WESTERN ARCHITECTURE STUDIO...

CELILO SPRINGS

2023 National Architecture Awards Sustainability Checklist

SUPPORTING EVIDENCE

METHODOLOGY

For clarity, supporting evidence is provided in context of the checklist questions and the 500 words permitted in the checklist. Larger packages of documents are included as appendices.

Some additional supporting text is provided. This is coloured in **Blue**

A Contents table is provided.

OPENING NOTE:

I am pleased to see the requirement for this sustainability checklist in the awards process. We as architects can decide what makes a good building; the criteria isn't 'god given', it is up to us. We could decide that Corbousian, 80s revival or luxurious contemporary style is the metric by which we evaluate our work. But given the environmental condition, and given the role that architecture must have in solving the problem, surely sustainability is our metric.

I do notice the parallels between the Sustainability Checklist and the objectives of the Living Building Challenge. I feel the AIA checklist hits the right note by dealing with the key principles, but moving past some of the more evangelical parts of the Living Building Challenge (such as the inherent aspiration for total self-sufficiency despite the blatant inefficiencies in doing so).

This document has been assembled for ease of assessment for the purpose of the Architecture Awards. I have tried to provide evidence next to the relevant answers.

Celilo Springs is a fundamental and integrated approach to sustainability. It is a CO2 negative building, where the intent is to create environmental immersion; to bring people closer to the environment in which they live. To foster an appreciation for place, a respect for place and a will to preserve place.

It is a building where the site, the occupants, the form, the plan, the section, the materials, the environment, the systems are all designed to compliment and enhance each other. The sustainable product is bigger than the sum of its parts.

Thank you for your consideration,

Andrew Boyne.

Answers and Diagrams

CONTENTS

Appendices

SUPPORTING EVIDENCE

0 - GENERAL

500 words

Climate change and CO2 are major problems and need to be addressed immediately. But climate change is not a new discovery. Human CO2 emissions leading to climate change was described by Svante Arrhenius, a Nobel Laureate in the 1890s, and the greenhouse effect was a mainstream subject of scientific research half a century ago; nor is climate change our only environmental pressure: biodiversity loss, extinction, groundwater water pollution, air pollution, ocean acidification, soil degradation, micro-plastics, VOCs, asbestos contamination, , salinisation, marine deserts, etc. etc.

Perhaps Carbon dioxide emissions are not the simple central calamity they appear, but just the most critical symptom of a disease that lurks within the prevailing global culture.

European culture, which through whatever twist of fate underpins the modern global culture has for thousands of years regarded the supremacy of human beings over nature; where the environment is a resource; something to be tamed. Europeans are not necessarily unique in this regard, but the effects of the proliferation of the separation between the human world and the natural world are reaching a crisis.

Disconnection breeds apathy. And apathy is everywhere.

This is the disease from which the symptoms stem.

Architecture and the built environment have a critical role to play in the alleviation of symptoms. We must eliminate CO2. But we must not fool ourselves that strapping solar panels on buildings and specifying heat-pump hot water systems achieves anything to treat the disease; it is paracetamol to dampen a fever. We as architects must find ways to reconnect humans back to the systems of which we are a part, and of which we are dependent. We can longer afford to do anything else.

In order to save the world, we need to fall in love with it again.

Tim Winton 2022

Celilo Springs is centrally about sustainability. It achieves energy positive operation, and is life-cycle carbon negative, while using integrated, minimum technical systems.

... but the house is also about submersion in place to promote engagement with, and love for place. It is a small house settled into a garden, transparent to bird song and frog call. Where breezes flow and passing neighbours engage in conversation. It is a respectful part of the neighborhood, and draws on Western Australian cultural references to foster identity. Seasons are visible through flowering native plants, and the house plays a meaningful part in re-vegetation and urban canopy restoration.

Every decision has been made through the lens of sustainability. Every part of the building and the site is integral to the sustainability performance. All parts interact. Systems are celebrated and expressed.

