critical (*Figure 3)*.
- Extreme weather already delays approximately 45% of construction projects globally, increasing costs, disrupting programmes, and highlighting the need for resilience-focused design.[5]
- Material extraction (e.g. cement, steel, petrochemicals) is a major driver of biodiversity loss and ecosystem degradation. Cement alone contributes ~8% of global CO_2 emissions.[6]

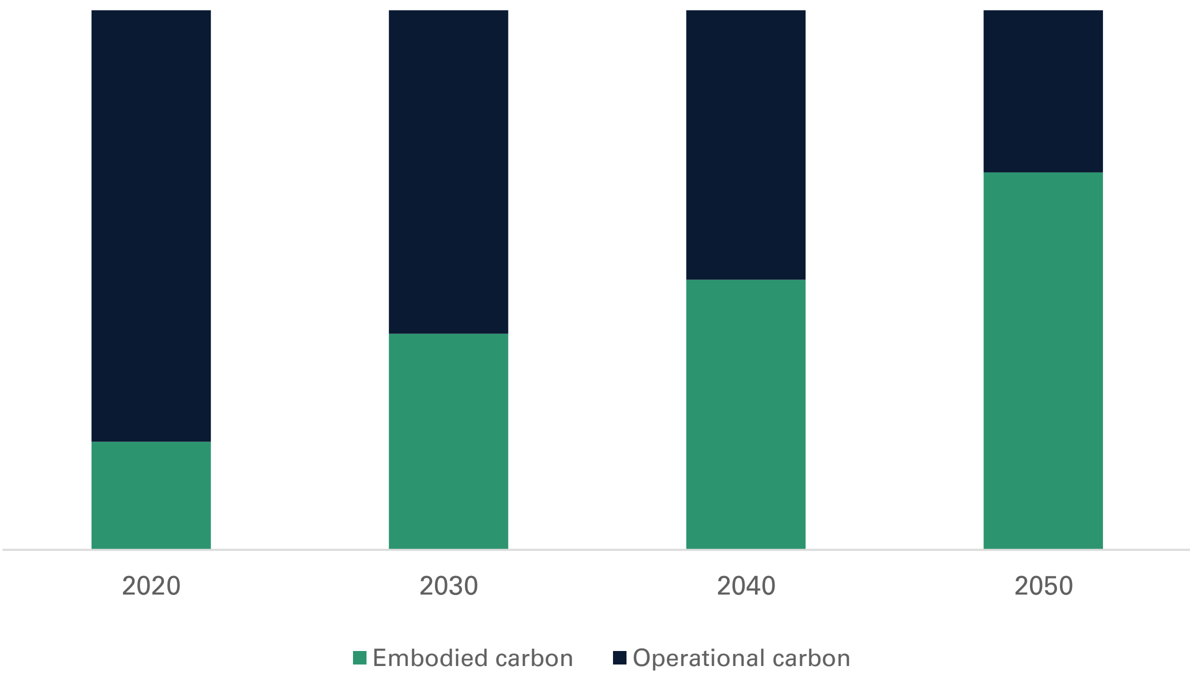

Figure 3: Illustrative example of the anticipated change in the contribution of embodied emissions and operational emissions to total whole-of-life building emissions over time as buildings become increasingly high-performance.

[3] UNEP. 2023. Building Materials and the Climate: Constructing a New Future. https://wedocs.unep.org/20.500.11822/43293.

[4] Operational carbon: Carbon emissions from building energy use and operational water use. Embodied carbon: Sum of all greenhouse gas emissions occurring at each stage of an entity's life cycle, excluding operational energy and water for whole buildings.

[5] Schuldt, S. J., & et al. 2021. *Weather-related delays in a changing climate: a systemic state-of-the-art review*. MDPI Sustainability.

[6] WEP. 2024. *Cement is a big problem for the environment. Here's how to make it more sustainable*. World Economic Forum.

SUSTAINABLE DEVELOPMENT IN PROFESSIONAL STANDARDS

The climate impact of the built environment is now directly shaping regulation, procurement, and professional expectations. Around the world, architectural practice is being steered toward transparent, low-carbon and responsible material choices.

Global Regulation

- Denmark's BR23 and France's RE2020 now impose operational and embodied-carbon caps on new buildings. Under RE2020, France sets a whole-of-life embodied-carbon limit of 530 $kgCO_2e/m^2$, signalling that high-carbon materials will progressively lose compliance pathways.[7]
- The EU Corporate Sustainability Reporting Directive (CSRD) and the EU Taxonomy both favour buildings and materials with verified low-carbon performance and transparent sourcing, increasing pressure on manufacturers and specifiers to provide reliable data.[8]
- UK, EU and Nordic countries are moving toward mandatory whole-of-life carbon disclosure for buildings.[9]

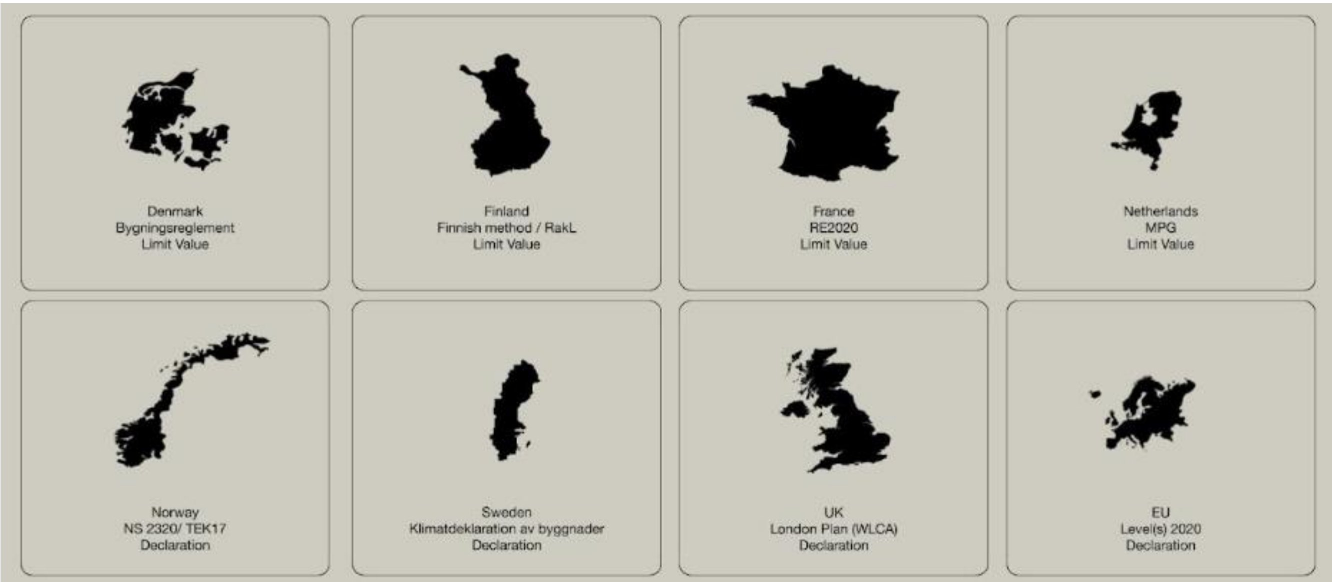

Figure 4: Overview of EU Building Regulations, illustrated by Revalu Impact AG.

These changes reflect a global consensus: material decisions are now climate decisions, and architects must be able to evaluate and justify them with defensible, life cycle-based evidence.

New Zealand Professional Expectations, Policy and Guidance

New Zealand's architectural profession is undergoing a similar shift toward measurable, transparent sustainability performance. The New Zealand Institute of Architects (NZIA) has introduced new sustainability criteria for the 2025 Architecture Awards, He Korowai Tiaki – Protecting Our Futures, signalling a major step toward embedding climate responsibility within design excellence.

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7 Breschi, T. 2023. *Green Construction in Europe: Taxonomy, EPBD, and Building Regulations.* Revalu.
8 European Commission. 2020. *EU taxonomy for sustainable activities.* European Commission.
9 Climate Council. 2024. *EU Energy Performance of Buildings Directive.* Climate Change Advisory Council.

These criteria require architects to demonstrate:

- Embodied carbon & LCA: whole-of-life emissions disclosure in $kgCO_2e/m^2$.
- Circularity: reuse of existing structures and design for disassembly.
- Kaitiakitanga: ecological guardianship and engagement with iwi.
- Climate resilience: response to flooding, overheating and extreme weather.
- Material whakapapa: traceable sourcing and supply-chain transparency.

Together, these expectations make sustainability a core professional competency rather than a supplementary consideration, and they push architectural practice toward low-carbon, regenerative material choices such as wool.[10] New Zealand also has a number of policy frameworks and guidance which set clear expectations around sustainable development in the built environment:

- MBIE Building for Climate Change work programme emphasises low-carbon design and material emissions transparency.[11]
- NZGBC Homestar[12] and Greenstar[13] frameworks reward biogenic, circular, low-toxicity materials and verified environmental data.
- The 2025 Government Construction Procurement Guide now directs agencies to use wool fibres where practical and appropriate, signalling a clear shift in public-sector expectations. This requirement positions wool and other bio-based materials as mainstream options rather than niche alternatives, and it reinforces the move toward locally sourced, low-carbon products in government-funded projects.

For architects and architecture students, these shifting expectations mean material selection is no longer just about performance and cost - it now requires the ability to:

- Read and compare Environmental Product Declarations (EPDs) and Product Carbon Footprints (PCFs) to understand verified environmental impacts.
- Model embodied carbon and interpret results at both building and component level.
- Work confidently with biogenic materials, understanding carbon storage and emissions profiles.
- Design for moisture safety, indoor air quality, fire performance, and long-term durability.
- Integrate circularity and end-of-life strategies into construction assemblies and detailing.
- Demonstrate material whakapapa, traceability, and cultural alignment, particularly within Aotearoa's regulatory and professional context.

This report is designed to support these competencies and provide the evidence, methods, and frameworks needed for informed, sustainability-led material decisions.

[10] NZIA. 2024. *New sustainability criteria for 2025 New Zealand Architecture Awards.* NZIA.
[11] MBIE. 2020. *Building for climate change: transforming the building and construction sector to reduce emissions and improve climate resilience.* Ministry for Business, Innovation & Employment.
[12] NZGBC. 2024. *Homestar: A practical design guide to lower carbon healthier homes.* NZGBC.
[13] NZGBC. 2024. *Green Star Buildings NZ.* NZGBC.

Why Wool is Relevant in Contemporary NZ Architectural Practice

Up until the mid-20th century, most building materials were sourced from biomass and locally available natural resources. Construction was largely shaped by renewable, low-toxicity materials that followed the rhythms of place and climate.

Today, however, business-as-usual material selection is dominated by extractive, non-renewable, and energy-intensive products, largely driven by cost, standardisation, and compliance pathways rather than ecological fit.

However, the future demands regenerative, low-carbon design where material choices are guided by a material's ability to enable less unsustainable buildings[2]. Wool offers a rare combination of technical performance, human and ecosystem health benefits, circularity, and NZ-specific environmental fit.

NEW ZEALAND'S WOOL CONTEXT

Wool has been engineered and used by humans for more than 12,000 years[14] and it remains one of Aotearoa's most culturally and economically significant fibres. New Zealand produces approximately 120,000 tonnes of wool each year, making it the third-largest wool producer in the world.[15]

For much of the 20th century, wool was one of New Zealand's most important export commodities long before the rise of dairy and it played a central role in shaping rural communities, land use, and the national economy.

Because of this history, wool is more than a construction material. It carries narratives of labour, craft, intergenerational farming knowledge, and the evolution of New Zealand's primary industries.

Within the built environment, using wool connects architectural practice to this lineage of stewardship, land-based economies, and cultural identity, aligning strongly with contemporary expectations around material whakapapa, transparency, and kaitiakitanga.

TECHNICAL PERFORMANCE

Environmental Product Declarations (EPDs) are third-party-verified documents that provide transparent, comparable data on a product's environmental impacts across its life cycle. Evidence from EPDs and technical studies shows that wool:

- Has thermal conductivity $\lambda \approx 0.033\text{–}0.039$ W/mK[16], comparable with glass and mineral wool products.[17]
- Retains insulation performance even when absorbing up to 35% moisture by weight[18], while many synthetic insulants lose performance and can slump when wet.
- Is naturally fire resistant-, with an ignition point around 570–600°C; wool chars rather than melts, does not drip, and does not release dense toxic fumes when exposed to flame.[19]

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[14] IWTO. 2023. *History of wool.* International Wool Textile Organisation.

[15] NZ Government. 2025. *NZ Wool Industry fact sheet.* Beehive.

[16] Rockwool. 2025. *Basic Theory*. Rockwool.

[17] Hetimy, S., & et al. 2024. *Exploring the potential of sheep wool as an eco-friendly insulation material: a comprehensive review and analytical ranking.* Sustainable Materials and Technologies.

[18] Denes *et al.* 2019. *Utilisation of Sheep Wool as a Building Material.* Procedia Manufacturing 32 (2019) 236 - 241

[19] IWTO. 2020. *Wool & Fire.* International Wool Textile Organisation.

- Exhibits hygroscopic behaviour[20], buffering indoor humidity and helping to prevent interstitial condensation and mould in timber structures.[21]
- Offers good acoustic absorption across typical building relevant- frequency ranges when used in batts, panels, or felts.[22]

CULTURAL INTEGRITY AND NARRATIVE

Wool holds a uniquely Aotearoa identity that extends well beyond its technical performance:

- It is deeply woven into the history of rural communities and New Zealand's export economy[23] shaping landscapes, livelihoods, and national storytelling.
- It reflects the whakapapa of land use, connecting buildings to whenua, farming practices, and principles of kaitiakitanga through materials that arise directly from the ecosystems they inhabit.
- It serves as a story-carrying material, aligning with NZIA's focus on material whakapapa and narrative integrity enabling architecture to express cultural grounding through honest, place-responsive material choices.

Together, these characteristics position wool as an exemplar of what contemporary architectural practice is being asked to deliver: low-carbon, healthy, traceable, regenerative materials that are culturally anchored and transparent in their origins.

Figure 5: Image Credit - Stu Jackson Photography.[24]

[20] Hetimy, S., & et al. 2024. *Exploring the potential of sheep wool as an eco-friendly insulation material: a comprehensive review and analytical ranking.* Sustainable Materials and Technologies

[21] Heygi, A., & et al. 2021. *Improving indoor air quality by using sheep wool thermal insulation.* MDPI Materials.

[22] NZ Government. 2022. *Acoustic wool panels the latest innovation for New Zealand strong wool.* Beehive.

[23] MPI Economic Intelligence Unit. 2019. *Wool Data Book.* Ministry for Primary Industries.

[24] The Campaign for Wool New Zealand Trust

Summary

Architects play a central role in shaping a low-carbon, regenerative built environment. Buildings account for roughly 37% of global energy-related emissions, and as operational energy continues to decarbonise, embodied carbon in materials becomes the dominant contributor to whole-of-life climate impact. At the same time, climate disruption, supply-chain volatility, and resource constraints are increasing project risk, making material choices both a design challenge and a resilience issue.

Globally, expectations of architectural practice are shifting. Embodied-carbon caps, mandatory whole-of-life reporting, and transparent material sourcing are becoming standard requirements. In Aotearoa, the NZIA's He Korowai Tiaki, MBIE's Building for Climate Change, NZGBC's Green Star and Homestar, and the Government Construction Procurement Guide all signal the same direction of travel: sustainability is no longer an optional layer of design — it is a core professional competency.

Architects influence sustainability far beyond form-making. They operate as *system shapers* through:

1. Design decisions: selecting low-carbon, biogenic, and circular materials; designing for longevity, adaptability, and disassembly.
2. Policy & regulation: interpreting new standards and elevating client expectations.
3. Finance: communicating long-term carbon, health, and cost benefits.
4. Infrastructure: supporting local supply chains and material-recovery pathways.
5. Data & metrics: requiring EPDs, LCAs, and verified transparency.
6. Collaboration: working with iwi, clients, engineers, manufacturers, and councils to create coherent sustainability outcomes.

Within this landscape, wool is strategically relevant for New Zealand architecture. Aotearoa produces around 120,000 tonnes of wool annually, with strong wool demonstrating significantly lower carbon footprints than generic international datasets. Sheep and beef farms steward approximately 25% of New Zealand's remaining native vegetation, linking wool supply chains directly to biodiversity, ecological restoration, and kaitiakitanga.

Beyond its environmental profile, wool offers robust thermal, acoustic, fire-safety, and moisture-management performance, improves indoor air quality, and supports circularity through recycling, reuse, and biodegradation. Its cultural grounding, traceability, and connection to whenua further strengthen its alignment with modern architectural values.

Taken together, these characteristics position wool as an exemplar of the type of healthy, low-carbon, regenerative, and culturally anchored material that architects are increasingly expected — and professionally obligated — to specify within a sustainable built environment.

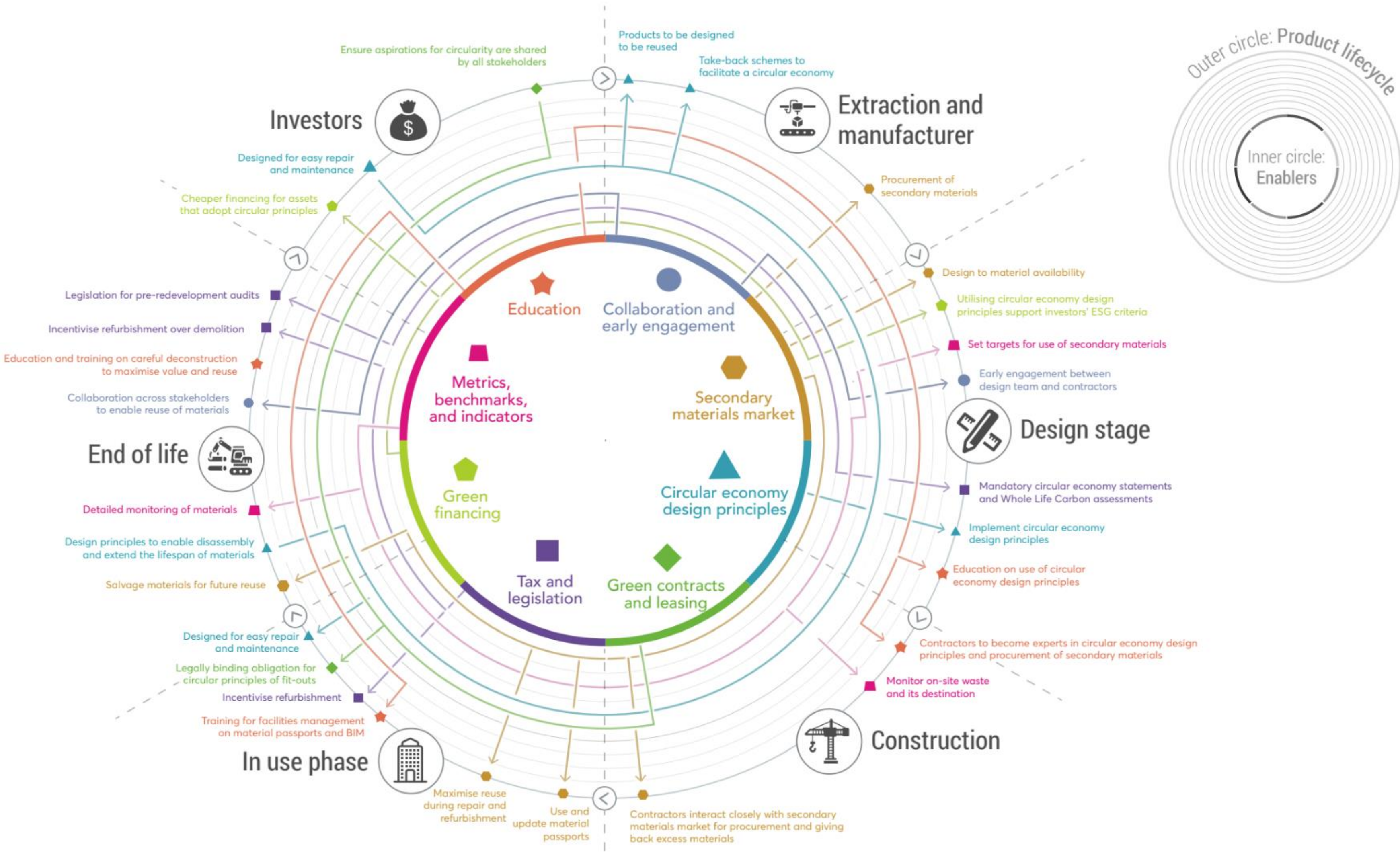

Figure 6: The role of architects in shaping a low-carbon, regenerative built environment.[25]

[25] UKGBC. 2023. *System Enablers for a Circular Economy.* UK Green Building Council.

