ON THE DRAWING BOARD:

Quick and easy life cycle assessment for carbon-zero homes

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The Sorensen family's recently completed house was designed for working from home. It features timber frame construction with radial-sawn pine cladding, plywood internal lining, a polished concrete slab floor for thermal mass, and Kommerling double-glazed windows. The all-electric house has 8.3kW of solar PV, achieved an 8.4-Star NatHERS energy rating, and smashed the ecovillage's carbon reduction target with a RapidLCA result of -159 per cent GWP (read all about this measure below), ensuring it will easily be carbon-negative over its lifetime. Image: Jo Thierfelder

At Witchcliffe Ecovillage in Western Australia, life cycle assessment (LCA) to ensure homes are net zero or better for both operational and embodied energy is a requirement for approval of the design. Ecovillage project manager Jeff Thierfelder and LCA expert and eTool CEO Richard Haynes explain their collaboration to produce a fast, easy-to-use app to help – and what it can offer to homeowners everywhere.

Sustainability 2.0 at Witchcliffe Ecovillage

Words Jeff Thierfelder

Designing a truly net-zero home – one that produces enough energy to cover its own operation, plus offset the energy used in its materials and construction – requires tracking of the building's whole life cycle, from the initial sourcing of material inputs all the way to the end of its useful life. Historically, sustainable design has focused on reducing *operational* energy via improving the building envelope and appliance energy efficiency. *Embodied* impacts – which include

material manufacture and transport, construction and demolition waste, and maintenance – have been a secondary consideration. Sometimes described as 'sustainability 2.0', life cycle assessment takes into account both operational and embodied impacts, providing designers with a complete picture from which to optimise a home's performance and minimise carbon emissions.

At Witchcliffe Ecovillage in Western Australia, life cycle assessment is required for all homes – and we collaborated with the team at eTool to develop a fast, easy-to-use app to help. Here's the story.

REALISING A DREAM

After first meeting at a permaculture design course back in 1994, developers Mike Hulme and Michelle Sheridan realised they had a shared dream to design and build the most sustainable community possible. They studied other sustainable communities in Australia and overseas, and decided that the ecovillage model most accurately matched their aspirations. This included clustered housing to encourage social interaction, passive solar home design to minimise energy use for heating and cooling, ambitious design guidelines to require low-carbon building materials, and decentralising key services such as power, water, and sewerage.

They researched rainfall patterns, soil types, town planning regulations, and population growth projections, and eventually decided on a bucolic 120-hectare site adjacent to the tiny hamlet of Witchcliffe, seven kilometres south of Margaret River in Western Australia.

Now, almost 13 years later, their vision for the Witchcliffe Ecovillage is becoming a reality, with the first four stages released and almost fully sold; the final stage will go on sale in 2023. There are currently about 60 homes under construction and 30 households have already moved in.

STRINGENT REQUIREMENTS

Witchcliffe Ecovillage is characterised by sophisticated site development controls, thorough building design guidelines and design review process, and high standards for energy efficiency and material selection. The project requires every new house to achieve a minimum of 8 Stars under the NatHERS energy rating system to ensure high thermal efficiency and low energy use. Overall, approved ecovillage house designs are averaging 8.3 Stars, with 18 homes achieving more than 9 Stars.

However, we in the ecovillage design team knew that energy efficiency alone was only one part of the challenge of ensuring the village's homes help address the threat of climate change. The missing part of the equation was the embodied energy in the building materials, and thus carbon emissions (as most industrial processes and the majority of grid energy generation in most states still comes from burning fossil fuels, there is a direct correlation between energy use and carbon emissions). If we wanted the ecovillage to be truly sustainable, we knew that we needed to find a way to encourage the selection of low embodied carbon building materials.

This launched a fascinating exploration of how life cycle assessment (LCA) might be used as a tool to help us measure and reduce the whole-of-life carbon in the proposed ecovillage house designs. The search led us first to sustainability consultant Andrew Moore of Life Cycle Logic; our design team challenged Andrew to demonstrate how his methodologies and technologies could help assess the embodied energy in single

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Tim and Anne-Marie chose strawbale for the external walls of their 100-square-metre cottage at the ecovillage. The strawbale is lime rendered inside and out, internal walls are lined with pine, and doors and trims are of recycled jarrah. The burnished concrete floors are sealed with Livos natural oil, and the couple opted for low-VOC biopaints. All these material choices and a 6.6kW solar PV system contributed to the 8.4-Star home's RapidLCA result of -115 per cent GWP. Image: Frances Andrijich

dwellings, something that had never been done in Australia at the scale of an entire community.