0.1 *Does your practice have sustainability measures in place? Consider if there is any in-house sustainability consultants, training measures, certification of practice, B-Corp, signatory of Architects Declare Australia, carbon-neutral commitments, material specification guidance.*

WAS is committed to continued sustainability training. We are signatories of Architects Declare. Andrew Boyne is trained in eTOOL LCA.

0.2 *Does your practice have a sustainability action plan (SAP)?*

WAS is a small practice producing minimal CO2. We developed a SAP in 2022 to further improve the impact of our practice. Our SAP acknowledges that our greatest impact is in the work we produce.

0.3 *Were project Certification Systems used? For example - Living Building Challenge, One Planet Living, Passivhaus, EnerPHit, Well Building, Green Star, NABERS, NAtHERS, BASIX, BESS, Climate Active, Other (please type under Column E)"*

eTOOL LCA certification has been used to assess life-cycle CO2. *See Appendix 2*

A NatHERS equivilent calculation of Mj energy consumption for heating and cooling is prodived *See Appendix 6*

1 - PROTECTION OF LAND AND ECOLOGICAL SYSTEMS

500 words

Celilo Springs aims to submerge the occupants in the Western Australian context. As a single-family home in inner city Perth, on a cleared site, this aspiration could only be achieved through deliberate restoration of land and ecological systems. By submerging people in this environment, by teaching them about these systems; the house fosters a connection to place and a will for preservation.

Preservation and contribution to ecology is the primary consideration in the design of all landscape and architecture at Celilo Springs.

1.1 *Has the design acknowledged opportunities to harvest, use, or recycle on-site resources during the construction? E.G.: Rainwater, existing landscape, trees etc.*

Originally a steep, cleared dry-grass site with minimal vegetation, construction stages included:

- Installation of a new subsoil drainage system to collect water from the existing surface groundwater spring. This was then distributed through low-pressure irrigation to allow early planting of the site. Re-vegetation efforts using only Western Australian species including tube-stock and planting of native trees and shrubs that had been grown off-site in preparation.

- A Balanced adjustment of levels – with no additional fill or waste to establish building pad and garden contours.

- Establishment of the rain-garden culvert to provide the early collection of rain runoff and the opportunity for growth of wetland species.

- Retention of small existing trees.

Early forming of the rain garden and extensive endemic planting before construction allowed early establishment of mature multi-leveled re-vegetation.

Figure 1 - Site condition comparison photographs

August 2018

Present

1.2 Has the design acknowledged opportunities to harvest, use, or recycle on-site resources during the life of the building? E.G.: Rain water, edible landscape etc

The house utilises existing resources during operation by:

- Directing the surface spring through a pond (now home to 4 species of frogs). The pond is designed to overflow through a spout and flows via a stream to the rain-garden. At the base of the pond is a sump drain which feeds a low pressure irrigation system. The entire lower garden is irrigated through this system. It permits a complex variety of Western Australian species. Birds, frogs and insects

- Distributing all rainwater through the rain-garden. Resulting in a seasonal wetland that allows biodiversity.

- Solar PV offsets the house energy usage.

- Passive/stack ventilation strategy naturally promotes airflow.

1 - PROTECTION OF LAND AND ECOLOGICAL SYSTEMS

1.3 Does the project include strategies to minimise pollution to air, earth and water? E.G.: acid sulphate soils, salinity

Pollution is minimized by:

- Rain-garden filtration
- A native garden which does not permit phosphate use.
- Re-vegetation by large trees (eucalyptus) assisting water table stabilization, providing shade, and cleaning air.
- Minimization of energy consumption through passive and active systems
- Reduced use of paints and solvents.

1.4 Does the project include strategies to protect, support or regenerate the sites ecology? This may include but is not limited to: Retention of site top soil, removal of invasive plant species, specification of endemic species, creation or linkages to habitat for native animals, water sensitive urban design (WSUD) including stormwater filtration prior to reconnecting with existing systems.

Regeneration of ecology is a major focus of the house and includes:

- Retention of all topsoil.
- Re-vegetation by only Western Australian plants (200 species) selected for all-season flowering. Arranged in micro biomes to increase diversity.
- Habitat creation through diverse landscaping, gradient, levels, vegetation, shade differentiation.
- Canopy re-establishment with full understory planting
- Stormwater through in-ground collection and bio-filtration rain-garden

Figure 2 - Site landscape photograph

1.5 Has construction waste been minimised or recycled? Please list how many waste streams have been provided for collection and how minimisation of landfill has been considered.