MODULE 2:

Sustainability Profile of Wool

Module 2: Sustainability Profile of Wool

The most widely used definition of sustainability comes from the Brundtland Report (1987)[26], which describes sustainable development as:

"Meeting the needs of the present without compromising the ability of future generations to meet their own needs."

In 2009, the Stockholm Resilience Centre defined nine planetary boundaries that together describe a "safe operating space" for humanity. These boundaries reflect the stable conditions of the Holocene—the period in which human civilisation flourished.[27] These boundaries are used to track the changes to the planet and gauge whether earth's systems are becoming less safe for humanity (see *Figure 7*).

The planet is considered to become unsafe for humans when the environmental conditions that support stable climates, healthy ecosystems, and reliable water and nutrient cycles are no longer operating in a stable and resilient manner. When these conditions are pushed too far, earth systems can cross tipping points and shift into irreversible states which do not enable or protect the sustainable development of humanity. Examples of these tipping points are the melting of the Greenland ice sheet, dieback of the Amazon rainforest, and the decline of coral reefs.[28]

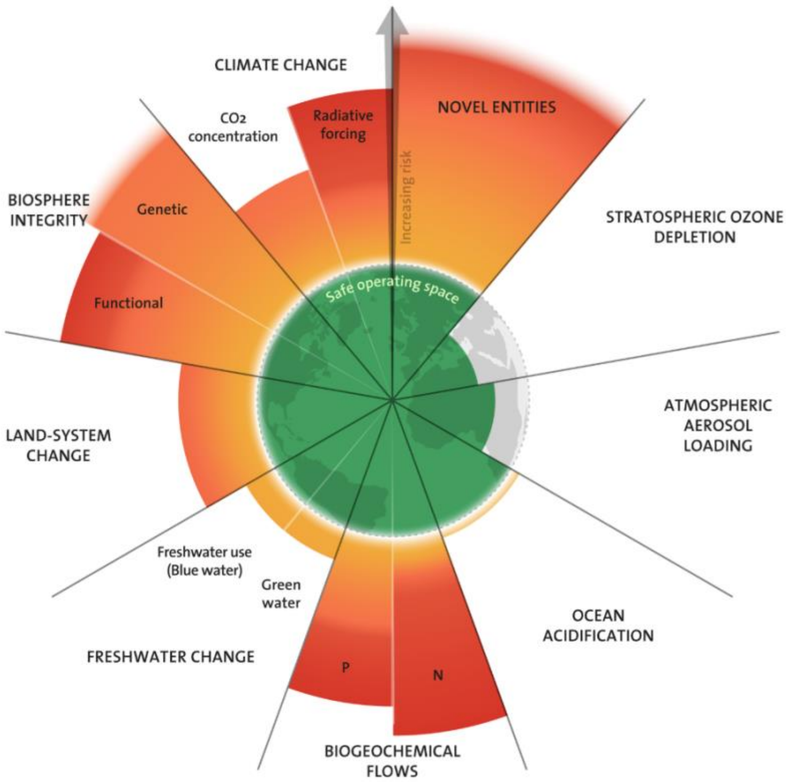

Figure 7: The nine planetary boundaries and their state of transgression beyond safe operating limits. Six of the nine boundaries are currently breached and indicate the destabilisation of earth systems, to the detriment of humanity.

[26] WCED. 1987. *Our Common Future*. World Commission on Environment and Development

[27] Richardson, K. *et al.,* 2023. *Earth beyond six of nine planetary boundaries.* Sci. Adv. 9. 10.1126/sciadv.adh2458

[28] Readfern, G. 2025. *Planet's first catastrophic climate tipping point reached, report says, with coral reefs facing widespread dieback.* The Guardian.

To help manage these planetary risks, in 2015 the United Nations introduced the 17 Sustainable Development Goals (SDGs)[29], a global framework for protecting people and the planet. The SDGs bring together environmental, social, and economic dimensions of sustainability and are now used across sectors, including architecture, to guide responsible decision-making.

Figure 8: The 17 United Nations Sustainable Development Goals.

[29] United Nations. 2025. *Sustainable Development Goals: Communications Materials.* Retrieved from: https://www.un.org/sustainabledevelopment/news/communications-material/

Environmental Impacts

Wool's environmental profile is shaped by biology, land management, production methods, and end of-life behaviour.

Wool interacts with the climate and with nature in various ways across its life cycle. The lifecycle of wool describes all resources and activities associated with wool products. As shown in *Figure 9*, the life cycle of wool includes:

- Rearing and farming of sheep
- Sheep shearing and wool processing
- Manufacture of wool products
- Sales and distribution of wool products
- Installation and use of wool products e.g in buildings
- Waste treatment for wool that is wasted either during manufacture, installation, or at its end-of-life.

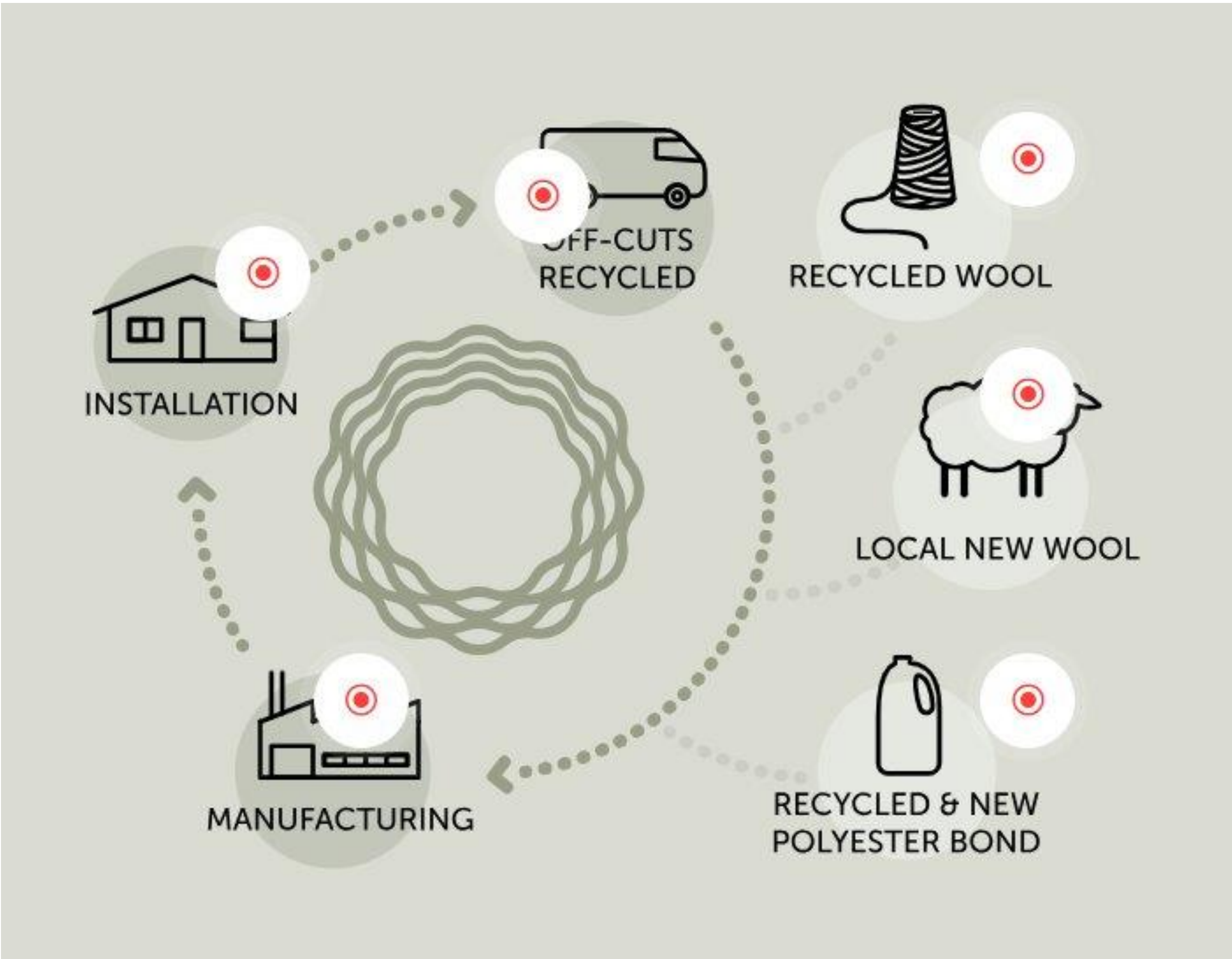

Figure 9: Terra Lana life cycle diagram of Terra Lana strong wool products.[30]

[30] Terra Lana. 2025. *Insulation Resources.* Retrieved from: https://www.terralana.co.nz/wool-product-resources/

EMBODIED CARBON & CLIMATE IMPACT

Climate Impact and Global Warming Potential

The climate impact of buildings and building products is understood via the greenhouse gas (GHG) emissions associated with the building and building products. Climate impact is measured via the global warming potential of the various greenhouse gases emitted. Global warming potential is most commonly measured over a 100-year time period, because this time frame provides a balance between the warming effects of short- and long-lived greenhouse gases.[31]

The International Panel on Climate Change (IPCC) Sixth Assessment Report (AR6) provides global warming potential (GWP) values for all greenhouse gases[32], which are reported in carbon dioxide equivalents ($kgCO_2e$). This unit of measurement is used to normalise the GWPs of the various GHGs, because the gases have varying GWPs (see Table 1). For example, non-fossil methane is 27x as potent as carbon dioxide.

Table 1. IPCC AR6 Major GHG global warming potentials

COMMON NAME	CHEMICAL FORMULA	GWP VALUES FOR 100-YEAR TIME HORIZON
Carbon dioxide	CO_2	1
Methane – non-fossil	CH_4	27.0
Methane – fossil	CH_4	29.8
Nitrous oxide	N_2O	273
Nitrogen trifluoride	NF_3	17,400
Sulfur hexafluoride	SF_6	24,300

Sheep farming causes significant emissions of methane and nitrous oxide from agricultural activities including feed, agrichemical applications, enteric fermentation (sheep digestion) and manure management.[33]

This is reflected in New Zealand's national greenhouse gas emissions inventory, which shows the contribution of sheep farming to national emissions and the types of greenhouse gas emissions the industry causes (*Figure 10*). As shown, methane is the predominant greenhouse gas associated with sheep farming.

Despite the significant greenhouse gas emissions associated with farming however, approximately 25% of all native vegetation in New Zealand is on sheep and beef farms.[34] This means New Zealand strong wool growers have the potential to actively reduce or remove 0.8 – 1.5 million tCO_2e by 2030.[35] This positions New Zealand strong wool as a strategic material for architecture, because the farms preserve, manage and protect substantial biodiversity strongholds which also remove carbon dioxide from the atmosphere at the same time.

[31] Climate TRACE. 2022. *Feeling the Heat: Global Warming Potentials and 20- vs 100-year Time Horizons.* Climate Trace.
[32] IPCC. 2024. *IPCC Global Warming Potential Values.* Greenhouse Gas Protocol.
[33] Mazzetto, A., Falconer, S. & Ledgard, S. 2023. *Carbon footprint of New Zealand beef and sheep meat exported to different markets.* Environmental Impact Assessment Review 98:106946.
[34] Beef+Lamb NZ. 2023. *Compendium of New Zealand Farm Facts.* Beef + Lamb New Zealand.
[35] Pollination. 2024. *Wool Impact emissions reductions and removals.* Pollination

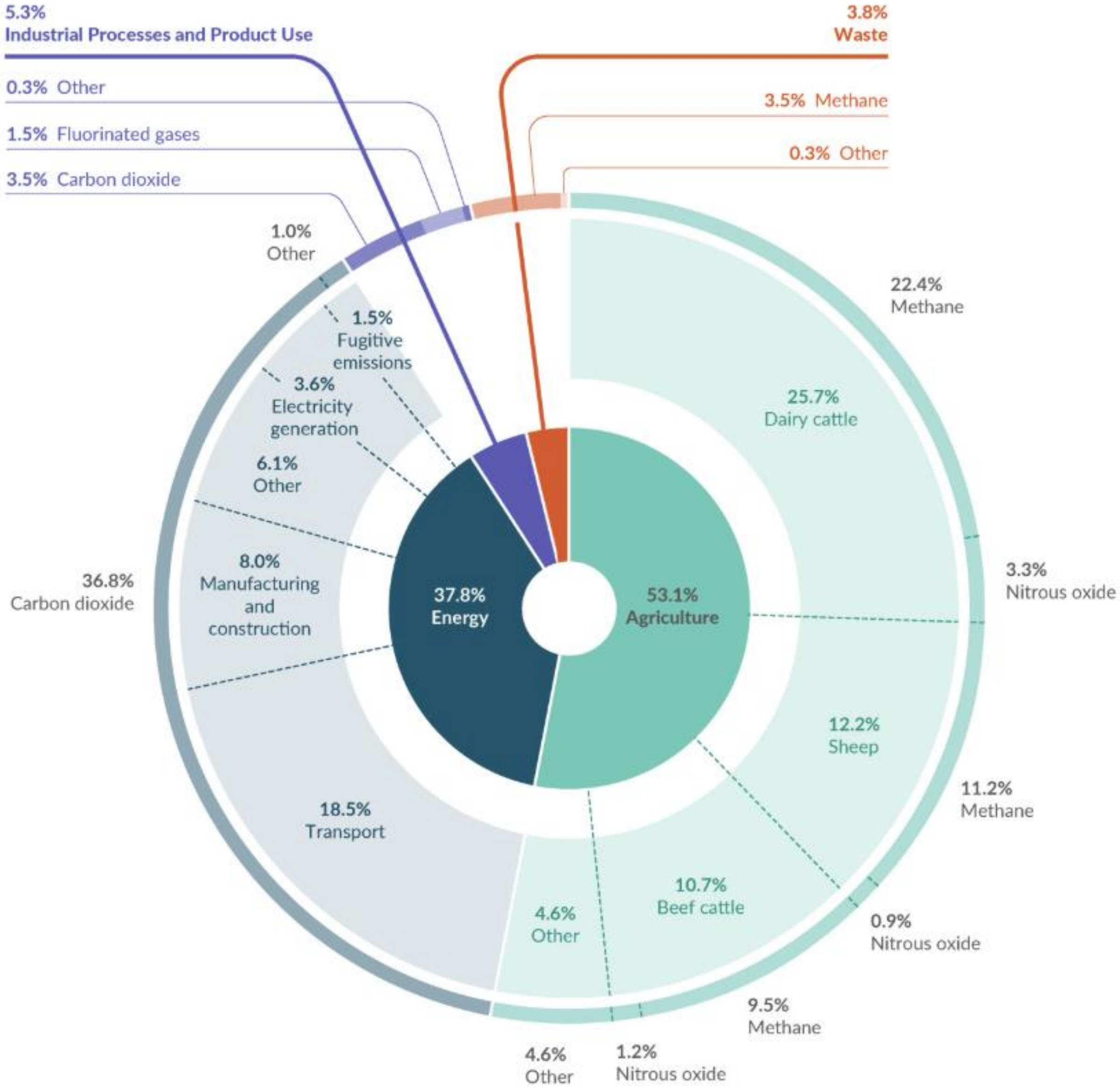

Figure 10: Sector-level breakdown of New Zealand's greenhouse gas inventory in 2023.[36]

[36] Ministry for the Environment. 2023. *New Zealand's greenhouse gas inventory.* Ministry for the Environment.

Whole-of-Life Embodied Carbon Emissions

To understand the climate impact of buildings, whole-of-life embodied carbon must be measured. This represents all greenhouse gas emissions associated with a building's life cycle—from the extraction of raw materials through to end-of-life treatment—and excludes operational emissions.

A key component of this is the set of emissions arising from raw material extraction, transport to manufacturing facilities, and product manufacturing. These are referred to as "cradle-to-gate" impacts.

For sheep wool as a raw material:

- On farm emissions (methane and nitrous oxide) dominate the -cradle to -gate- footprint of wool fibre.[37]
- NZ strong wool systems show significantly lower footprints than global generic datasets:
  - ~46% lower than global strong wool factors commonly used in LCA databases.[38]
  - A further ~29% reduction when on-farm vegetation carbon storage is included.
- The wool sector has insetting potential: modelling indicates NZ strong wool growers could remove or avoid GHG emissions through improved grazing, vegetation restoration and soil carbon enhancement. These potential removals are not currently accounted for in existing carbon emissions estimates.

A number of sheep wool building product manufacturers have published Environmental Product Declarations (EPDs) that disclose both cradle-to-gate and whole-of-life impacts (*Table 2*).

Table 2: Cradle-to-gate impacts (raw materials, inbound transport to manufacturing site, and manufacturing) of select sheep wool building products.

MANUFACTURER	PRODUCT	KGCO$_2$E PER M²
Thermafleece[39]	CosyWool Slab	1.03
Thermafleece[40]	UltraWool Slab	1.36
Floc NZ	Floc Acoustic	11.3
Havelock[41]	Insulation in Batts	4.42
Havelock[42]	Loose-fill Insulation	1.76
WoolConcept	Semi-rigid Sheep Wool Insulation	3.38
OneClick LCA	Average sheep wool thermal and acoustic insulation	1.51
OneClick LCA	Insulation in batts, from virgin wool	2.96

[37] Mazzetto, A., Falconer, S. & Ledgard, S. 2023. *Carbon footprint of New Zealand beef and sheep meat exported to different markets.* Environmental Impact Assessment Review 98:106946.