INITIAL ANALYSIS

Andrew was given one of our bespoke ecovillage house plans to use in his analysis work: a 160-square-metre three-bedroom, two-bathroom passive solar home designed to fit on one of our north-facing lots. We asked him to assume an industry-standard project build specification, and undertake a life cycle assessment on the home to establish a baseline carbon impact. From there, he improved the specification of various building components one at a time, to measure the individual impact of each. For example, changing the windows from aluminium-framed single glazing to uPVC-framed double glazing reduced the model building's overall carbon by 4 per cent, a combination of lower operational energy use due to increased thermal efficiency and reduced embodied carbon in the window materials themselves.

We repeated this process for all the major building components, testing a variety of materials for each. This analysis gave us the confidence to finalise the material recommendations in our sustainable building design guidelines, knowing that we were accounting for both thermal performance as well as carbon emissions in our requirements. We also took into account other important sustainability factors not covered by the carbon impact assessment, such as toxicity and chemical use during manufacture.

But the question still lingered: how would we ensure that the individual homes in the ecovillage were carbon-zero – or even better, carbon-negative? Andrew's study was extremely detailed and insightful but it took months to complete. The time and cost of this approach was not scalable for every build at the ecovillage.

Andrew referred us to eTool, a Perth-based life cycle assessment software company, whose team peer-reviewed Andrew's LCA report on the prototype ecovillage house to ensure consistency with international standards. Discussions with eTool's CEO Richard Haynes revealed that they had long hoped to develop a life cycle assessment solution that could be used for low-density residential homes – one that enabled true scalability through affordability and a dramatically streamlined user experience. "My co-founder Alex Bruce and I were spurred to start eTool in the first place because we had the audacious dream to help thousands of homes decarbonise with a simple software solution," explains Richard.

However, eTool's first software product, eToolLCD, ended up being too detailed and expensive for broad adoption in the housing sector, though it flourished in the multi-residential and commercial space. The team just needed a catalyst to launch the new project and a willing developer to be the guinea pig. This sounded great to us, and exactly what we needed to ensure that the ecovillage homes ended up overall carbon-negative. Through this partnership, eTool developed the RapidLCA software used at the Witchcliffe Ecovillage – see facing page for Richard's explanation of how it works.

TRACKING PROGRESS IN THE ECOVILLAGE

At Witchcliffe, the RapidLCA tool is used as part of the comprehensive design assessment that each home must undertake to obtain developer support before submitting plans to the local council.

Based on the original prototype work completed by Andrew, we set the minimum LCA achievement for homes in the ecovillage at -105 per cent GWP (Global Warming Potential – a measure of overall carbon impact) compared with 'business as usual', defined as the average carbon impact of similar-sized houses across the OECD countries. Achieving over 100 per cent reduction like this makes the building slightly carbon negative. Our houses do this by using solar generation to displace fossil fuel-generated grid electricity, saving more carbon equivalent over their estimated 80-year lifespan than they release in their construction and operation.

To date, our best score is -166 per cent, and the average for Stages 1 to 3 is -125 per cent. It turns out that building carbon negative buildings isn't that hard if you write informed design guidelines and set up appropriate measuring systems. Our aspiration is that this cumulative additional carbon 'credit' can be used to offset the carbon emitted in the civil construction of the ecovillage, making the entire project at least carbon neutral.

WHAT'S NEXT FOR RAPIDLCA?

The success of RapidLCA at Witchcliffe spurred eTool to test the tool with other early-adopter government and private sector organisations, further validating the solution's potential for supporting cost-effective low carbon design. The City of Vincent, for example, has been accepting RapidLCA assessments to support its ambitious performance targets for development applications: the city's built form policy requires a reduction of at least 50 per cent in life cycle carbon and net freshwater use against a 2010 benchmark design. The software has been used to great effect by residential development applicants who are significantly over-achieving against these targets; on average saving over 75 per cent life cycle carbon.