- Waste reduction was a major part of the planning for environmental and cost benefits. No skip bins for the entire construction. This was achieved through:
- Fastidious material design, quantities and ordering leading to no over-ordering or waste
- Balanced earthworks
- Use of any remaining building waste as drainage aggregate for planters.

1.6 Does the project include strategies for minimisation and recycling of operational waste including any on site treatment of waste E.G.: sewerage, compost, recycling programs etc.

Recycling and composting is provided through the Town of Vincent recycling and FOGO services. Composting is not appropriate for native plants so is best handled through the town.

2 - SITING AND URBAN DESIGN

500 words

The house is designed as a small, low-impact building that returns most of it's site back to re-vegetation of an environmentally significant site. The house is low, does not cast shadows on neighboring properties, and does not obstruct views. It preserves a line of sight through the entire length of the property from front to rear boundary. It preserves visual amenity of the streetscape..

2.1 Has the existing and/or future use of neighbouring sites been considered in the site planning?.

Figure 3 - Aerial context photograph

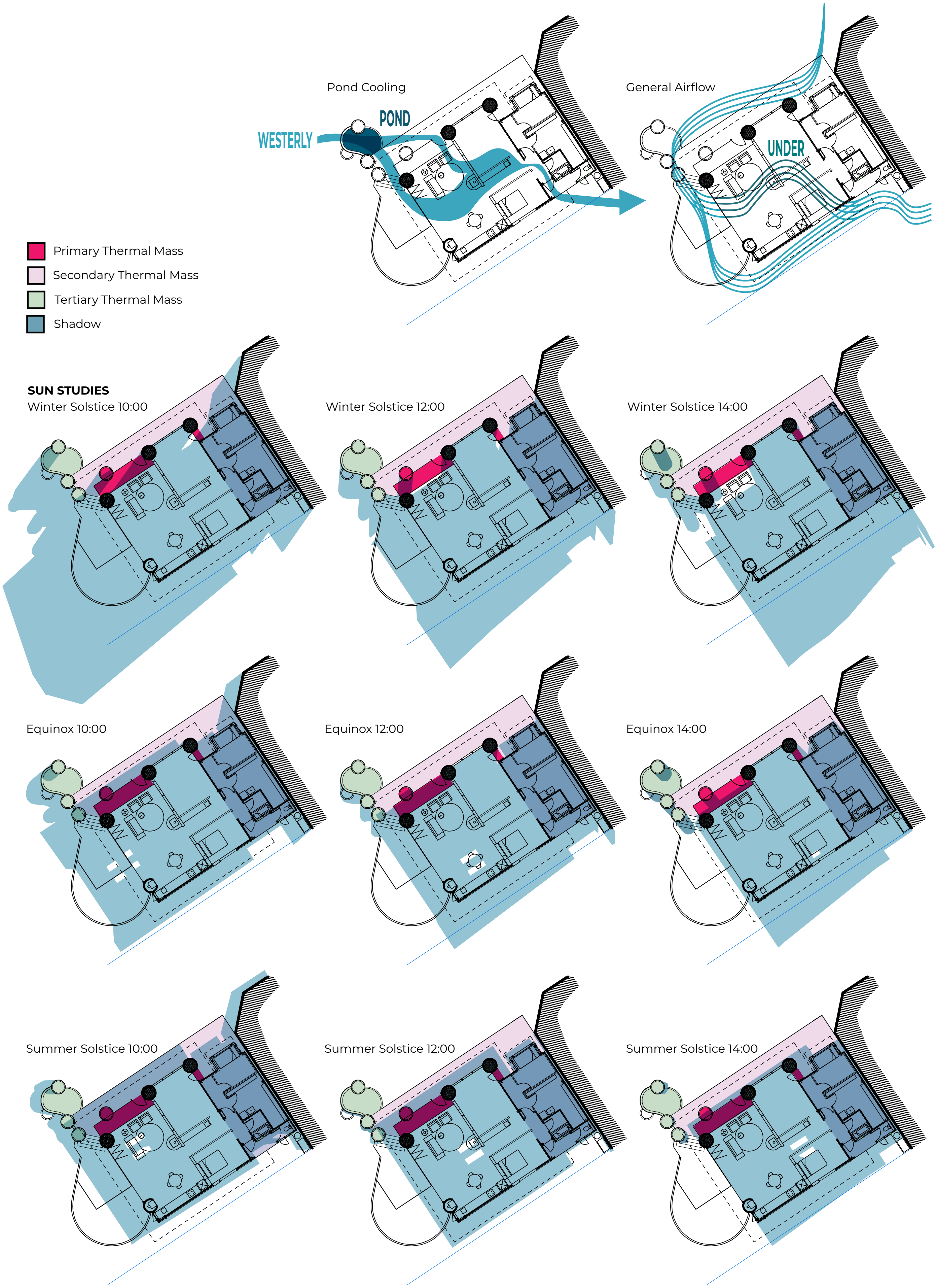
Neighboring sites directly adjacent to the house are residential backyards. Sewers running under the adjacent sites prevent development in the lower half of these lots. So too do soil conditions and a high water table. Zoned R12.5 with a heritage context, a relatively new scheme, and high density zones designated around the perimeter of the neighborhood it was considered that these yards would be undeveloped for some time. Consideration has however been given to the vulnerability of borrowed landscape, and the house has been fitted into a corner of the property to maximize landscape edges for future screening. These screens have been planted but will take time to mature. The unlikely prospect of the adjacent properties being developed in the near future provides time for vegetation to mature