[38] Wool Impact. 2024. *Wool's Impact: Carbon Footprint.* Wool Impact.

[39] Thermafleece. 2021. *Environmental Product Declaration Thermafleece Cosywool, Ultrawool.* EPD International.

[40] Thermafleece. 2021. *Environmental Product Declaration Thermafleece Cosywool, Ultrawool.* EPD International.

[41] Havelock Wool. 2020. *Environmental Product Declaration Havelock Wool Batt Insulation and Wool Loose-fill Insulation.* Havelock Wool.

[42] Havelock Wool. 2020. *Environmental Product Declaration Havelock Wool Batt Insulation and Wool Loose-fill Insulation.* Havelock Wool.

Sheep wool products show an initial removal of carbon dioxide, which is then re-emitted at end-of-life. This represents the biogenic carbon cycle, as shown in *Figure 11.*

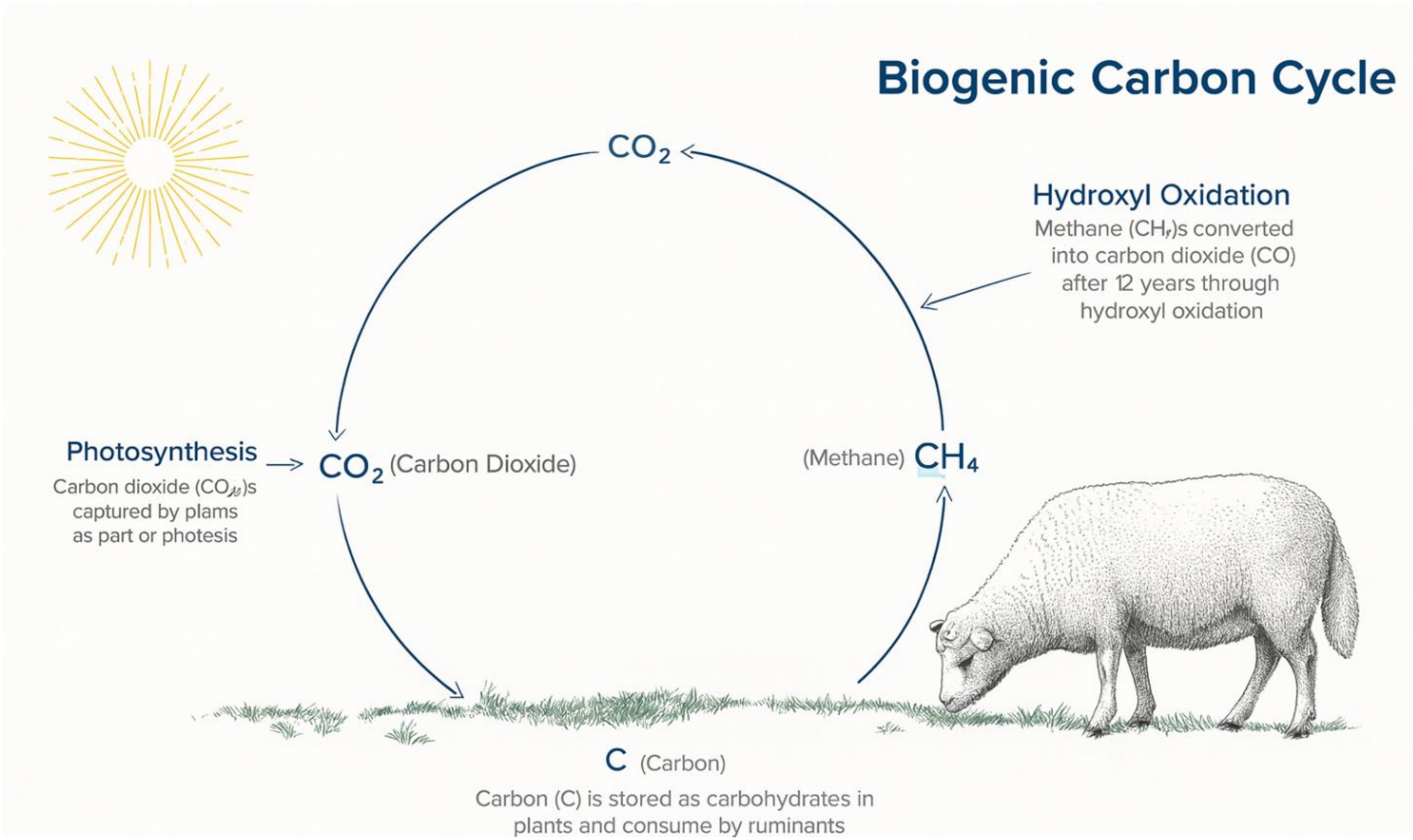

Figure 11: Biogenic carbon cycle diagram.[43]

[43] Adapted and re-drawn with AI assitstance, ChatGPT. 2025.

WATER, LAND AND BIODIVERSITY

Water, land, and biodiversity impacts are assessed by looking at how sheep wool products use water, affect local environments and habitats, and how sheep farming practices influence native biodiversity.

Water

Strong wool production in NZ generally involves rain-fed pastoral systems with low irrigation requirements, meaning fibre production water impacts are relatively low compared with water-intensive synthetic fibre supply chains.[44] However, sheep grazing and effluent can contribute to nutrient runoff and subsequent water pollution – particularly if stock are allowed to enter waterways.[45]

Land

Grazing systems can contribute to erosion and nutrient runoff if poorly managed, but there is increasing adoption of riparian planting, wetland protection, and regenerative practices which improve long-term ecological performance. Wool geotextiles and erosion-control products have been shown to stabilise slopes, support vegetation establishment and improve soil structure and water-holding capacity.[46]

Biodiversity

Around a quarter of New Zealand's native vegetation occurs on sheep and beef landscapes[47], indicating that wool supply chains intersect strongly with biodiversity stewardship. 92% of New Zealand sheep farmers see the value of managing native biodiversity on farms.[48]

Figure 12: Image Credit - Stu Jackson Photography.[49]

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[44] Massey, F. e. 2021. *Managing and protecting native biodiversity on-farm - what do sheep and beef farmers think?* New Zealand Ecological Society 45(1):3420

[45] Ministry for the Environment 2022. *Stock exclusion: Essential Freshwater.* Ministry for Primary Industries.

[46] Broda, J., & al., e. 2016. *Biodegradation of sheep wool geotextiles.* International biodeterioriation and biodegradation.

[47] Beef+Lamb NZ. 2023. *Compendium of New Zealand Farm Facts.* Beef + Lamb New Zealand.

[48] Massey, F. e. 2021. *Managing and protecting native biodiversity on-farm - what do sheep and beef farmers think?* New Zealand Ecological Society 45(1):3420

[49] The Campaign for Wool New Zealand Trust

CIRCULARITY AND END-OF-LIFE

Wool products can stay in use through both technical and biological cycles. The technical cycle covers things like reuse, repair, and recycling. The biological cycle covers processes such as biodegradation, composting, and returning nutrients to the soil. Wool naturally fits into both.

- Wool is renewably produced as part of normal animal welfare.[50]
- Wool products can incorporate recycled wool, reducing embodied carbon further.[51]
- Wool biodegrades naturally in soil, returning nutrients to the soil.[52]
- Wool biodegrades in marine environments, unlike synthetic fibres which contribute to microplastic pollution.[53]
- Wool waste pathways exist for recovery, reuse and recycling.[54]
- Mechanical recycling of wool offcuts and recovered products into new insulation, acoustic panels, or felted products is achieved by companies like Terra Lana.

However, wool's circularity and ability to biodegrade can be limited when products contain synthetic binders, glues, or mixed-material laminates, as these make recycling harder. In many regions there are also no large-scale collection systems for used wool insulation, which means post-consumer products often can't re-enter circular end-of-life pathways.

HUMAN HEALTH & ECOSYSTEM HEALTH

Studies and product data show sheep wool delivers a range of benefits to human and ecosystem health across its life cycle.

Human Health

Sheep wool is non-toxic and non-irritant when handled, unlike fibreglass which can shed respirable fibres and irritate skin and eyes. Sheep wool is classified as hypoallergenic[55] and can alleviate the symptoms of mild-to-moderate atopic dermatitis.[56]

In 2025, AgResearch scientists investigated sheep wool's capability to purify indoor air and found it can diminish formaldehyde concentrations to zero in four hours by absorbing the pollutant within its fibres.[57] Sheep wool also has one of the highest removal rates for nitrogen dioxide compared with alternate building fibres and can absorb almost 3x the quantity of sulphur dioxide that nylon fibres can.[58]

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[50] MPI. 2025. *Code of Welfare: Sheep and Beef Cattle.* Ministry for Primary Industries.
[51] Terra Lana. 2024. *Terra Lana wool insulation product data.* Terra Lana.
[52] Hodgson, A., Leighs, S., & van Koten, C. 2023. *Compostability of wool textiles by soil burial*. Sage Journals.
[53] Collie, S., Brorens, P., Hassan, M., & Fowler, I. 2024. *Marine biodegradation behaviour of wool and other textile fibres*. Water Air Soil Pollution.
[54] Broda, J., & al., e. 2016. *Biodegradation of sheep wool geotextiles.* International biodeterioriation and biodegradation.
[55] Allergy Standards. 2020. *New standard for bedding containing Merino Wool.* Allergy Standards.
[56] Zhou, H. Bai, L., Li, S., Wang, J. & Hickford, J. 2025. Wool: From properties and structure to genetic insights and sheep improvement strategies. Animals (Basel).
[57] IWTO. 2025. *Breathe Easy.* International Wool Textiles Organisation.
[58] IWTO. 2025. *Breathe Easy.* International Wool Textile Organisation.

Sheep wool is also shown to enhance sleep quality, by reducing sleep-onset latency compared with cotton. This benefit is attributed to wool's ability to buffer humidity, insulate from temperature fluctuations and improve general thermal comfort.[59]

Wool's hygroscopic properties also supports a more stable indoor humidity which reduces condensation risk and lowers the chance of mould growth, which has a big influence on respiratory health.[60]

Ecosystem Health

Many synthetic or petroleum-based materials such as polyester, nylon, viscose or acrylic fibres release microplastics, plasticisers, residual solvents and formaldehyde residues to the environment as they degrade[61], unlike sheep wool. It has also been found that many synthetic fibres do not readily degrade in marine environments, thereby contributing to persistent plastic pollution in marine environments.[62]

Figure 13: Image Credit - Ryan Cosgrove.[63]

[59] Li X., Halaki M., Chow C.M. How do sleepwear and bedding fibre types affect sleep quality: A systematic review. J. Sleep Res. 2024;33:e14217. doi: 10.1111/jsr.14217.

[60] Hetimy, S., & et al. 2024. *Exploring the potential of sheep wool as an eco-friendly insulation material: a comprehensive review and analytical ranking.* Sustainable Materials and Technologies

[61] Priyadarshini, S., Jagatee, S. & Das, A. 2024. *Synthetic fibres and microfiber pollution – an assessment of their global impact.* Renewable Energy Generation and Value Addition from Environmental Microfiber Pollution Through Advanced Greener Solution pp. 137 – 157.

[62] Broda, J., & al., e. 2016. *Biodegradation of sheep wool geotextiles.* International biodeterioriation and biodegradation.

[63] The Campaign for Wool New Zealand Trust

Life Cycle and Transparency

The life cycle of sheep wool products is described at a high level in "Environmental Impacts." Below, a more detailed deep-dive is taken to consider the information and transparency available at each life cycle stage. These life cycle stages follow the definitions outlined in the international building life cycle assessment standard EN 15973 (*Figure 14*) and are described in *Table 3* below.

Table 3: The life cycle stages of sheep wool building products, aligned to EN 15973.

LIFE CYCLE STAGE	MODULE	DESCRIPTION
Product stage	A1 – A3	On-farm production, shearing, scouring, carding, manufacturing and packaging of final products.
Transport stage	A4	May be compressed for shipping; often local sourcing (unlike synthetic materials).
Construction and installation stage	A5	Cutting, installing, reuse and recycling of offcuts.
Use stage	B1 – B5	Moisture buffering, mould resistance, noxious gas absorption
End-of-life stage	C1 – C4	Composting, biodegrading, or landfilling
Outside the product system	D	Recycling, material recovery, nutrient cycling

Wool supply chains can be traced to farm, flock or region through programmes such as RWS, ZQRX, NZFAP+ and other traceability schemes. Manufacturers like Terra Lana, Havelock Wool and others operate batch tracking systems to link products back to source. By contrast, synthetic insulation materials typically have no meaningful feedstock traceability – raw materials like petrochemicals, sand, slag, or basalt are bulk traded.

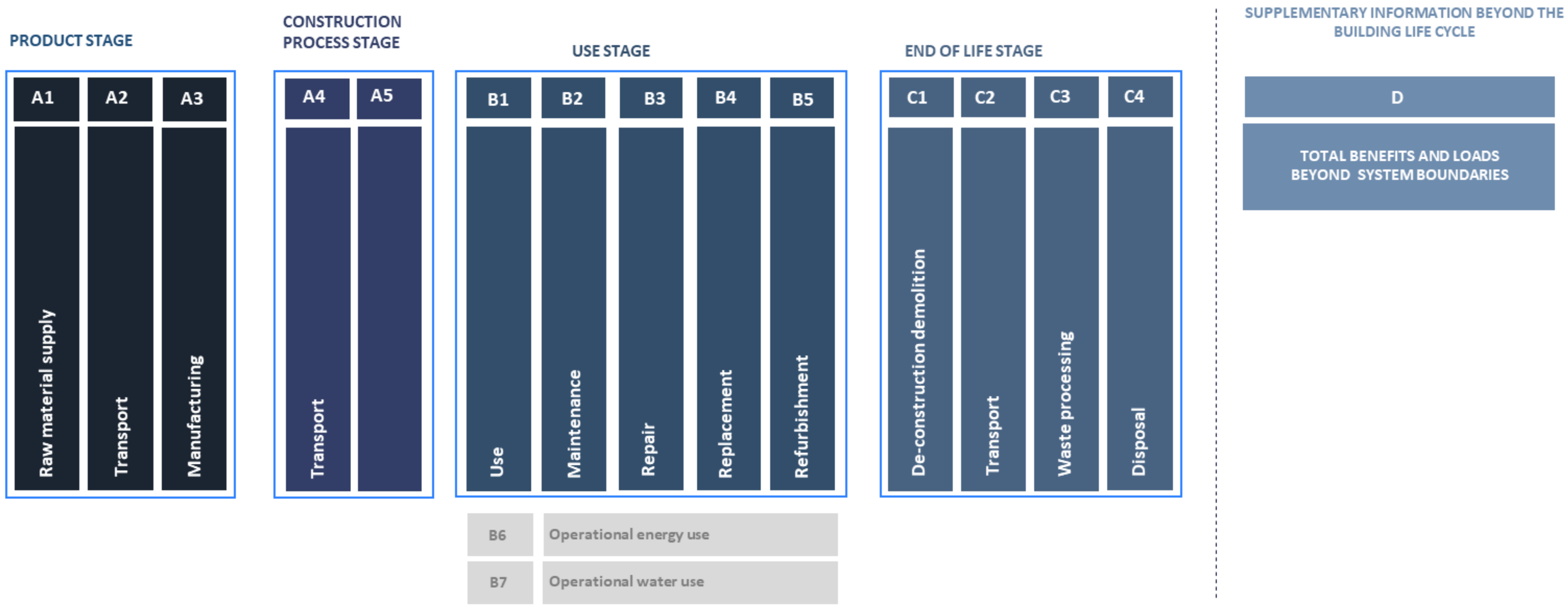


Figure 14: The cradle-to-grave life cycle stages of a building according to EN 15978:2011, the internationally-recongised standard for building life cycle assessment.[64]

[64] BSI. 2011. *BS EN 15978-1 Sustainability of Construction works – Methodology for the assessment of performance of buildings – Part 1: Environmental Performance.* UK National Standards Body.

Summary

The below table presents a Material Comparison Matrix which synthesises the technical and environmental features of sheep wool versus alternate materials. All values are indicative and are not product-specific specifications.

Table 4: Material comparison matrix for sheep wool, glass wool, mineral wool and petroleum-based synthetic materials.

ATTRIBUTE	SHEEP WOOL	GLASS WOOL	MINERAL WOOL	POLYSTYRENE/PIR/PUR
Thermal conductivity (λ)	0.033–0.039 W/mK	0.033–0.040 W/mK	0.035–0.045 W/mK	0.020–0.030 W/mK
Typical density (insulation batts)	18–24 kg/m³	10–16 kg/m³	30–60 kg/m³	25–35 kg/m³
Moisture behaviour	Hygroscopic; absorbs ~35% of its own weight in moisture	Loses R value; can slump when wet	Non hygroscopic; typically water repellent	Loses R value; long dry out times
Breathability / vapour diffusion	High; supports vapour open assemblies	Low	Low	Very low
Mould resistance	High – moisture buffering, organic but resistant when properly detailed	Can support mould if dust and moisture present	Inert but can trap moisture	Can trap moisture; mould risk on adjacent materials
Fire behaviour	Ignition at ~570–600°C; chars, doesn't melt or drip; low smoke toxicity	Melts; may release binder fumes	High melting point; good fire barrier	Some foams release dense, toxic smoke; require added flame retardants
VOC / IAQ profile	Adsorbs VOCs and acidic gases; no plasticiser off gassing	Binder off gassing possible	Generally low emissions	Off gassing risk from blowing agents, flame retardants, adhesives
Biodegradability	Fully biodegradable in soil and marine environments	Non biodegradable	Non biodegradable	Non biodegradable; contributes to microplastics
Circularity	Mechanically recyclable; compostable; suited to design for disassembly	Some recycling; often down cycling	Some recycling	Limited recycling; rarely recovered
Traceability	Strong – farm, flock, region and manufacturer tracked	Factory only	Factory only	No feedstock traceability
Climate impact (A1–A3)	1.0–4.4 kgCO_2e/m² (product specific)	~4.1 kgCO_2e/m²	~5.1 kgCO_2e/m²	2.1–3.0 kgCO_2e/m²

MODULE 3:

Tools for Architectural Practice

Module 3: Tools for Architectural Practice

Why LCA Tools Matter

Architectural students and future practitioners are increasingly expected to:

- Conduct comparative material assessments.
- Justify material choices with quantitative carbon evidence rather than qualitative impressions.
- Model upfront and whole of- -life carbon for studio projects using recognised methods.
- Demonstrate familiarity with NZ-specific embodied- carbon- frameworks used in practice and by NZGBC.
- A wide range of LCA-based tools is now available to help the design community assess environmental impacts — whether looking at a single material, a composite building assembly, or an entire building. This section focuses on the most relevant and NZ-centric options for architectural practice.
- BRANZ provides a suite of tools built on New Zealand–specific methodologies and verified carbon datasets. While architects should be familiar with the full BRANZ offering, this section highlights the tools that are most directly useful for everyday design, specification and comparative assessment.[65]

In Table 5, a detailed comparison of the tools is provided, summarising their function, use case, benefits and limitations.