While the first iteration of RapidLCA was project-specific, requiring tuning based on the design parameters of a property development, the eTool product team has recently released new functionality enabling one-off assessments on single homes not linked to a development (and so, perfect for *Sanctuary* readers who are designing their own homes).

Also on the short-term roadmap for RapidLCA are project dashboards (so project teams like Witchcliffe Ecovillage can monitor their entire development), expanded design configuration options, and improved carbon-plus-cost optimisation. The solution will also be tailored for New Zealand after Kāinga Ora (New Zealand's public housing entity) recently selected RapidLCA for their carbon measurement and reporting solution for thousands of new public housing dwellings.

"We are really grateful to Witchcliffe Ecovillage for providing us with the market validation needed to develop RapidLCA," Richard says. "It's exceeded our expectations, and most importantly it's saving lots of carbon!"

Under the bonnet of RapidLCA

Words Richard Haynes

RapidLCA gathers basic design metrics of a home to estimate the life cycle impacts of the building on the environment. This simple process is supported by vast databases of constantly updated materials information from eTool's research and archives.

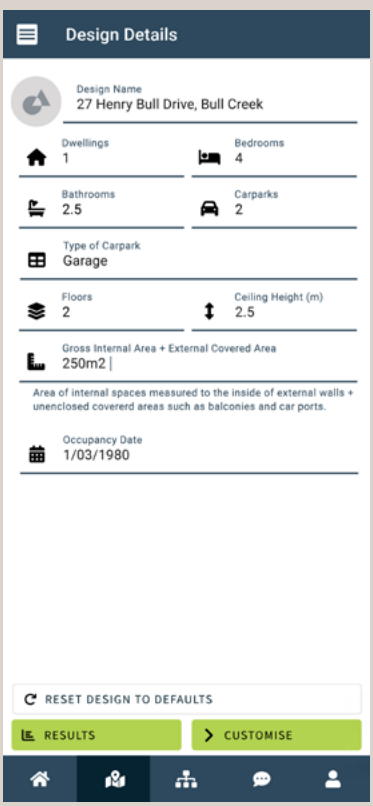
To start using RapidLCA, the designer, builder or homeowner enters a few key parameters such as project location, floor area, number of storeys, number of bedrooms, and construction type. While the software does not support the input of a precise floor plan (to keep it simple), it is possible to adjust some of the assumed measurements and quantities manually if users wish to dive deeper or are using an uncommon building component.

RapidLCA then estimates the building component quantities required for such a house, based on a proprietary algorithm backed by eTool's databases. The algorithm produces outputs that are over 90 per cent accurate at the scale of a house. (This level of accuracy was deemed to be sufficient and an acceptable tradeoff for the ease and speed of RapidLCA compared to a comprehensive life cycle assessment that can take a couple of solid days and cost several thousand dollars.) Additionally, across an entire multi-dwelling development project, the accuracy approaches 100 per cent, as some homes will be slightly over- and some under-estimated.

The software provides predefined specifications for easy selection of building components via drop-down lists. Building materials used for these different components (wall type, floor type and so on) and operational services (like lighting, heating, cooling) can be quickly changed, allowing the user to understand the carbon impact of different material choices. After selecting all the design inputs, RapidLCA provides the overall life cycle impact score of the building as a percentage comparison against the OECD average for the same sized house. Any score reflecting a better than 100 per cent reduction can be considered carbon-negative, as Jeff explains on the facing page. The final report also highlights the hotspots in the specifications that could be adjusted to further reduce the carbon impact of the design.

Under the hood, RapidLCA is very robust. It uses the Australian National Life Cycle Inventory Database (AusLCI) environmental data sets, and the calculations are in accordance with International standards ISO 14044 and EN15978. The automated quantity algorithms are the result of statistical regression analysis of hundreds of single dwelling assessments conducted in eToolLCD, and were tuned using CSIRO's NatHERS certificates database.

RapidLCA gives accurate and detailed environmental performance feedback on an individual house design in about 30 minutes. The cost is low to encourage wide adoption, with very low and zero carbon targets costing less: for example, an assessment resulting in a carbon saving of 25 per cent or less costs $100, while a carbon saving of 100 per cent costs $50 (or the eTool team can produce a RapidLCA report for you for $300 per dwelling). It can be accessed on any browser or downloaded as a smartphone app.



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RapidLCA is designed to be straightforward and fast to use.