2.3 Does the site planning improve passive thermal comfort to open spaces & enclosed habitable rooms? Including but not limited to solar, wind, and humidity.

The house is set back from northern boundary to ensure solar access into the main living space and secondary bedroom. This is filtered by low eaves. The house is raised at the highest part of the site with a centrally located and high roof-top ventilation opening. This is the highest practical point the house could reach to maximise access to the prevailing breezes. The pond is deliberately located in the western corner. It provides a cooling effect from the SW'erly summer breeze while limiting the impact of winter easterlies. Boundary setbacks are wider than minimum and the floor is raised for air circulation. The house and the landscaping have been positioned to create different micro-climates, allowing for the growth of many different species.

SUPPORTING EVIDENCE

Figure 4 - Passive ventilation and Passive Solar diagrams



2 - SITING AND URBAN DESIGN

2.4 *Were any of the existing elements on the site retained and adapted for this project? For example: trees, buildings, materials, facilities, infrastructure, etc*

Existing trees were small but retained. Rubble found throughout the site is used as drainage aggregate.

2.5 *Has the design considered strategies to improve resilience and adaptation relating to climate change events including bush-fire, cyclone, flood, storm surge, sea level rise, extreme temperature?*

Though primarily passive, indirect evaporative cooling has been included in anticipation of extreme heat. This system is very efficient in high temperatures. Primary steel structure is fitted for increased strength.

2.6 *Has the project enabled an increase to the anticipated mature tree canopy cover as compared to the existing tree canopy cover to the site?*

There was almost no existing canopy. New Planting includes 4x Karri trees, Marri, Illyarrie, Chindoo Mallee. It is anticipated that over 60% of the property will be covered by canopy. This is already close to being achieved

2.7 *Does the design enable adaptability/ future proofing where a masterplan for the area is in place?*

N/A – no masterplan in place.

2.8 *Has there been any consideration towards facilitation of pedestrian and non-motorised transport?*

The property has a 'battle-axe' arrangement, but vehicles are now parked at the street boundary/cross-over. What would normally have been used as a driveway, vehicle turning and parking has been re-purposed as a pedestrian staircase, gardens and a lawn; transferring 212m² (a third of the site) from vehicles to gardens. The house embraces the pedestrian only lane at the bottom of the property which connects East Perth Train Station and Banks Reserve. A deliberate pathway links the two frontages. Removing cars from the site returns gardens, pedestrian access and shade.