Figure 15: Image Credit - Stu Jackson Photography.[66]

[65] BRANZ. 2025. *Calculators and tools.* Building Research Association of New Zealand.
[66] The Campaign for Wool New Zealand Trust

An Overview of the Tools Available

LCA QUICK

LCAQuick is a free Excel tool specifically developed by BRANZ for NZ architects, designers, and engineers. It combines material quantities and energy data with environmental impact data to calculate a building's potential environmental LCA impact.[67] It delivers carbon footprint results, provides element-by-element embodied carbon breakdowns, supports benchmarking against NZ targets and allows easy material hotspot identification within a building design.

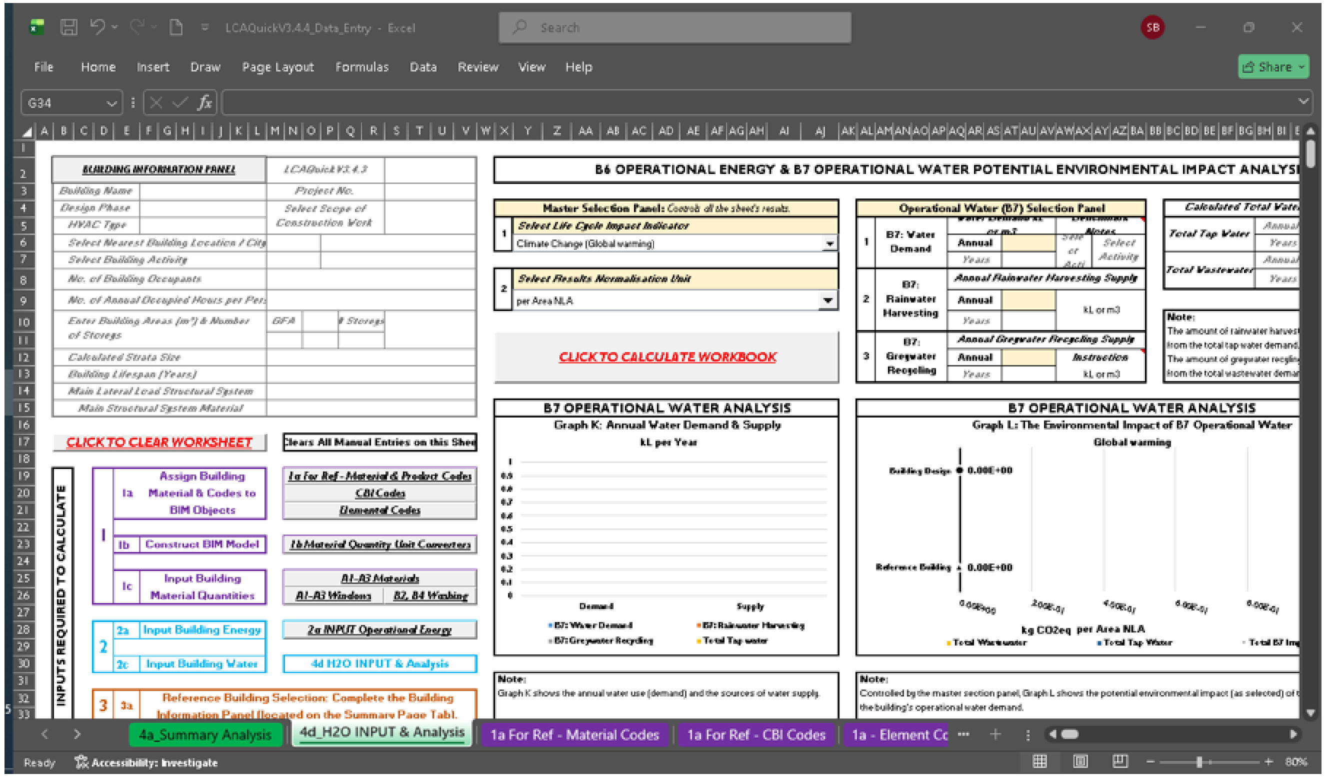
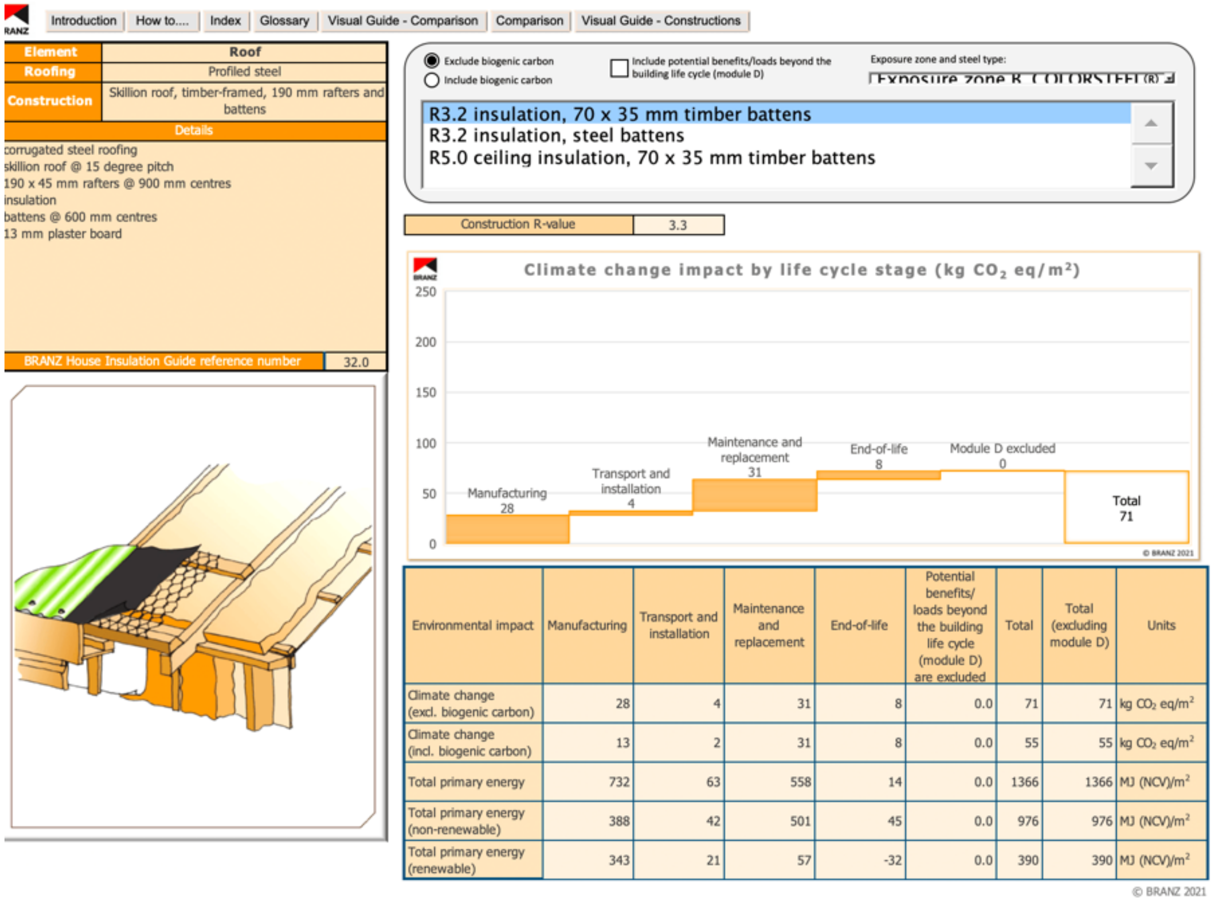


Figure 16: Tool Interface for the BRANZ LCAQuick Excel building LCA tool.

[67] BRANZ. 2025. *LCAQuick: Life cycle assessment tool.* Building Research Institute of New Zealand.

CO_2RE

This tool is provided by BRANZ to help architects and designers understand the climate impact of individual building products and specific elements of a building.[68]



Environmental impact	Manufacturing	Transport and installation	Maintenance and replacement	End-of-life	Potential benefits/ loads beyond the building life cycle (module D) are excluded	Total	Total (excluding module D)	Units
Climate change (excl. biogenic carbon)	28	4	31	8	0.0	71	71	kg CO_2 eq/m^2
Climate change (incl. biogenic carbon)	13	2	31	8	0.0	55	55	kg CO_2 eq/m^2
Total primary energy	732	63	558	14	0.0	1366	1366	MJ (NCV)/m^2
Total primary energy (non-renewable)	388	42	501	45	0.0	976	976	MJ (NCV)/m^2
Total primary energy (renewable)	343	21	57	-32	0.0	390	390	MJ (NCV)/m^2

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Figure 17: Tool Interface for the BRANZ CO_2re building LCA tool.

[68] BRANZ. 2025. *LCAQuick: Life cycle assessment tool.* Building Research Institute of New Zealand.

$NECO_2$

NECO2 is endorsed by Ministry of Business, Innovation and Employment (MBIE), and backed by Registered Master Builders and the New Zealand Institute of Architect as shareholders of CIL Masterspec. This tool is New Zealand's national embodied carbon data repository and provides data on thousands of New Zealand construction materials.[69]

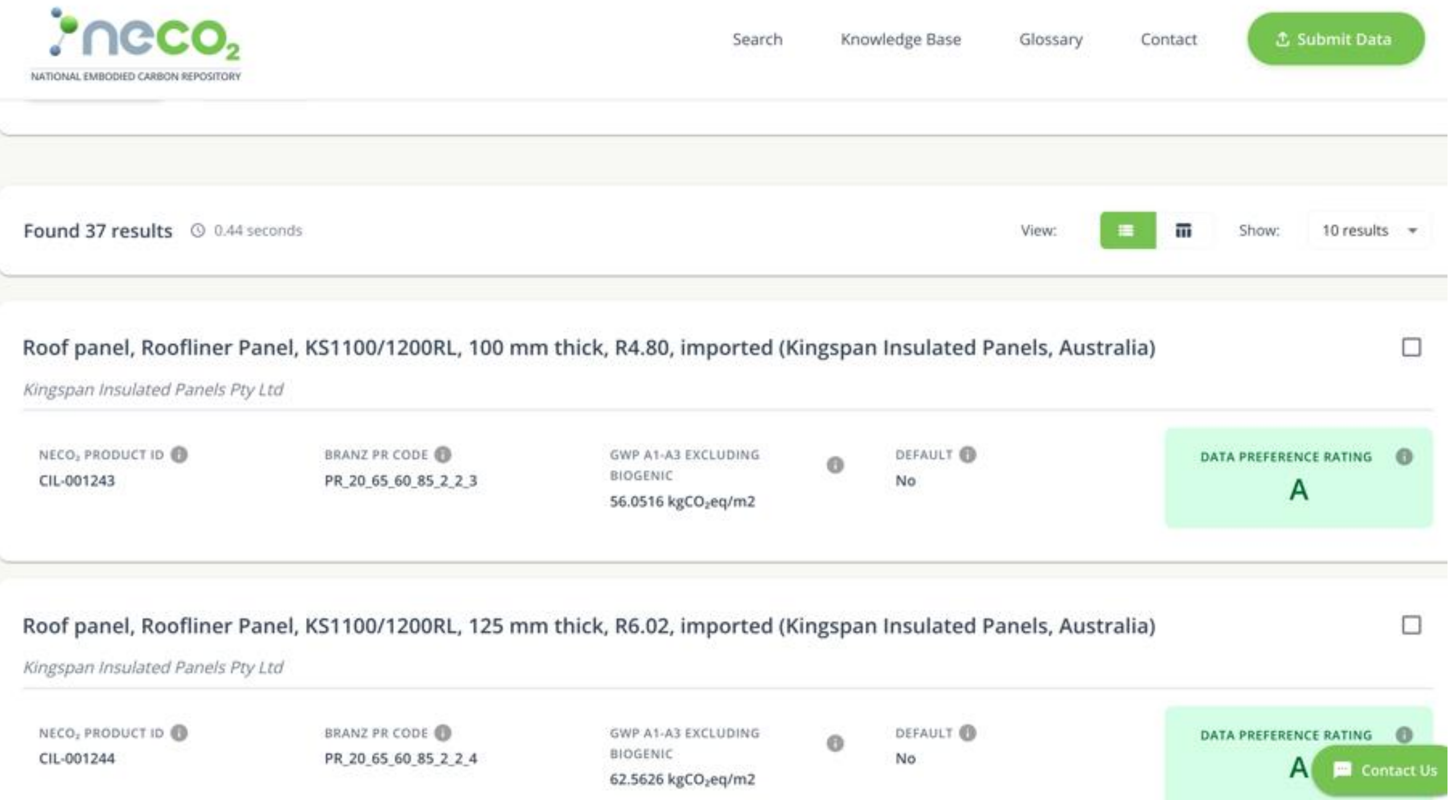

Figure 18: Tool Interface for the BRANZ $NECO_2$ building LCA tool.

[69] BRANZ. 2025. *National Embodied Carbon Repository.* NECO2.

ONE CLICK LCA

One Click LCA, is a licensed web-based software specifically customised for buildings. Users manually input the quantities of construction materials for the building being analysed. It can retrieve localised information and may be used either to find specific building product environmental information or to calculate full building life cycle assessments.[70]

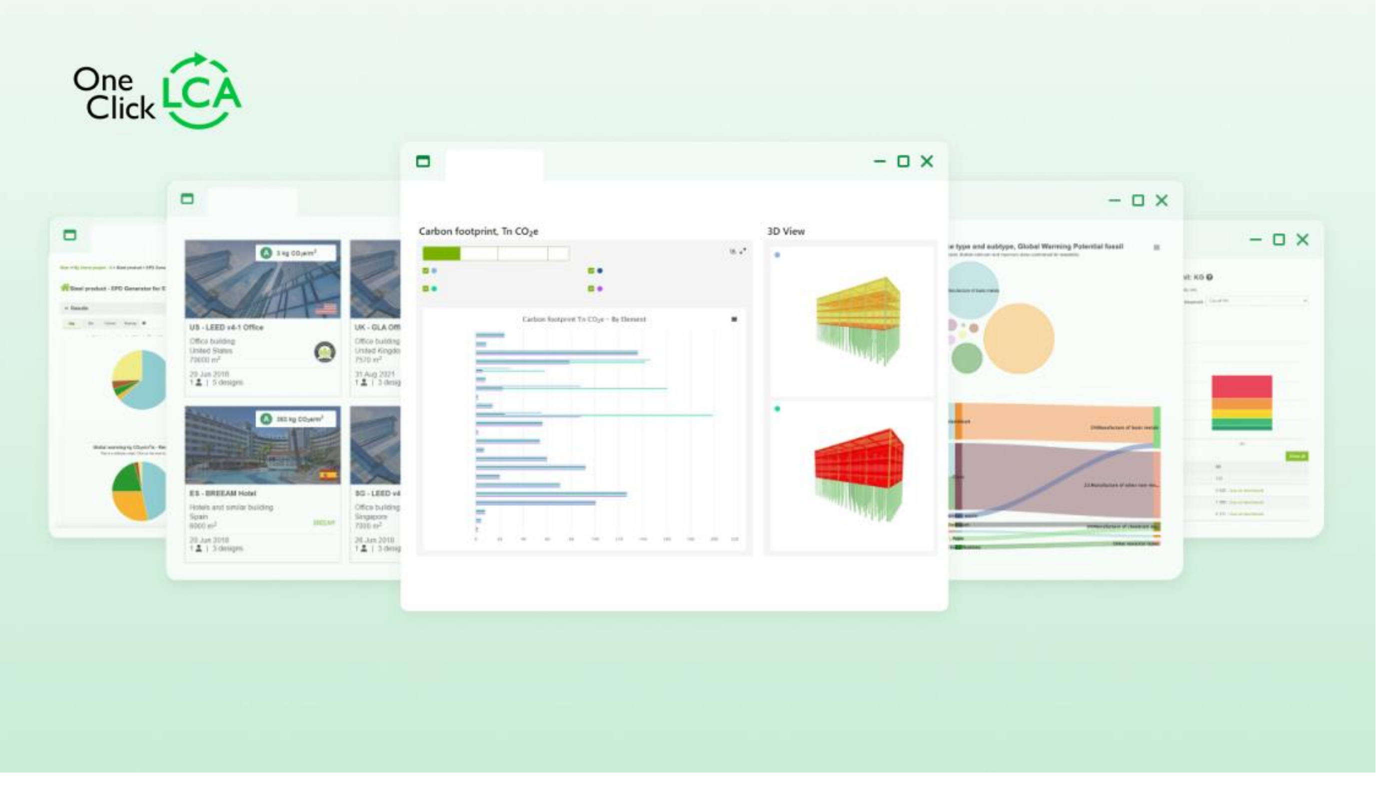

Figure 19: Screenshot of the One Click LCA web-browser, cloud-based tool.

[70] One Click LCA. 2025. *One Click LCA*. OneClickLCA.

SIMA PRO CRAFT

SimaPRO Craft is a desktop-based software for conducting LCA's of products and services. It is used by professionals for applications like carbon accounting and sustainable product design.[71]

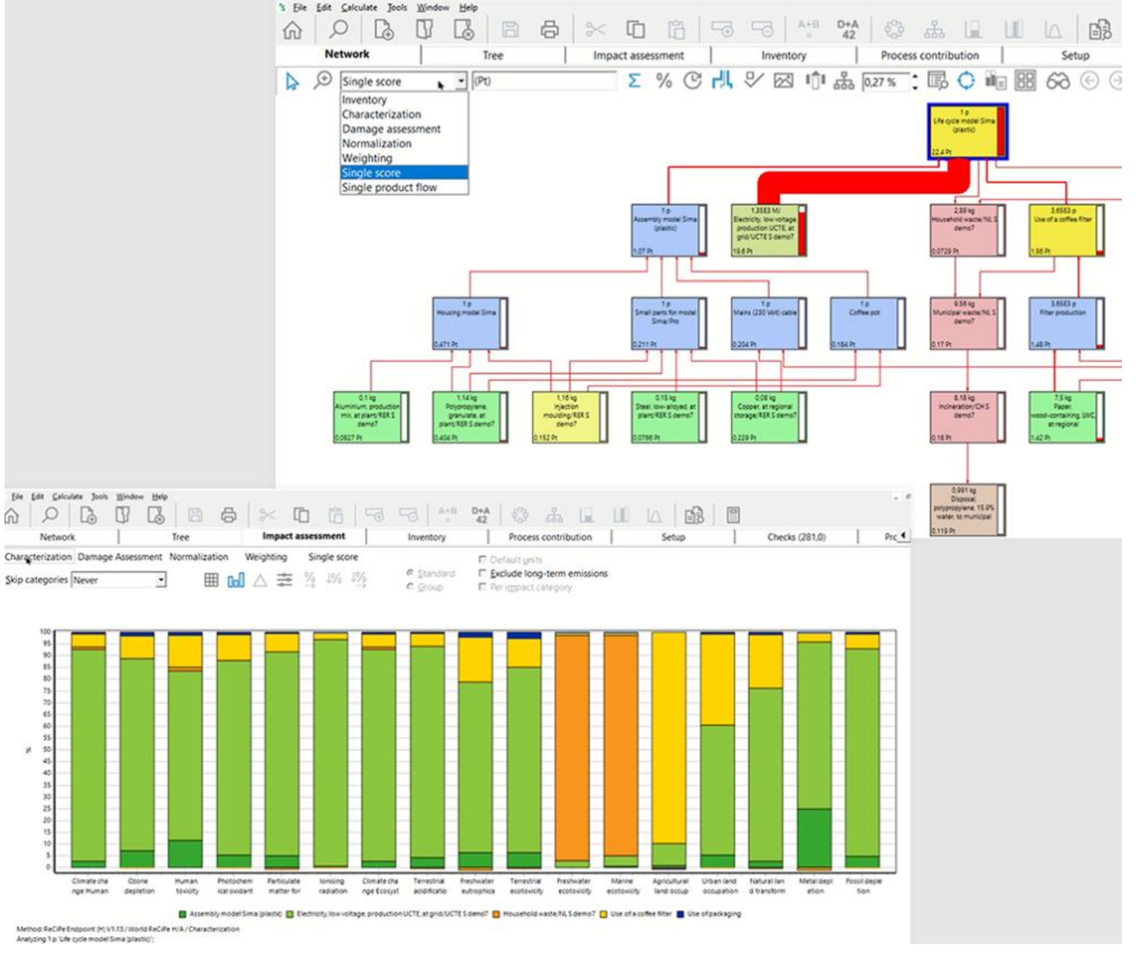

Figure 20: Tool Interface for Sima Pro Craft.