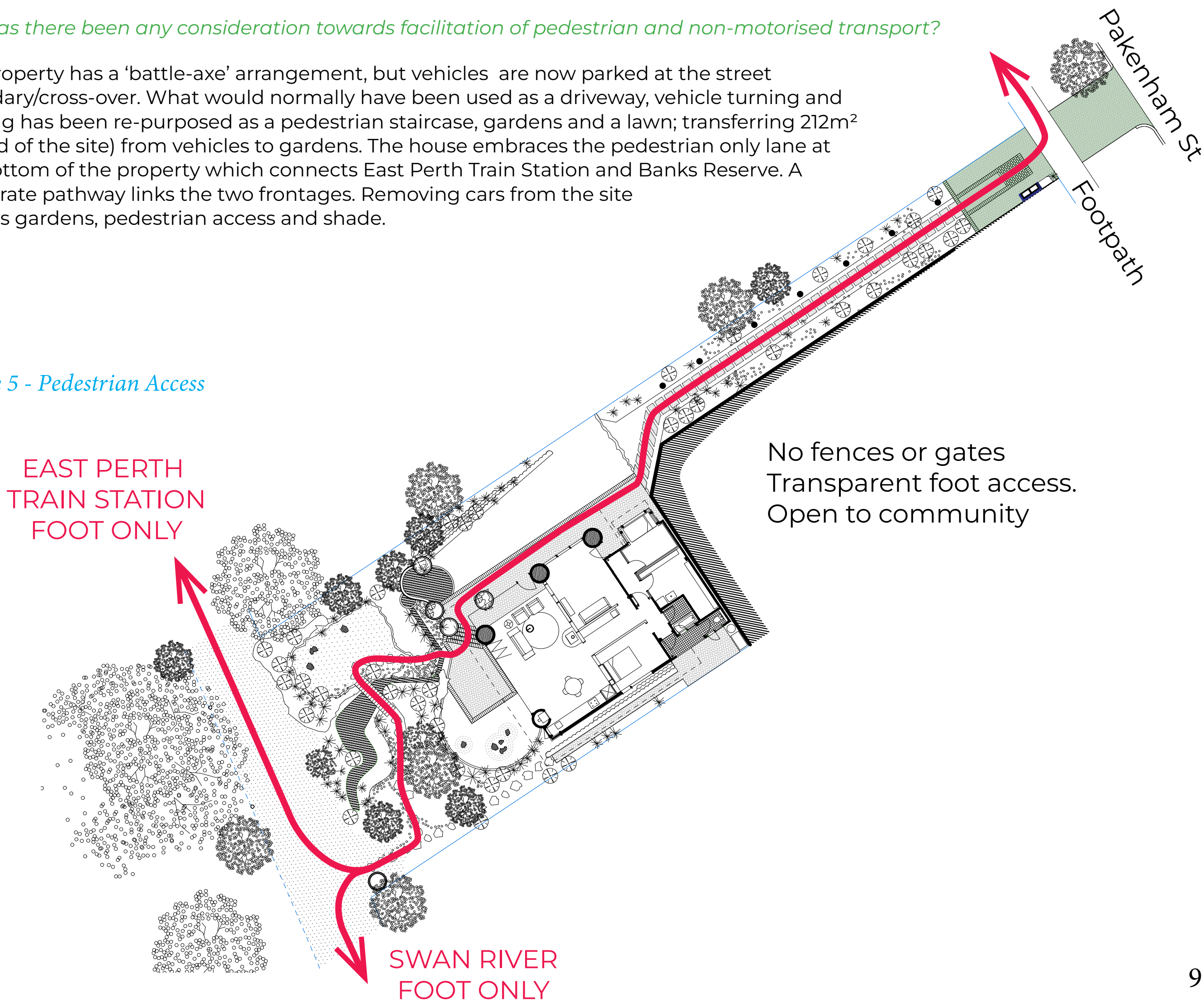


Figure 5 - Pedestrian Access

3 - ENERGY EFFICIENCY AND CONSUMPTION

500 words

3.1 Is the building 100% electric?

No gas connection. 100% electric appliances and equipment. A wood heater is fueled by wood collected from local golf courses. Wood collected in this way is classified as renewable biomass.