[71] SimaPro. 2025. *LCA software for informed changemakers.* SimaPro.

ETOOL

eTool is an Australian developed web-based LCA software, customised for construction projects including buildings and infrastructure. Users can customize the scope of their assessments.[72]

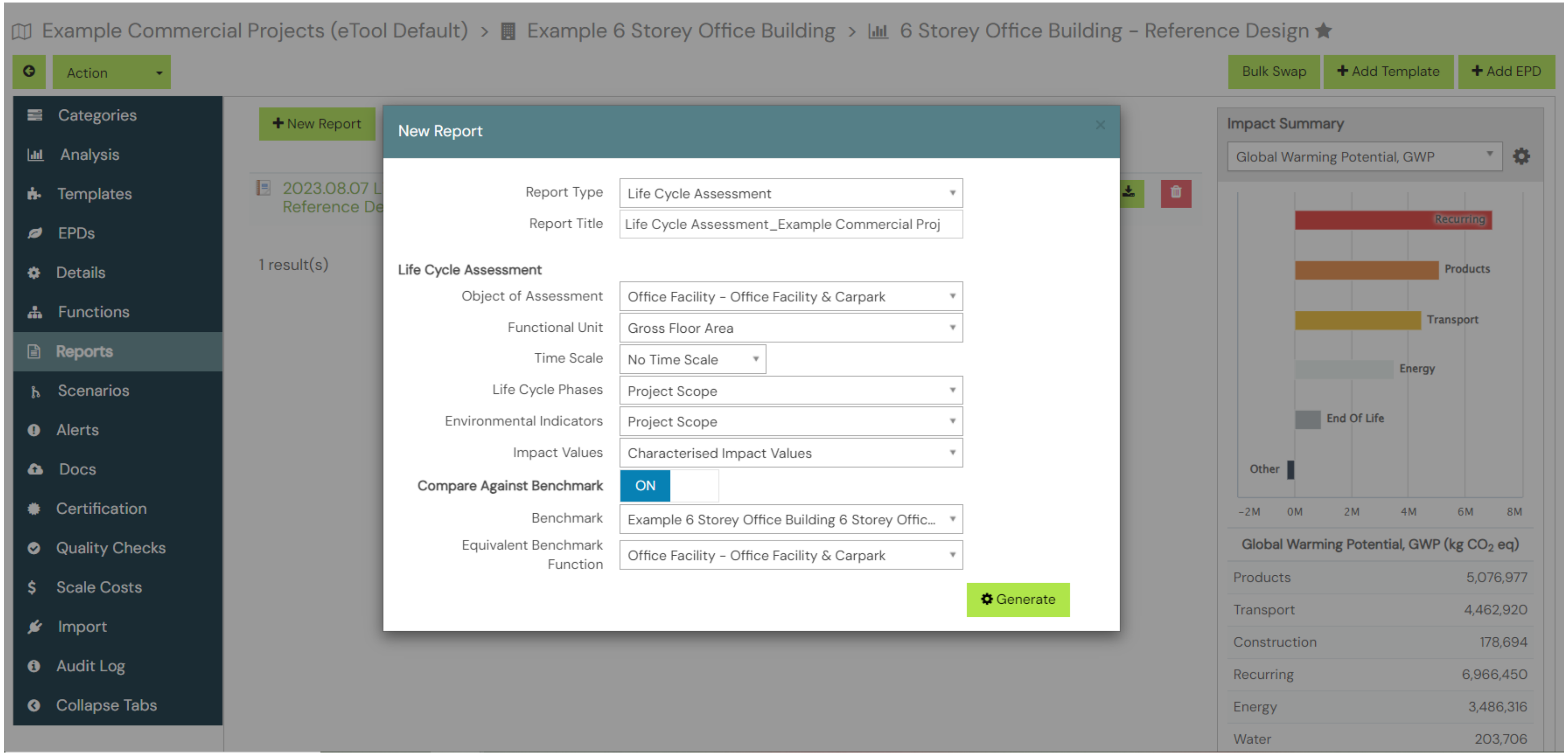

Figure 21: Tool Interface for eTool.

[72] Cerclos. 2025. *Top LCA tool for decarbonising large buildings and infrastructure.* eTool.

SPHERA

Sphera is a USA based company that offer specialized LCA databases for the construction industry and tools to help identify environmental hotspots, optimize sustainability, and achieve whole building certifications. Sphera's LCA for Experts[73] software solution is used to complete product life cycle assessments (LCA) which are often used for Environmental Product Declarations (EPDs).

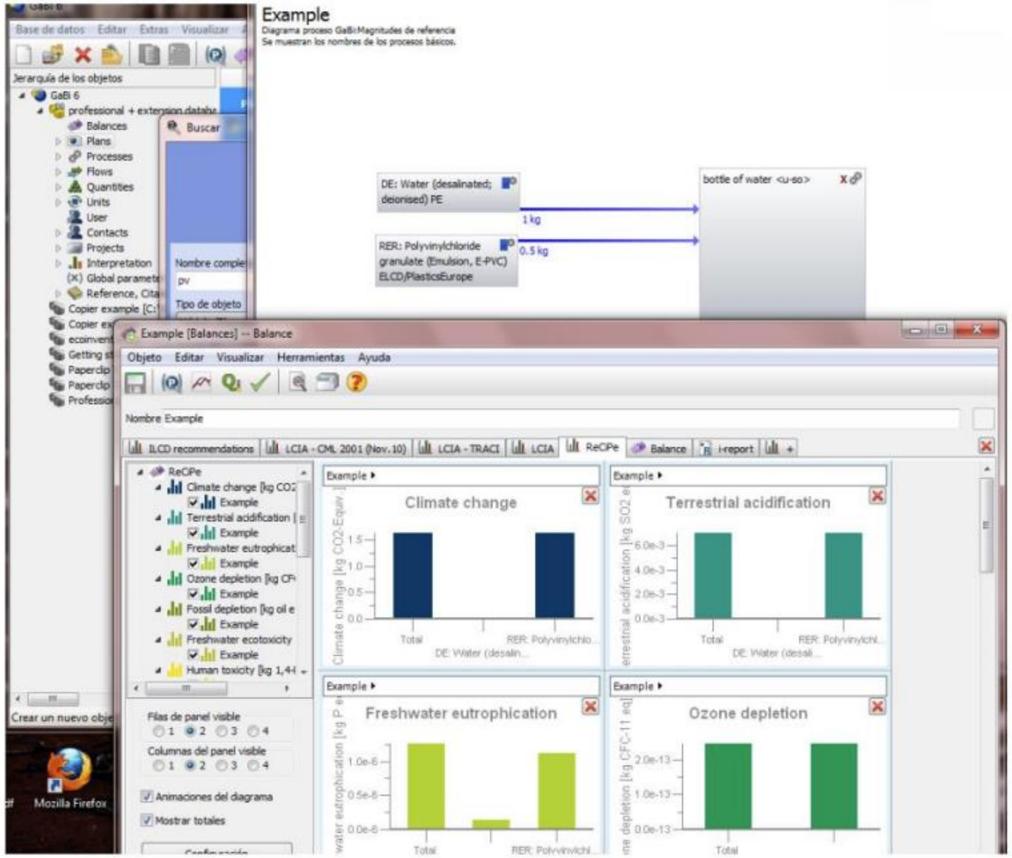

Figure 22: Tool Interface for the LCA For Experts Product LCA tool.

[73] Sphera Solutions. 2025. *LCA for Experts.* Sphera Solutions.

Summary Overview

A range of LCA tools is used across different stages of building design, each offering distinct levels of detail, modelling scope, and data flexibility. Tools such as CO2RE and OneClick LCA are commonly used during early design because they support rapid, high-level comparisons of material choices or system configurations. These platforms are designed to generate indicative results with minimal modelling time, which aligns with the limited information available at early project stages.

As design information becomes more detailed, platforms such as LCAQuick or OneClick LCA are often used to develop building-level assessments. These tools support modelling of whole-building assemblies, operational energy, maintenance cycles, and end-of-life scenarios. Their structure enables quantification of embodied and operational impacts while accommodating typical design development inputs such as quantities, material specifications, and construction details.

For applications requiring deeper methodological control, process-level modelling, or high-resolution inventory data, tools such as SimaPro Craft provide a broader modelling environment. These platforms allow users to build or modify supply-chain processes, integrate custom datasets, adjust allocation methods, and perform sensitivity or scenario analyses with greater technical flexibility. They are frequently used in research settings or in projects requiring detailed behind-the-scenes modelling rather than templated workflows.

Platforms like eTool occupy an intermediate space. They support whole-building and infrastructure LCAs, are aligned with major international standards (e.g., EN 15978, ISO 14040/44), and include template libraries, BIM integrations, and reporting functions. Their workflow is structured around standardised building templates and datasets, which allows efficient modelling of common design scenarios. However, the degree of customisation can be more constrained than in open-ended research tools, and the depth of region-specific datasets (including New Zealand-specific inputs) may require verification or user supplementation depending on project needs.

Overall, the tools differ in modelling depth, data flexibility, methodological transparency, and intended use cases. This variation allows them to support different stages of the design process - from rapid early-stage comparisons, to building-scale assessments, to detailed process modelling in specialised or research-oriented contexts.

Table 5: Comparison of the features, use case, benefits and limitations of each tool considered in this report.

TOOL	OWNER	TYPE	SCOPE & SYSTEM BOUNDARIES	DATABASES USED	TYPICAL NZ USE CASE	BENEFITS	LIMITATIONS
LCA Quick	BRANZ	Excel-based	Whole-of-life embodied carbon assessment for buildings (aligned with EN 15978 modules A–C)	BRANZ NZ-specific emission factors	Whole-building LCAs; comparative design studies	NZ-specific data; free; supports whole-of-life modelling	Manual data entry; requires training; limited material database depth
CO_2RE	BRANZ	Excel-based	Element-level embodied carbon calculations for typical NZ roof, wall and floor systems (primarily upfront impacts)	BRANZ datasets and construction assemblies	Early-stage material/element comparisons	Simple interface; NZ-specific; rapid assessments	Limited scope; fixed assemblies; not a full building LCA
$NECO_2$	CIL Masterspec & BRANZ (endorsed by MBIE & NZGBC)	Webapp	NZ embodied-carbon material database supporting upstream modules (primarily A1–A3)	NZ-specific carbon factors sourced through BRANZ/Masterspec	Material-level carbon factors; integration into design/specificatio n tools	Centralised NZ dataset; consistent data source; sector alignment	Newly released (2025); ongoing data expansion; not an LCA tool itself
OneClick LCA	One Click LCA	Cloud-based LCA platform	Cradle-to-gate and cradle-to-grave LCA modelling for building products, elements and whole buildings	EPDs, ecoinvent, manufacturer datasets, tool-specific emission factors	Whole-of-life building LCAs; Homestar & Green Star submissions	Large dataset library; BIM integrations; streamlined reporting	Tiered licensing; NZ datasets depend on user inputs; paywall for advanced features
Sima Pro Craft	Software	Professional LCA tool	Cradle-to-grave product LCA; process-level modelling; full-system supply-chain modelling	ecoinvent, Industry Data 2.0, and others	Detailed research; product LCAs; advanced comparative modelling	High transparency; extensive database control; configurable methods	Steep learning curve; requires training; not optimised for rapid early-stage work

eTool	CERCLOS	Cloud-based LCA platform	Whole-of-life building and infrastructure LCA (EN 15978 modules A–D)	ecoinvent-based datasets with regionalisation	Building-scale LCAs; scenario testing; LCC integration	BIM integration; established workflow; scenario/“what-if” analysis	Commercial licensing; structured workflows limit deep customisation; training useful
LCA for Experts	Sphera	Software	Product life-cycle modelling with detailed process inventories	Sphera in-house datasets and extensions	Product LCAs; manufacturing and material-level assessments	High data resolution; extensive process libraries	Licensing cost; training required; not building-LCA-specific

MODULE 4:

Working Example, Embodied Carbon

Module 4: Working Example, Embodied Carbon

To make climate impacts actionable, emissions are measured through carbon footprints—quantifying the GHG emissions associated with materials, products, buildings, organisations, or whole countries. In New Zealand, emission factors (e.g., 1 litre of petrol = 2.46 kgCO_2e) are published by the Ministry for the Environment, allowing consistent calculation of carbon footprints across sectors (see *Figure 23*).

CALCULATION METHODOLOGY

$E = Q \times F$

Where:

E	=	emissions from the emissions source in kg CO_2-e per year
Q	=	activity data eg, quantity of fuel used
F	=	emission factor for emissions source

This formula applies to the calculation of both CO_2-e emissions and individual carbon dioxide, methane and nitrous oxide emissions, with the appropriate emission factors applied for F.

The preferred form of data is in the units expressed in the emission factor tables, which results in the most accurate emission calculation. If the data cannot be collected in this unit, use the appropriate conversion factors.

Figure 23: The Ministry for the Environment carbon footprint calculation methodology.

This example is designed to show how wool and glass wool insulation can be compared on a like-for-like basis using EPD data and simple calculations.

To calculate the whole-of-life embodied carbon impact of sheep wool vs glass wool, the following information is required:

Carbon requires four key data components:

- Building material quantities
- Transport distances from material suppliers to construction site
- Construction activities and waste
- Emission factors

The following standards and guidance are used to calculate building whole-of-life assessments in New Zealand:

- IPCC Global Warming Potential Values
- ISO 14040 / 14044 – Life cycle assessment principles
- ISO 21931-1 – Life cycle assessment for buildings
- EN 15978 – Life cycle assessment for buildings
- NZGBC Embodied Carbon Methodology
- SR349 BRANZ New Zealand whole building whole of life framework

Building Specification

This example is for a 150 m² single-storey NZ timber-framed dwelling in Auckland, NZ and designed to meet NZBC H1/AS1 (2023) insulation requirements.[74] The insulation requirements are summarised in *Table 6* below. 1395 m²·R is required across the building.

Table 6: Illustrative insulation data for the building, based on BRANZ housing insulation requirements for roofing, walls and floors.

BUILDING ELEMENT	AREA (M^2)	R-VALUE	TOTAL INSULATION REQUIRED (M^2R)
Roof	150	R6.6	990
External wall	90	R2.0	180
Timber floor	150	R1.5	225

The typical technical data for sheep wool insulation and glass wool insulation is provided in Section 2: Summary. For this particular example, two specific products are selected:

- Thermafleece CosyWool Roll, CosyWool Slab and UltraWool Slab sheep wool products
- Comfortech Pink®Batts®Classic glass wool products
- Comfortech Pink®SuperBatts glass wool products

These product manufacturers are selected because they both have Environmental Product Declarations (EPDs) that can be used to derive carbon footprint data for the products.

- See 'Eden Renewable Innovations Ltd EPD-IES-0004468:001 (S-P-04468) for Thermafleece: Cosywool, Ultrawool product environmental data
- See 'Tasman Insulation New Zealand Ltd EPD-IES-0020965-001 for Comfortech Pink®Batts® product environmental data

The technical data for each set of products required to calculate modules A1 – A3 emissions is summarised in *Table 7* and *Table 8.*

The actual distance from product suppliers to the example building site is not known, so default data has to be used to close the gap. BRANZ default interregional 2 transport scenario is used to define this module, which is 500km by road freight.[75]

New Zealand default waste data is used to assume the end-of-life fate of the insulation products – 95% sent to landfill, and 5% reused.[76]

The data for module A4 transport to site is summarised in Table 9 and the data for end-of-life is summarised in *Table 10*.

[74] BRANZ. 2023. *Housing Installation Guidance.* BRANZ.

[75] Dowdell *et al*. 2016. *New Zealand whole-building whole-of-life framework: Development of datasheets to support building life cycle assessment.* BRANZ. Retrieved from: BRANZ

[76] NZGBC. 2024. *Embodied Carbon Methodology.* NZGBC. Retrieved from: NZGBC.org

Table 7: The product technical data requirements for Thermafleece sheep wool insulation products.

PRODUCT	APPLICATION	R-VALUE	TOTAL AREA OF PRODUCT REQUIRED (M^2)	$KGCO_2E$ / M^2	PRODUCT MASS (KG/M^2)
CosyWool Roll (140mm)	Roof	3.59	276	0.05	0.702
UltraWool Slab (70mm)	External wall	2.0	90	0.0461	1.09
CosyWool Slab (50mm)	Floor	1.32	170	0.0624	0.798

Table 8: The product technical data requirements for Comfortech glass wool insulation products.

PRODUCT	APPLICATION	R-VALUE	TOTAL AREA OF PRODUCT REQUIRED (M^2)	$KGCO_2E$ / M^2	PRODUCT MASS (KG/M^2)
R7 Pink®SuperBatts®	Roof	7.0	150	3.81	3.48
R2.2 Pink® Batts® Classic	External wall	2.2	82	1.10	0.94
R1.8 Pink® Batts® Classic	Floor	1.8	125	1.10	0.79

Table 9: Outbound transport of products to site data.

PRODUCT	DISTANCE (KM)	MASS (KG)	$KGCO_2E$ / TKM	TOTAL CARBON IMPACT ($KGCO_2E$)
Thermafleece products	500	0.427	0.105	22.4
Comfortech products	500	0.725	0.105	38.1

Table 10: End-of-life of products at landfill.

PRODUCT	MASS (KG)	FATE	$KGCO_2E$ / KG	TOTAL CARBON IMPACT ($KGCO_2E$)
Thermafleece products	406	Landfill	1.62	658
Comfortech products	689	Landfill	0.014	9.9

Carbon Data

Table 11: Whole-of-life embodied carbon emissions for Thermafleece sheep wool insulation vs Comfortech glass wool insulation in a 150m² building.

PRODUCT	A1 – A3 KGCO$_2$E	A4 KGCO$_2$E	C1 – C4 + D KGCO$_2$E	TOTAL KGCO$_2$E
Thermafleece products	28.6	22.4	658	709
Comfortech products	799	38.1	9.90	847

Figure 24: Image Credit - Ryan Cosgrove.[77]

[77] The Campaign for Wool New Zealand Trust

Summary

The results indicate the sheep wool insulation solution is ~16% lower whole-of-life embodied emissions impact than the glass wool insulation solution (*Figure 25*). The A1 – A3 impacts of the sheep wool insulation is extremely low, owed to the biogenic carbon that is removed from the atmosphere and stored in the wool.

Carbon dioxide is absorbed from the atmosphere by photosynthesizing plants, such as the grass in the paddocks of sheep farms. This carbon dioxide is then locked away in the plant matter as biogenic carbon. When the sheep graze on this plant matter, they subsequently store the biogenic carbon in their own wool fleeces. This represents a removal of carbon dioxide from the atmosphere, which is then stored in the product made from the sheep wool. However, at end-of-life when the sheep wool biodegrades, it is released again back into the atmosphere. This is why the C1 – C4 impacts of sheep wool insulation are extremely large compared with the glass wool insulation product.

It is important to consider additional sustainability criteria not included in this carbon footprint example: the use stage effects and performance of sheep wool vs glass wool; the realistic end-of-life pathways and pollution risks of sheep wool vs glass wool. These qualities are discussed in section 1 and 2.

Critically, it is important to remember that climate impact is only one dimension of material sustainability. Regardless of the carbon footprint, sheep wool often performs strongly as a sustainable material.

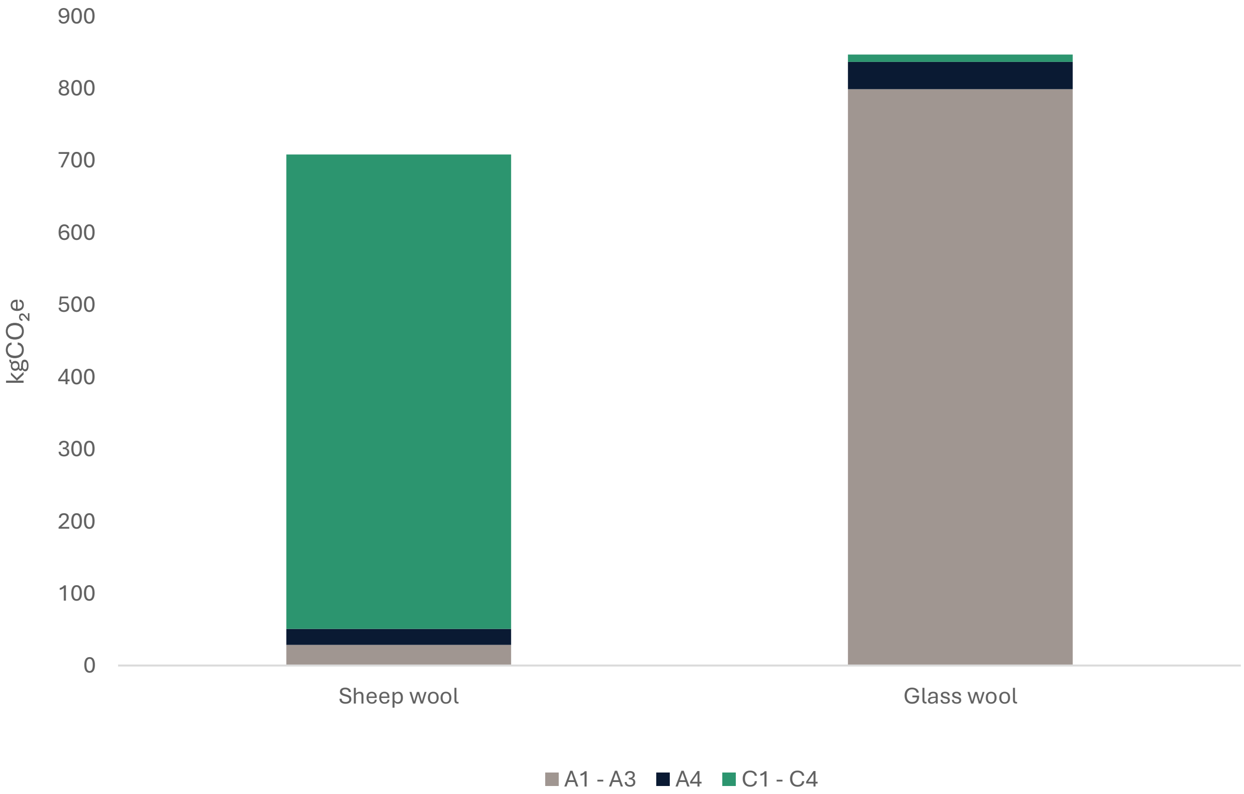

Figure 25: Life cycle stages of total climate impact of sheep wool insulation vs glass wool insulation in building example.

MODULE 5:

Standards and Tools, Sustainability Mapping

Module 5: Standards and Tools, Sustainability Mapping

NZGBC Homestar & Green Star Certifications

NZGBC's whole building assessment and certification scheme Homestar is relevant for residential buildings, and Greenstar is relevant for other non-residential buildings. Both assessment methods now rely on the Responsible Products Programme (RPP). The certification criteria are shown in *Figure 26*.

The RPP replaces NZGBC's Product Certification Scheme, introducing a clearer, and more comparable method of rewarding products that have been recognised by an existing approved product certification scheme. The RPP doesn't certify products directly, but instead it recognises those products that have been independently certified by an existing certification initiative. From this, it calculates a Responsible Product Value to be used towards Green Star or Homestar credits.

The RPP evaluates building products based on five criteria: Responsible, Healthy, Positive, Circular, and Leadership. Wool's contribution to these criteria is explored in *Table 12*.

Table 12: A summary of the Responsible Products Programme (RPP) evaluation criteria and how wool contributes towards meeting these criteria.

CRITERIA	HOW WOOL CONTRIBUTES TOWARDS MEETING THE CRITERIA
Responsible	Traceable biological supply chains; well-understood and quantified environmental impacts; farmers and manufacturers operate under stringent labour, animal welfare, and health & safety standards; certification pathways like NZFAP+, ZQRX and RWS provide third-party verification and ongoing improvement mechanisms; local production reduces exposure to high-risk global supply chains.
Healthy	No formaldehyde binders, petrochemical additives, plasticisers or hazardous flame retardants; improves indoor air quality; safe to install; non-irritant and hypoallergenic; supports community wellbeing through rural employment
Positive	100% renewable fibre that requires no extractive or harmful mechanical processes; NZ wool has a lower carbon footprint than global wool defaults; on-farm vegetation stores carbon and regenerates biodiversity; wool biodegradation returns nutrients to soils instead of polluting ecosystems; regenerative land practices provide pathways for continuous improvement.
Circular	Wool supports both technical cycles (repair, reuse, recycling) and biological cycles (biodegradation, composting); biodegradation can occur naturally; renewable feedstock enables continuous supply.
Leadership	Shift from extractive, carbon-intensive synthetic materials to regenerative, biogenic fibres; aligns with NZIA He Korowai Tiaki criteria; enables responsible material selection; supports the NZ transition towards local supply chains and reducing reliance on imported petrochemical materials; exemplifies best practices in cultural integrity and connecting built environments to land stewardship, rural communities and mātauranga Māori.

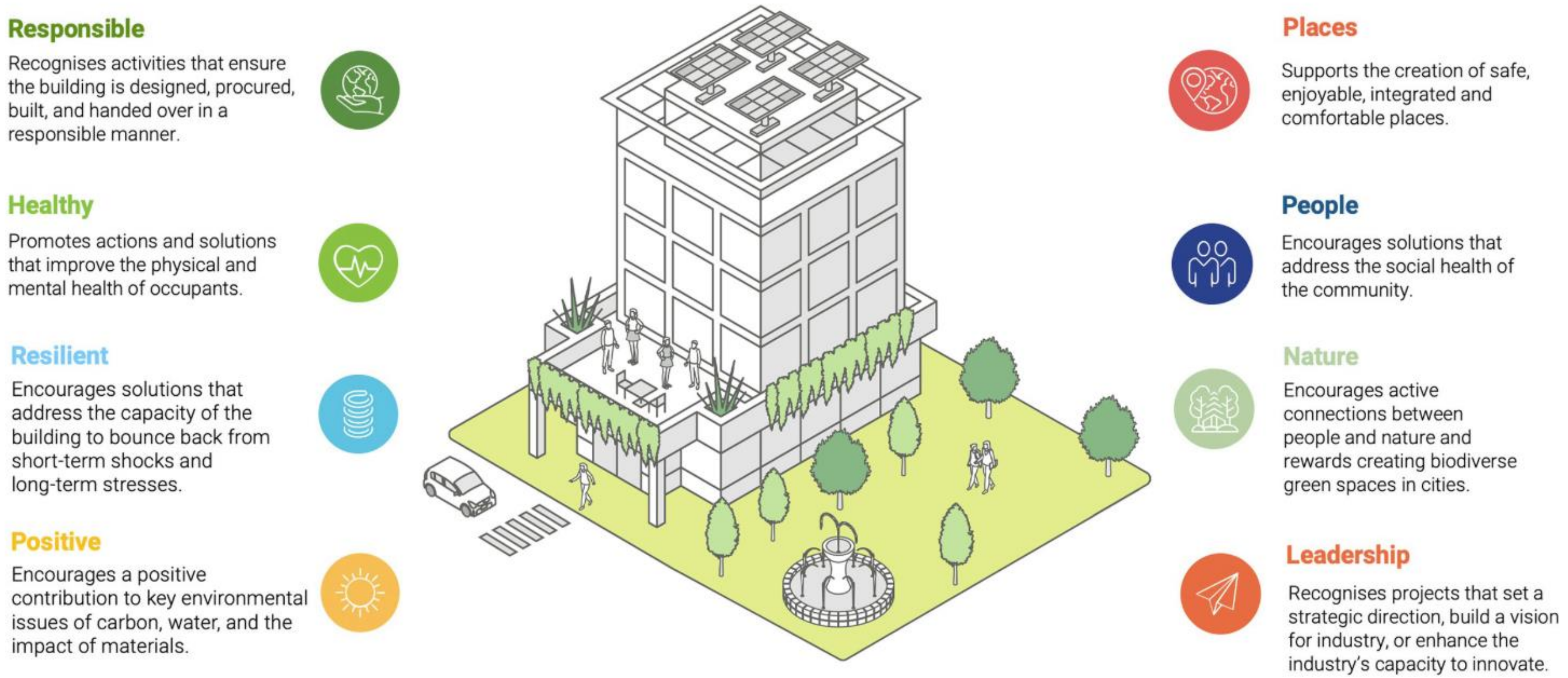

Figure 26: The key features of Green Star Buildings in New Zealand, based on the eight categories specified by Green Star to enable owners and developers to act on sustainable development in the built environment.[78]

[78] NZGBC. 2025. *Key features of Green Star Buildings NZ.* New Zealand Green Building Council.

The WELL Building Standard

The WELL Building Standard™ version 2 (WELL v2™) is an evidence-based system for measuring, certifying and monitoring the performance of building features that impact human health and well-being.[79]

It emphasizes the use of materials that do not emit harmful volatile organic compounds (VOCs) and are "Red List Free" (free of certain hazardous chemicals). New Zealand wool is naturally low in VOCs and is considered a healthy material for indoor environments. Declare™ Red List Free approved products offer full transparency for the specifier and user.

Table 13: How sheep wool building products contribute towards meeting the WELL Building Standard.

CRITERIA	HOW WOOL CONTRIBUTES TOWARDS MEETING THE CRITERIA
Air	Sheep wool naturally absorbs and neutralizes VOCs (like formaldehyde), improving indoor air quality.
Water	Indirect benefit: wool carpets/panels don't release harmful contaminants into water systems during use.
Nourishment	No direct impact (building materials rarely affect this) unless used as weed mat or geotextiles, whereupon biodegrading sheep wool contributes nutrients into soils.
Light	Wool acoustic panels can reduce glare and reflections when used on walls/ceilings.
Movement	Wool carpet improves walking comfort and reduces joint stress, supporting movement-friendly spaces.
Sound	Wool is an excellent sound absorber, improving acoustic comfort and reducing noise levels.
Materials	Wool is natural, non-toxic, biodegradable, and low-emitting — supporting safer, healthier material choices.
Mind	Natural materials like wool support biophilic design, improving mood and well-being.
Community	Using wool supports sustainable agriculture and local supply chains (where applicable), contributing to community values.

[79] IWBI. 2025. *Well v2™ Standard.* International WELL Building Institute (IWBI).

Living Building Challenge

Living Future has released the Living Building Challenge v4.1[80], which projects may qualify for by satisfying at least three of the seven categories: Water, Energy, Materials, Place, Health & Happiness, Equity, and Beauty.

To meet their “Materials” category, projects must avoid a list of hazardous chemicals known as the Red List, source materials locally where possible, and incorporate salvaged or recycled content. Some wool products meet the requirements of this category, for its capability to blend recycled wool with primary wool, being easier to procure locally than petroleum-based products and being an inherently renewable material.

Table 14: How sheep wool building products contribute towards meeting the Living Building Challenge.

CRITERIA	HOW WOOL CONTRIBUTES TOWARDS MEETING THE CRITERIA
Air	Sheep wool naturally absorbs and neutralizes VOCs (like formaldehyde), improving indoor air quality.
Water	Indirect benefit: wool carpets/panels don’t release harmful contaminants into water systems during use.
Nourishment	No direct impact (building materials rarely affect this) unless used as weed mat or geotextiles, whereupon biodegrading sheep wool contributes nutrients into soils.
Light	Wool acoustic panels can reduce glare and reflections when used on walls/ceilings.
Movement	Wool carpet improves walking comfort and reduces joint stress, supporting movement-friendly spaces.
Sound	Wool is an excellent sound absorber, improving acoustic comfort and reducing noise levels.
Materials	Wool is natural, non-toxic, biodegradable, and low-emitting — supporting safer, healthier material choices.
Mind	Natural materials like wool support biophilic design, improving mood and well-being.
Community	Using wool supports sustainable agriculture and local supply chains (where applicable), contributing to community values.

[80] Living Future. 2025. *Living Building Challenge 4.1 Program Manual.* Living Building Challenge.

Eco Choice Aotearoa (formerly Envio-Choice NZ)

ECA is ecolabel awarded to businesses that prioritise environmental and social responsibility, based on science-backed criteria and onsite audits showing evidence of continuous improvement (link here). It can be used to gain recognition/credits in several environmental building award schemes, including NZGBC's Homestar/Green Star and NZIA's Sustainability Award Scheme. Criteria are lifecycle-based, and include categories as: enviro-management, product stewardship, emissions to air, waste management, hazardous substances and raw materials. There are several ECA-developed specifications that wool products associated can gain ecolabels for:

Carpets and Rugs, Ecolabel EC-63-22 link (no wool products awarded)

Building Insulants, Ecolabel EC-25-25. Link (1 wool product awarded, Terra Lana)

Wool Scouring Services, Ecolabel EC-31-12. Link (no wool products awarded)

Textiles, Skins and Leather. Ecolabel EC-31-12. Link (1 wool product awarded, Terra Lana).

Table 15: How sheep wool building products contribute towards meeting Eco Choice Aotearoa.

CRITERIA	HOW WOOL CONTRIBUTES TOWARDS MEETING CRITERIA FOR BUILDING INSULANTS
Product composition & hazardous substances	Sheep wool is a natural fibre and typically requires no formaldehyde binders; avoids hazardous additives.
Sustainable & renewable raw materials	Renewable agricultural fibre; biodegradable; non-petroleum-based.
Embodied energy & manufacturing impacts	Processing involves scouring, carding and needling; low-energy processes; on-farm benefits can be achieved via revegetation and reforestation.
Emissions to air & water	Wool insulation manufacture generates very low VOC emissions; minimal chemical effluents.
Indoor air quality	Naturally absorbs and buffers indoor pollutants including formaldehyde and VOCs.
Energy performance	Sheep wool insulation reliably provides stable R-values and manages humidity without losing insulation value.
Durability & product performance	Sheep wool is naturally moisture-buffering; natural crimp and resilience helps maintain long-term performance.
Packaging requirements	Many New Zealand sheep wool product suppliers already use recyclable packaging and minimal plastic.
Waste & recycling	Sheep wool is biodegradable; can be reused, recycled or composted.
Fitness for purpose & safety	Non-irritating, does not require personal protective equipment to handle or install sheep wool building products.
Environmental Management System	New Zealand farm traceability and assurance programmes.

NZIA Protecting Our Futures – Sustainability Criteria Award

The recently released New Zealand Institute of Architects award criteria[81] assess how projects demonstrate an ethical approach to architectural practice, minimising environmental impact and enhancing wider interconnected environmental systems through design excellence. The concept of kaitiakitanga (guardianship) is applied, which is about caring for the natural world and all its living creatures in the search for best-practice approaches to climate change, biodiversity loss and pollution.

Questions which are of specific interest to wool products include questions on: LCA application, upfront embodied carbon (i.e. LCA Modules A1 – A5), whole-of-life embodied carbon, total sequestered biogenic carbon, circular economy principles implemented and whether benchmarking tools, certification and/or relevant standards were applied. As the award system is new in 2025, award questions will likely be refined with time.

Table 16: How sheep wool building products contribute towards meeting NZIA Protecting Our Futures

CRITERIA	HOW WOOL CONTRIBUTES TOWARDS MEETING CRITERIA
Whole of life carbon	Sheep wool, when used in thermal insulants, has less of an overall whole of life carbon impact than other, like-for-like insulation products for equivalent insulative levels. Reduces in-use carbon for spatial conditioning. Recognition for third party certifications, such as EPD’s.
Upfront carbon	Sheep wool has a very low upfront carbon value compared to other thermal insulants, due to the biogenic carbon that is removed from the atmosphere and stored in the wool. Recognition for third party certifications, such as EPD’s.
Circular economy principles implemented	Using wool products supports sustainable agriculture and local supply chains reducing reliance on imported petrochemical materials (where applicable). Recognition for third party certifications, such as Eco Choice Aotearoa, Global Green Tag and others.
Certification and benchmarking tools applied	A variety of NZ wool products that are used in construction have national and international certification systems, that support national and international rating tools, ad award schemes.

[81] NZIA. 2024. *New sustainability criteria for 2025 New Zealand Architecture Awards.* New Zealand Institute of Architects.

LCA principles	Wool is natural, non-toxic, biodegradable, and low-emitting — supporting safer, healthier material choices. Sheep wool naturally absorbs and neutralizes VOCs (like formaldehyde), improving indoor air quality. Indirect benefit: wool carpets/panels don't release harmful contaminants into water systems during use.

Summary

Architects and designers in Aotearoa interact with a growing ecosystem of sustainability frameworks—such as NZGBC Homestar and Green Star, the Responsible Products Programme (RPP), the WELL Building Standard, the Living Building Challenge, Eco Choice Aotearoa, and the NZIA Protecting Our Futures 2025 criteria—to improve building performance, reduce carbon impacts, and enhance occupant wellbeing. Each framework emphasises different aspects of environmental responsibility, but all share the common goal of encouraging healthier, lower-impact, ethically sourced materials. Sheep wool building products offer strong alignment across these systems and can help practitioners achieve certification outcomes with minimal specification complexity.

Under NZGBC Homestar and Green Star, architects increasingly rely on the Responsible Products Programme, which rewards products independently certified as responsible, healthy, circular, and low-impact. Wool aligns naturally with these RPP values: it is traceable, locally produced, renewable, non-toxic, biodegradable, and regenerative. These attributes help projects earn material credits without requiring additional treatments or complex documentation. Because wool improves indoor air quality and has low embodied carbon, it supports Green Star categories relating to health, carbon, and circularity simultaneously.

For buildings targeting the WELL Building Standard, wool contributes to healthier indoor environments by absorbing VOCs such as formaldehyde, offering low-emitting and Red-List-friendly material choices, and improving occupant comfort through acoustic absorption, soft surfaces for movement, and biophilic qualities that enhance psychological wellbeing. Wool's natural chemistry allows it to meet WELL criteria without synthetic additives, simplifying pathways to compliance.

Projects pursuing the Living Building Challenge can also benefit from wool's inherent advantages. Because LBC requires materials to avoid Red List chemicals, prioritise local sourcing, and support circularity, wool's bio-based, non-toxic, compostable nature aligns directly with its stringent Materials Petal. Its availability from local farms and manufacturers supports the Place and Equity principles, while its regenerative agricultural origins and nutrient-returning biodegradation strengthen ecological integrity.

Eco Choice Aotearoa provides third-party ecolabel recognition that feeds back into NZGBC and NZIA frameworks. Wool products meeting Eco Choice criteria demonstrate verified low-toxicity composition, responsible raw material sourcing, low embodied energy, minimal emissions, and strong end-of-life pathways—all qualities increasingly prioritised in procurement and certification.

Finally, the NZIA Protecting Our Futures 2025 award criteria emphasise ethical design practice, whole-of-life carbon reduction, circularity, cultural responsiveness, and kaitiakitanga. Wool supports these values through low-embodied-carbon production, renewable biogenic origins, local supply chains, and alignment with Te Ao Māori principles of respecting land systems, ecosystems, and community stewardship. Its long-term performance stability and natural moisture buffering also contribute to resilient, passive, and climate-adapted building envelopes.

Across all major frameworks, sheep wool offers architects a material that naturally meets or exceeds sustainability criteria with fewer trade-offs, providing a straightforward, culturally grounded, and future-proof option for responsible building design in Aotearoa.

MODULE 6:

Circularity & End-of-Life Framework

Module 6: Circularity & End-of-Life Framework

Circular design requires architects to anticipate what will happen to materials at the end of their use in a building. Wool performs well in a circularity framework[82] when informed design and procurement choices are made.

There are a number of options to retaining materials within the system, of which there is a hierarchy order of preference:

1. to reduce materials consumed and avoid the extraction of new materials;
2. to extend the use and lifetime of the material;
3. to recover the material at its end-of-life and repurpose it for something new.

Key Decision Questions for Insulation

The following questions are intended to guide architects and designers through their material selection whilst considering end-of-life of the products they intend to specify in a building project.

1. Necessity & Reduction
    a. Can you refuse unnecessary components or materials?
    b. Does this material reduce the need for virgin material?

2. Longevity & Service Life
    a. Is the material of sufficiently high quality to ensure a long service life?
    b. Is the material designed for longevity and adaptability over time?
    c. Can the material be easily maintained and repaired throughout his life?

3. Design for Disassembly & Future Recovery
    a. Can the material be used within a Design for Disassembly approach?
    b. Can the material contribute to a Building as Material Bank model?
    c. Does the material come with a Material Passport?

4. Supplier Responsibility
    a. Does the supplier offer a verified take-back programme or material recovery pathway?

5. End-of-life Flexibility
    a. Can this material be reused, repaired or reimagined at end-of-life?
    b. Can this material by recycled, reused or repurposed without harmful down-cycling or contamination?

6. Regeneration & Restoration
    a. Does the material support regeneration, ecosystem recovery or carbon removals?

[82] Ellen MacArthur Foundation. 2022. *Circulate products and materials.* Ellen MacArthur Foundation.

The table below outlines how sheep wool building products in New Zealand can typically perform against some of these end-of-life questions.

Table 17: Illustrative set of answers for how wool performs against these questions.

QUESTION TOPICS	HOW WOOL PERFORMS AGAINST THESE TOPICS
Supplier responsibility	Terra Lana and some others accept offcuts and waste wool for reuse or remanufacturing.
End-of-life flexibility	Wool batts and panels can be shredded and re-felted into new products when not heavily contaminated with adhesives or mixed fibres. Rigid petrochemical foams or laminated composites are difficult to recycle and often end up as waste.
Regeneration & restoration	Wool biodegrades into nutrients under appropriate conditions. Synthetic fibres do not biodegrade and can fragment into microplastics.

Sheep Wool in Landfill

Sheep wool is a keratin-based protein fibre, making it naturally biodegradable within a timescale of months to a few years.[83]

As a material, it does not contain harmful chemicals, plastics or retardants which contribute to soil and groundwater pollution. The main effect of sheep wool in landfill is the re-release of carbon dioxide, as discussed in section 2.

Table 18: The behaviour of sheep wool vs glass wool, mineral wool and foam insulation in landfill.

MATERIAL	END-OF-LIFE PATH	WHAT HAPPENS	MAIN ENVIRONMENTAL OUTCOME
Sheep wool	Landfill	Wool slowly decomposes; can release methane if anaerobic; nutrients remain trapped.	Moderate impact; loss of a biodegradable resource; small methane contribution.
Sheep wool	Composting	Wool biodegrades fully, releasing nitrogen and enriching soil.	Positive: soil improvement, closed-loop cycling, no toxic residues.
Glass wool	Landfill	Does not biodegrade; remains inert indefinitely.	Long-term accumulation; takes up landfill space; no nutrient or material recovery.
Mineral wool	Landfill	Does not biodegrade; remains inert indefinitely.	Long-term accumulation; takes up landfill space; no nutrient or material recovery.
Foam insulation	Landfill	Very slow or no biodegradation; can break into microplastics.	Persistent pollution; microplastics risk; high landfill burden.

[83] Holt, G. A., et al. 2015. *Biodegradability of wool fibers.* Journal of Polymers and the Environment, 23(3), 341–345.

Summary

Circular design (see Figure 27) asks architects to plan for what happens to materials after a building's life. Wool can perform strongly in a circular system when designers make informed choices. Circularity prioritises first reducing material use, then extending product life, and finally recovering materials for new uses.

A set of guiding questions helps architects assess insulation choices. These include reducing unnecessary materials, selecting products with long service lives, ensuring they can be maintained or repaired, and choosing materials compatible with Design for Disassembly, Material Passports, or Building-as-Material-Bank approaches. Supplier responsibility is also key—such as take-back schemes for offcuts. Designers should favour materials that can be reused, repaired, or repurposed without harmful downcycling, and that support regeneration or ecosystem restoration.

Wool generally performs well against these criteria. Some suppliers, such as Terra Lana, accept offcuts for remanufacturing. Wool batts and panels can be shredded and re-felted, unlike many petrochemical foams. Wool also biodegrades under appropriate conditions, returning nutrients to the soil.

In landfill, wool naturally breaks down because it is a keratin-based fibre and contains no harmful additives; its primary impact is the release of biogenic carbon as it decomposes.

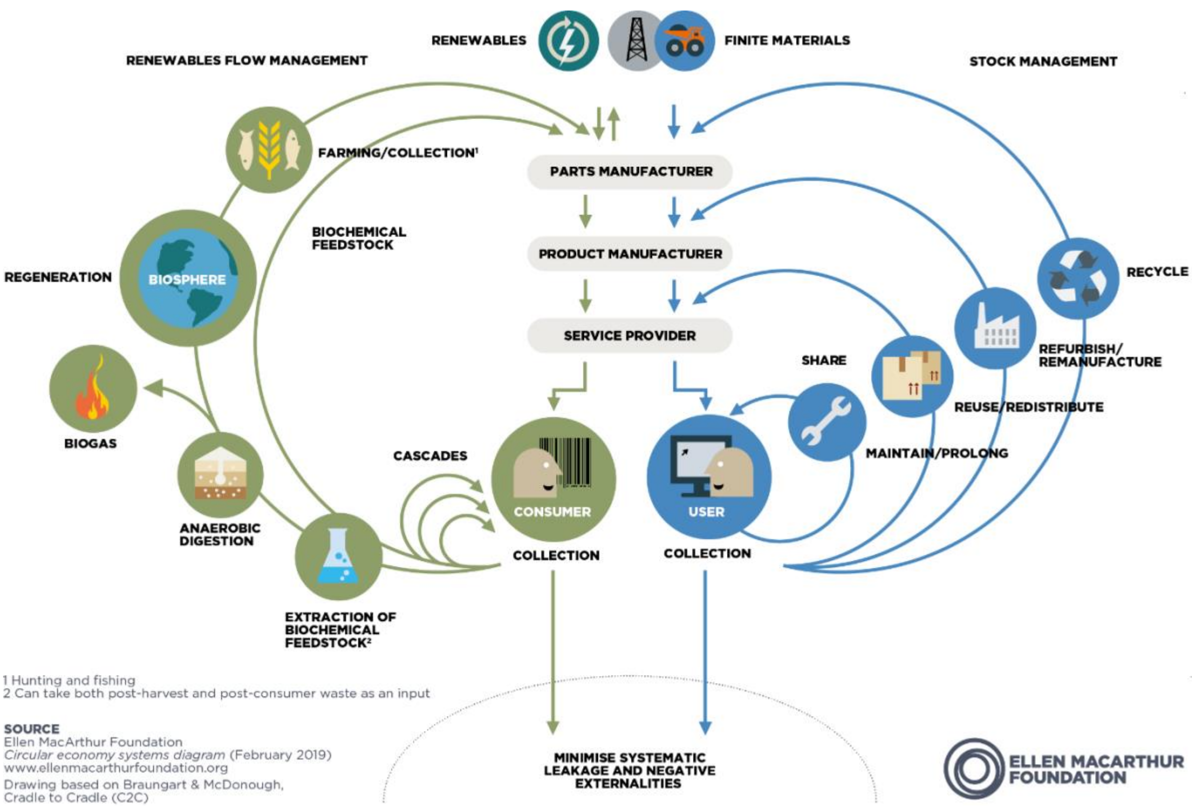

Figure 27: Ellen Macarthur Foundation circular economy butterfly diagram, showing biological cycles and technical cycles that enable a circular economy.[84]

[84] Ellen MacArthur Foundation. 2021. *The butterfly diagram: visualizing the circular economy.* Ellen MacArthur Foundation.

MODULE 7:

Specification and Sourcing Guide

Module 7: Specification and Sourcing Guide

Architects increasingly need a clear, accessible reference to who supplies what, how to assess product performance, and where to find reliable technical and environmental data.

Considerations when specifying and sourcing materials include:

- Does the material align with regulatory and procurement expectations?
- What technical evidence exists to support specification?
- What are the implications of specifying wool?
- Who are the suppliers, and what wool products are available in New Zealand?

There are a number of New Zealand sheep wool product suppliers, including:

- Terra Lana – wool insulation batts, acoustic products, erosion control products; operate-s offcut return schemes.
- Wool Insulation NZ – blown in- and batt wool insulation systems.
- Textile-based manufacturers – wool acoustic and thermal panels for interiors.
- EnviroWool – loose fill- wool insulation (e.g. for ceilings).
- Floc – acoustic panels using wool and other natural fibres.
- Wool-rich carpet and rug brands (e.g. Bremworth, Wools of New Zealand, others) for flooring applications.

Students should verify current offerings and specifications with suppliers, as product ranges evolve.

Table 19: Technical characteristics and criteria to consider when selecting a sheep wool building product.

CRITERIA TO CONSIDER	CONSIDERATION
R-value	Always match required R values using manufacturer data.
Thermal conductivity	Cross-check against EPDs and technical datasets.
Hygrothermal performance	Confirm moisture absorption behaviour, use in vapour open build ups, and compatibility with membranes.
Fire performance	Review test results (e.g. AS/NZS 1530.3, ISO 9239 1) and ensure suitability for the intended application.
Acoustic performance	For interior linings and panels, assess absorption coefficients over relevant frequencies.
VOC	Look for declarations of low emissions or pollutant absorbing properties.
Durability and pest resistance	Review any treatments or additives used and their sustainability implications.

List of New Zealand-Specific Suppliers

Table 20: The below table presents a (non-exhaustive) list of New Zealand sheep wool building product suppliers currently available to architects (as of December 2025).

SUPPLIER	EXAMPLE PRODUCT	TECHNICAL CHARACTERISTICS	CERTIFICATION STATUS	LOCAL VS IMPORTED CONTENT
Terra Lana (Thermal)[85]	Terra Lana Wool Insulation (Ceiling / Wall / Floor batts)	NZ-made wool/polyester blend insulation; needle-punched batts and rolls; available for ceiling, wall and floor systems; moisture-buffering, durable, low VOC.	Eco Choice Aotearoa, BRANZ Appraisal, Declare® Red List Free, GREENGUARD approved. An EPD is in development.	Made in NZ from NZ-grown wool with some polyester binder.
Wool Insulation NZ[86]	Wool Insulation NZ – Ceiling, Wall, Floor, Garage Door (incl. blown-in option)	Wool-rich batts and blown-in loose-fill options; designed for thermal and acoustic buffering; moisture-regulating; suitable for retrofit and new builds.	n.a.	Primarily NZ wool; regional processing with some imported synthetic binder.
Textile Products Ltd[87]	Textile Wool Insulation (Ceiling / Wall / Floor / Garage Door)	Wool-based batts and rolls; regional manufacturing; suitable for thermal and acoustic use; low VOC and soft-to-touch installation.	n.a.	NZ-made using high proportions of NZ-grown wool.
BJ Carter[88]	Enviro Wool Blown-In Ceiling Insulation	Loose-fill blown wool insulation for ceiling cavities; excellent coverage, moisture buffering, non-irritant; ideal for retrofits.	n.a.	Uses NZ-grown wool processed regionally.
Floc[89]	Floc Panel – Wool Acoustic Wall Lining	100% NZ strong-wool needle-punched acoustic liner; 6–8 mm thick; NRC ≈ 0.4 direct-fix; compostable, Red List Free; supplied in 1.2 m × 25 m rolls.	Environmental Product Declaration (EPD); Red List Free.	Made entirely from NZ-grown and processed strong wool; NZ-based manufacturing.
Bremworth[90]	Bremworth Wool Carpet	100% NZ wool carpet; durable, low VOC, natural moisture buffering; available nationwide in multiple styles and grades.	Declare® labels for selected products; manufacturer sustainability programme. Has an EPD for its broadloom carpets.	Made in NZ using NZ-grown wool.

[85] Terra Lana. 2025. Retrieved from: https://www.terralana.co.nz/
[86] Wool Insulation NZ. 2025. Retrieved from: https://www.woolinsulation.kiwi/
[87] Textile Products Ltd. 2025. Retrieved from: https://textile.co.nz/
[88] BJ Carter. 2025. *Envirowool.* Retrieved from: https://www.bjcarter.co.nz/envirowool
[89] Floc NZ. 2025. Retrieved from: https://www.floc.nz/
[90] Bremworth. 2025. Retrieved from: https://bremworth.co.nz/

SUPPLIER	EXAMPLE PRODUCT	TECHNICAL CHARACTERISTICS	CERTIFICATION STATUS	LOCAL VS IMPORTED CONTENT
Nodi[91]	Nodi Wool Carpet (Indian made)	Hand-crafted wool carpets and rugs; natural fibres; premium interior finishes; imported.	GoodWeave-certified.	Imported (Indian production), uses NZ and/or international wool.
Feltex[92]	Feltex Wool Carpet	Wool-rich carpets; low VOC; durable; suitable for residential and commercial fit-outs.	Declare® LBC Red List Free. Environmental Certification Scheme ECS Level 4+.	Mostly NZ-made using NZ wool (varies by product line).
Wools of NZ[93]	Wools of NZ Carpet	Broadloom carpets using NZ-grown wool; low VOC, natural, biodegradable; strong supply chain traceability.	Australian Carpet Classification Scheme ECS Level 3 Certification	NZ-grown wool; manufacturing varies (some NZ, some offshore partners).
Flooring Xtra[94]	Loom Wool Carpet	Residential carpets using NZ and/or international wool; available through FlooringXtra.	Australian Carpet Classification Scheme ECS Level 3 Certification	Mixed NZ and imported fibre sources; manufacturing varies.
Godfrey Hirst[95]	Godfrey Hirst Wool Carpet	Machine-tufted wool carpets; range of styles; low VOC; widely available.	Declare® certification for some wool ranges. Global GreenTag, GreenRate Level A.	NZ wool used; production varies (NZ + AU).
Wool Insulation Worx[96]	R1.5 Underfloor Wool Insulation	70% wool / 30% polyester underfloor rolls; stapled between joists; moisture buffering; natural feel; safe installation.	n.a.	Manufactured in NZ from NZ wool + imported polyester binder.

[91] Nodi. 2025. Retrieved from: https://nodi.co.nz/
[92] Feltex. 2025. Retrieved from: https://www.feltex.com/nz
[93] Wools of NZ. 2025. Retrieved from: https://woolsnz.co.nz/
[94] Flooring Xtra. 2025. *Loom.* Retrieved from: https://www.flooringxtra.co.nz/
[95] Godfrey Hirst. 2025. Retrieved from: https://www.godfreyhirst.com/nz
[96] Wool Insulation Worx. 2025. Retrieved from: https://www.woolinsulationworx.com/

MODULE 8:

Case Studies

Module 8: Case Studies

Terra Lana

Terra Lana pioneered the commercialisation of making insulation and eco-textiles from recycled wool. They were also the first New Zealand company with wool-based insulation products to be appraised by BRANZ in 2012.

What they make:

- Thermal insulation: made from sheep wool and recycled plastic (PET)
- Weedmats: made from dag wool
- Acoustic insulation: made from 75% recycled Terra Lana insulation offcuts
- Transport blankets

RURAL PASSIVE HOUSE WĀNAKA

Passive Houses take a fabric-first approach to ensure the building design minimises energy needs for active heating and cooling systems. This means extremely high-performance insulation, glazing, a lower surface-to-volume ratio and fewer openings, to more effectively regulate temperature (see *Figure 28*). For this house, Terra Lana sheep's wool insulation was used to increase the thermal performance of the envelope. Wool was first choice in this project owed to the integrity of the materials used, and minimal site wastage. Any insulation waste was able to be returned to Terra Lana and repurposed to make more insulation.[97]

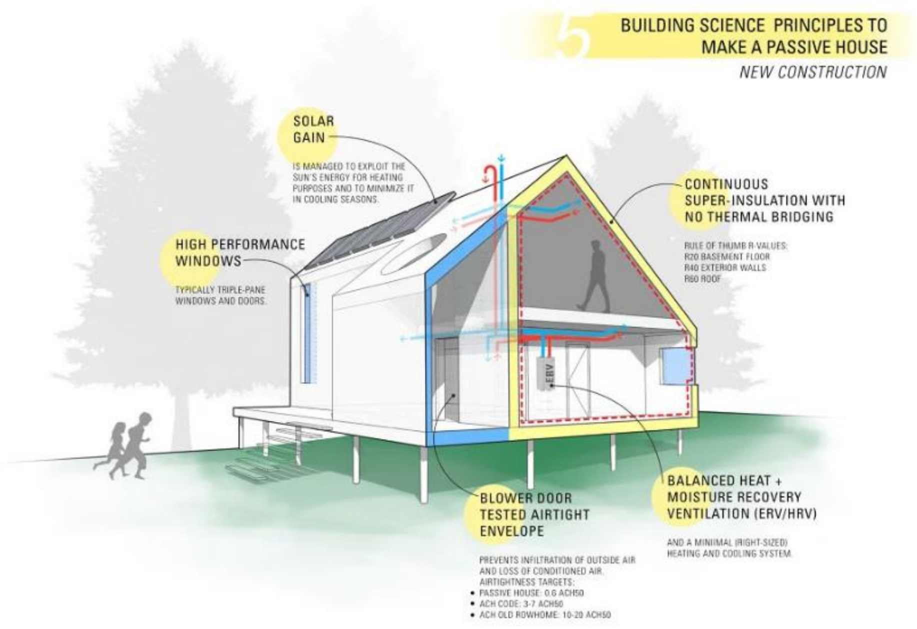

Figure 28: Illustration of Passive House building design.[98]

[97] Terra Lana. 2024. Sustainable materials elevate energy efficiency for rural passive hosue. Retrieved from Eboss: https://www.eboss.co.nz/ebossnow/terra-lana-sustainable-wool-insulation-passive-house

[98] Novo. 2025. *Passivhaus – 10 design strategies.* Novo Design UK.

FOREST LODGE CHERRY ORCHARD

Forest Lodge cherry orchard use the Terra Lana wool-based weed matting as a natural solution to suppress weeds and, insulate the soil by locking in moisture and shading the ground[99]. These wool mats slowly biodegrade over time without releasing any micro-pollutants to soil or water.

Table 21: The sustainability profile of Terra Lana sheep wool insulation products.

EMBODIED CARBON & CLIMATE IMPACT	WATER, LAND & BIODIVERSITY	CIRCULARITY & END-OF-LIFE	HUMAN HEALTH & ECOSYSTEM HEALTH	TRANSPARENCY & TRACEABILITY
Climate impacts are not yet quantified. Terra Lana uses recycled sheep wool, recycled plastic, minimises transport distances from farm to factory.	No VOCs, plastic used in some products may cause micro-plastic pollution at end-of-life. Weed mats provide a toxin-free biodegradable alternative to synthetic products.	Terra Lana help you to return your offcuts so they can be recycled back into more Terra Lana products. .	Wool is sourced from family-owned farms <1 hour from the factory location.	Climate impacts are not yet quantified.

[99] Forest Lodge. 2025. *Our Partnership with Terralana.* Electric Cherries.

Figure 29: Forest Lodge Cherry Orchard.[100]

Lanaco

Lanaco focusses on creating air filter media with strong moisture and water handling, fire and temperature resistance, and which is able to reduce VOCs such as toluene, acetic acid, and ammonia.

What they make:

- Air filter media for Mechanical Heat Recovery Ventilation Systems
- Air filter media for healthcare, automotive, electronics, industrial machinery, and consumer appliances.

MECHANICAL HEAT RECOVERY VENTILATION (MHRV) SYSTEMS

MHRV systems are important in buildings for delivering filtered fresh air without creating uncomfortable drafts or unnecessary demand on heating and cooling systems. These systems work by recovering warmed internal air to precondition the colder outside fresh air coming in.[101] MHRV systems are more commonly installed in airtight new builds and they help combat poor air quality. DVS New Zealand use Lanaco's air filter media in the filter bags for their ventilation systems.

[100] https://www.bnz.co.nz/business-banking/business-moments/forest-lodge-orchard-harvesting-a-zero-emissions-revolution
[101] Fantech. 2025. MVHR – Mechanical Ventilation with Heat Recovery.

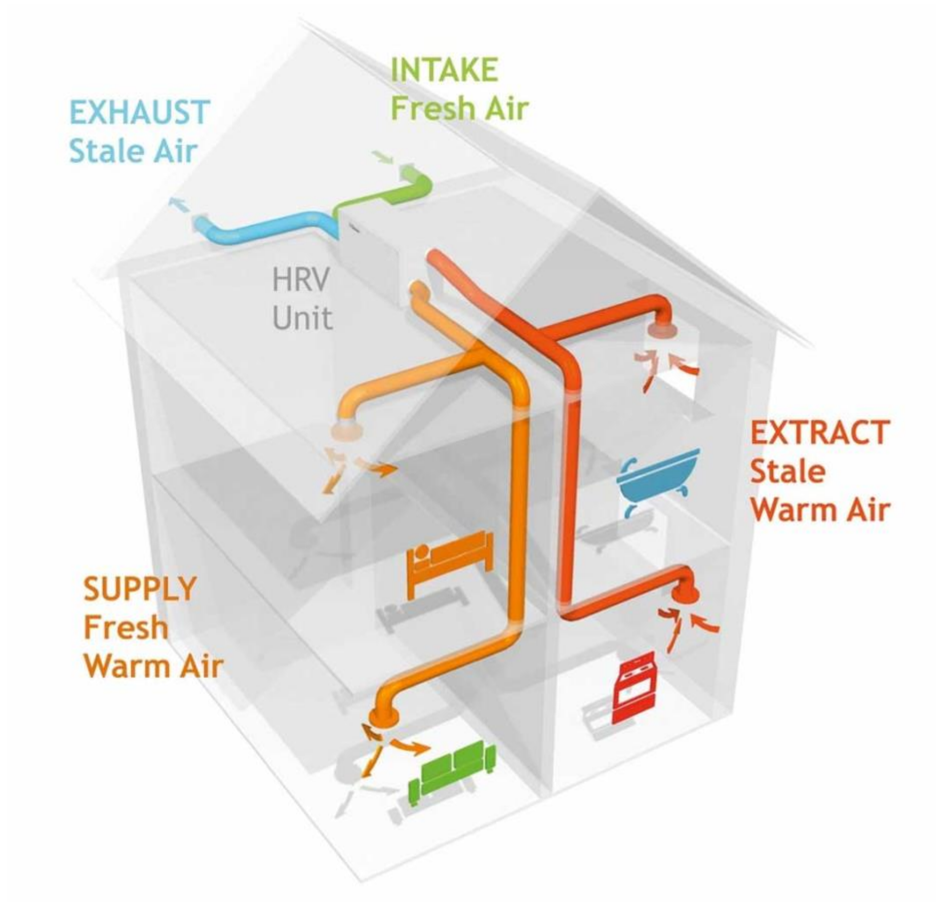

Figure 30: Illustration of a Mechanical Heat Recovery Ventilation (MHRV) system.[102]

SHEEP WOOL AIR FILTERS IN NASA SPACECRAFT

Lanaco's air filter media has replaced glass HEPA filters that were previously being used on the Artemis Orion spacecraft, because the glass HEPA filters were clogging up from hot toxic particles and water vapour.

[102] Swes Group. 2025. *Swes Ventilation: What is an MHRV system and how does it work?* Swes Group.

Figure 31: NASA's Space Launch System (SLS) rocket with the Orion spacecraft aboard on Wednesday, Aug. 17, 2022, at NASA's Kennedy Space Center in Florida. Photo credit: NASA / Joel Kowsky.[103]

Table 22: The sustainability profile of Lanaco sheep wool insulation products.

EMBODIED CARBON & CLIMATE IMPACT	WATER, LAND & BIODIVERSITY	CIRCULARITY & END-OF-LIFE	HUMAN HEALTH & ECOSYSTEM HEALTH	TRANSPARENCY & TRACEABILITY
Climate impacts are not yet quantified.	Lanaco's EcoStatic® is USDA Certified Biobased and biodegrades readily in natural environments when disposed.	Products are not specified as recyclable or as using recycled content.	Wool is sourced from New Zealand farms and offers a different revenue option for sheep farmers.	Climate impacts are not yet quantified.

Willesden Farms, Banks Peninsula

Based in Canterbury, Willesden Farms is a productive farming system which co-exists with thriving native forest. Banks Peninsula is where Terra Lana source their sheep wool from.

What they make:

- Sheep products
- Cattle (beef) products

[103] Lanaco. 2025. *Lanaco filters going to moon, and back, onboard Artemis!* Lanaco.

- Native bush

SHEEP FARMING + NATURE RESTORATION

"I think all farmers in New Zealand are passionate about the environment. I grew up on a farm and always wanted to be a farmer, and I think producing food is ultimately the most important career you could have in the world." – Matt Iremonger, 2025.

Matt Iremonger, manager at Willesden Farms, explains that native forest and productive farmland co-exist together because their real business is farming a land asset – and protecting it. The productive part of the farm exists to create a profit that can be re-invested back into the land assets[104].

Willesden partnered with Bio Protection Aotearoa, who are exploring the role of soil carbon in supporting ecosystem resilience and hope to use this knowledge to design, support and sustain productive landscapes elsewhere that can build resilience to climate change.

Table 23: The sustainability profile of Willesden Farms sheep wool.

EMBODIED CARBON & CLIMATE IMPACT	WATER, LAND & BIODIVERSITY	CIRCULARITY & END-OF-LIFE	HUMAN HEALTH & ECOSYSTEM HEALTH	TRANSPARENCY & TRACEABILITY
Restoring and expanding native vegetation, naturally removes carbon; maximising the efficiency and productivity of the animals.	Restoring and stewarding vast swathes of native vegetation and forest, productive areas and natural areas form a mosaic across the land. Regenerative agriculture, restoring natural systems, removing pests and boosting biodiversity.	n.a	High employee wellbeing; partnerships with neighbours; assists pastoral studies and graduate education at Lincoln university	Collaboration with Bio Protection Aotearoa, several sections are covenant or dedicated reserves; encourages environmental study and research on the land.

[104] Pure Advantage. 2025. Extra For Experts Episode 2: Matt Iremonger and Shannon Bennett.

Havelock

Havelock Wool was founded by Andrew Legge, who discovered the power of wool when building his own home in New Zealand. Havelock have a deep belief in biophilic design and aims to challenge the excessive waste prevalent in the built environment.

What they make:

- Insulation panels for residential buildings
- Insulation panels for commercial buildings
- Insulation for vehicles

THE BLOCK PROJECT

BLOCK homes are USD $75,000 per unit, and can be built in six months, breaking the notion that sustainable materials cannot be used on a tight budget. The BLOCK Project aims to foster understanding of the factors creating homelessness and environmental destruction at the pace of its community, BLOCK home at a time.

The organisation used The Living Building Certification for a holistic sense of measurement that fosters environmental accountability and is fully Petal certified. Havelock Wool was purchased to be used as insulation for the dwellings for its suitability in partnership with juniper timber, contribution to air quality, lower risk of environmental impact from any waste generated either in manufacturing or at end-of-life.

Figure 32: Illustration of the BLOCK Project house design.[105]

[105] BLOCK Project. 2025. *I gave a little of my backyard and it opened a much bigger world*. Block Project.

Table 24: Sustainability profile of Havelock wool

EMBODIED CARBON & CLIMATE IMPACT	WATER, LAND & BIODIVERSITY	CIRCULARITY & END-OF-LIFE	HUMAN HEALTH & ECOSYSTEM HEALTH	TRANSPARENCY & TRACEABILITY
Wool is a renewable, carbon-storing fibre with lower embodied carbon than most synthetic insulations, though full LCA data from Havelock is still emerging.	Sourced from New Zealand farms with renewable annual wool growth, but broader impacts of grazing, washing and transport are not fully disclosed.	Wool insulation is biodegradable and compostable, offering low-waste end-of-life potential, though formal take-back or reuse systems are not documented.	Natural, non-toxic, and VOC-free, wool improves indoor air quality and regulates moisture, reducing risks of irritants or mold.	Havelock shares clear sourcing (NZ wool) and sustainability intent, but lacks a publicly available third-party EPD/LCA for full traceability.

Figure 33: Havelock Wool healthy indoor air residential insulation.[106]

Bremworth

Bremworth believe in New Zealand wool for its durability and health benefits which founders Tony Timpson and Grant Biel say weaves luxury to practicality to create spaces that inspire and endure. Bremworth celebrate not only sheep wool but also their industry friends: Wise Wool, Autex, Wool Works, Lanaco and others.

What they make:

- Carpets
- Rugs

THE BRAKE HOUSE

Brake House is situated in the Titirangi bush and was originally designed by architect Ron Sang. It has been recognised by DOCOMOMO New Zealand as one of the top 20 modern buildings, sites and neighbourhoods, and was awarded the NZIA Enduring Architectural Award in 2001.

[106] https://havelockwool.com/pages/applications-residential

Figure 34: Bremworth carpets in the Brake house.[107]

Table 25: Sustainability profile of Bremworth carpets

EMBODIED CARBON & CLIMATE IMPACT	WATER, LAND & BIODIVERSITY	CIRCULARITY & END-OF-LIFE	HUMAN HEALTH & ECOSYSTEM HEALTH	TRANSPARENCY & TRACEABILITY
Wool is a natural, renewable fibre with comparatively low embodied carbon and the ability to store carbon, though Bremworth does not publish full product LCAs.	Uses New Zealand-grown wool, supporting local pastoral landscapes, but broader impacts of grazing, scouring and transport are not fully detailed.	Wool carpets are durable and biodegradable, offering better end-of-life potential than synthetic carpets, though large-scale recycling pathways remain limited.	Wool is low-VOC, moisture-regulating and naturally fire-resistant, contributing to healthier indoor environments compared with synthetic fibres.	Bremworth is vocal about NZ sourcing and industry partners, but does not yet provide complete third-party verified transparency documentation like EPDs.

[107] Bremworth. 2025. *The Brake House.* Bremworth Carpets.

Glossary & References

Glossary

TERMINOLOGY	DEFINITION
Activity Data	Primary data about the building.
Biogenic carbon	Carbon removals from biomass e.g photosynthesising trees and carbon emissions from biomass e.g timber sent to incineration.
BRANZ	Building Research Institution of New Zealand.
CO_2	Carbon dioxide.
CO_2e	Carbon dioxide-equivalent - the sum of all greenhouse gas emissions, expressed as equivalents of carbon dioxide.
Cradle-to-grave	The entire lifespan of something, from its beginning to its end.
Decarbonisation	Reduction or elimination of carbon dioxide emissions.
Embodied carbon	MBIE defines embodied carbon as the sum of all the greenhouse gas emissions that occur at each stage of an 'entity's 'life cycle. In construction, an entity may be a single building product, a collection of products (an element), or a whole building. For whole buildings, it excludes all operational-related carbon, typically related to energy and water needs. Emissions are measured in units of kg CO2e (carbon dioxide equivalent).
Emission Factors	A coefficient that quantifies the carbon emissions per unit (e.g kg, m^2) of resource or activity.
Emissions	The production and discharge of greenhouse gases.
End-of-Life Carbon	The carbon emissions associated with deconstruction/demolition, transport from site, waste processing, and disposal phases of a building's life cycle which occur after its use.
Enviro Choice Aotearoa	ECA is and ecolabeling and certification program providing third-party verification, identifying products and services which are genuinely environmentally preferable and safe for New Zealanders'. It awards an ecolabel to businesses that prioritise environmental and social responsibility, meeting strict checks. The scheme is voluntary.
EPD	An Environmental Product Declaration is a standardised assessment that reports the life-cycle environmental impact of a product. It provides verified data on a product's environmental effects, such as resource consumption and emissions, allowing for fair comparisons between products having a similar function.
Fossil carbon	Carbon emissions from non-biogenic sources e.g fossil fuel combustion
Green Star	Green Star is NZGBC's national sustainability certification for the design and construction of non-residential buildings – both for major retrofits and new builds. It has been developed by and for industry.
Greenhouse Gases	Atmospheric gases that trap heat and alter the planet's climate.
GreenTag	GreenTag is an internationally recognized ecolabeling and certification program that provides verification of a product's health and sustainability credentials. It assesses building materials and other products for their environmental impact and health impacts, and helps architects, builders, and consumers make informed, eco-conscious purchasing decisions.
Homestar	Homestar is NZGBC's national holistic certification for the design and construction of more sustainable residential buildings. It has been developed by and for industry.
Insetting	Carbon removals achieved when a company invests in projects within its own supply chain or operations to reduce greenhouse gas emissions and sequester carbon, rather than buying carbon offsets from external projects.
Kiatiakitanga	Māori concept of guardianship, protection, and preservation, based on a worldview that sees humans as an integral part of the natural world.

TERMINOLOGY	DEFINITION
Land use and land use change	Carbon emissions and removals from alterations to carbon stocks such as soil carbon and vegetation caused by land use and any changes in land use e.g converting forest to urban land or converting industrial land to grassland.
LCA	Life Cycle Assessment (LCA) is a formalised, analytical tool for the systematic, quantitative evaluation of the environmental impacts of a product or service. It takes a “cradle to grave” approach.
Life cycle	Lifecycle in construction refers to the production, manufacture, transportation and construction processes, maintenance activities, and what happens at end-of-life. Depending on the scope of the study, it may also include issues associated with the building’s operation in use. Also known as ‘whole of life’.
Living Building Challenge	The Living Building Challenge is an international sustainable building certification program, managed by the International Living Future Institute. It can be applied to development at all scales, from buildings, to infrastructure, landscapes, and neighbourhoods. Its goal is to encourage the creation of a regenerative built environment.
NZGBC	The New Zealand Green Building Council is the leading national green building certification and education body. They advocate for regulatory and industry-wide change, supporting New Zealand building on its path to a low carbon future.
Operational Carbon:	The carbon emissions associated with energy used to operate the building and operational water use.
Removals	Extracting greenhouse gases from the atmosphere to reduce the carbon dioxide concentration.
Sequestered	In life cycle studies, sequestered refers to the process by which carbon dioxide (CO2) is removed from the atmosphere and stored, typically in biomass (like trees and plants) for extended periods. Consequently, this carbon has been isolated from the atmosphere, providing a potential (though often temporary) climate change mitigation benefit.
Strong Wool	Strong wool is a type of wool with thick, coarse fibres, characterized having a diameter of greater than 30 microns. It is more durable and resilient than finer wools and typically used for products that require heavy use, such as carpets, upholstery, and insulation.
Upfront carbon	Life cycle modules A1-A5 are sometimes referred to as ‘up-front embodied carbon’. That is, the total carbon emissions that occur during the production of a building's materials, transport to site and its construction prior to occupation. See European standard EN 15978.
Use Stage Embodied Carbon	Carbon emissions associated with materials and processes needed to maintain the building during use such as for maintenance, repair or refurbishments.

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