3.2 What is the annual estimated energy consumption (kWh/m2/yr)? Please state whether this estimate was modelled through the Passive House Planning Package (PHPP), or Nationwide House Energy Rating Scheme (NatHers), or via another system. Has the implementation of passive thermal design principles enabled the building's operational energy to be reduced across the seasons?

Actual metered energy: -8kWh/m2/year (NEGATIVE)

Nathers Equivalent (kWh): Heating: 0kwh/m2/yr Cooling: 0.3kWh/m2/yr

Nathers star ratings are based on heating and cooling consumption only. Heating at Celilo Springs is via a wood heater consuming a renewable resource (Biomass). No electricity or fossil fuel combustion. Cooling energy is calculated by:

*avg. days over 35*c (26.5) x measured draw of air-con (250w) x typical no. of hrs operated (6h) / floor area (125m2) = 0.3kWh/m2/yr*

A NatHERS equivalent calculation of MJ energy consumption loads for heating and cooling is prodived *See Appendix 5*
NatHERS Equivalent 9.5 Stars

Figure 6 - Energy consumption records

synergy

Account number: 000XXXXXXXX

Consumption History

Billing period end date	Number of billing days	Average daily usage	Total usage for period	Amount	Solar export (units)	CO2
21 Dec 2022	58	3.8	223	85.74	614.400	219
24 Oct 2022	61	5.9	359	144.92	401.304	351
24 Aug 2022	58	8.4	488	195.65	188.002	479
27 Jun 2022	61	7.1	435	177.72	194.244	426
27 Apr 2022	64	4.3	277	123.33	354.505	272
22 Feb 2022	64	7.3	468	145.39	827.253	458
20 Dec 2021	60	3.2	189	67.25	719.506	185
21 Oct 2021	59	3.6	213	93.22	439.087	209
23 Aug 2021	60	4.8	288	133.28	196.556	282
24 Jun 2021	62	3.4	213	104.43	293.468	208
23 Apr 2021	63	4.3	269	103.04	554.184	263
19 Feb 2021	65	3.4	218	67.78	873.578	214

Excerpt from Synergy Electricity Supply data. See Appendix 3

Average Measured Annual Grid Consumption = 1820kWh
Average Measured Annual Grid Export = -2828kWh
Average Measured Net Energy Consumption = -1009kWh
Average Measured Net Energy consumption/m2 = -8kWh/m2/yr

NOTES:
Synergy data is provided over a 2 year period due to a number of unusal occurances that dont accurately reflect actual usage of the house under normal circumstances:

1) Baby born in March 2022 - As a result energy use in March and onward has included a lot of boiling for steralising bottles and equipment
2) January and February 2022 a heatwave occured. The house had not yet had the evaporative air conditioner installed.
A temporary portable air conditioner was brought into the house. The operation of which resulted in much higher energy usage than would have been observed had the permanent indirect evaporative air conditioning system been available.

For fair comparison a corrected calculation has been provided to represent probable energy usage.
This calculation is based on Feb through Dec 2021 + 10% + 25 days running indirect evaporative cooler @ 500W for 7 hours/day

Corrected Average Annual Grid Consumption = 1616kWh
Corrected Average Annual Grid Export = -2828kWh
Corrected Average Net Energy Consumption = -1212kWh
Corrected Average Net Energy consumption/m2 = -9.7kWh/m2/yr

Corrected Average Net Energy Consumption Per Person= -404kWh

3 - ENERGY EFFICIENCY AND CONSUMPTION

DESIGN OCCUPATION PATTERN

The occupation and operation strategy for the house is integral to the performance of the house. For most of the year the house is kept in general ventilation mode. When optimal temperatures cannot be maintained due to very cold or very hot weather, the house requires little energy for rapid temperature correction due to the high insulation / low thermal mass strategy. This approach compliments the occupation design where the house is anticipated to be unoccupied during office hours.

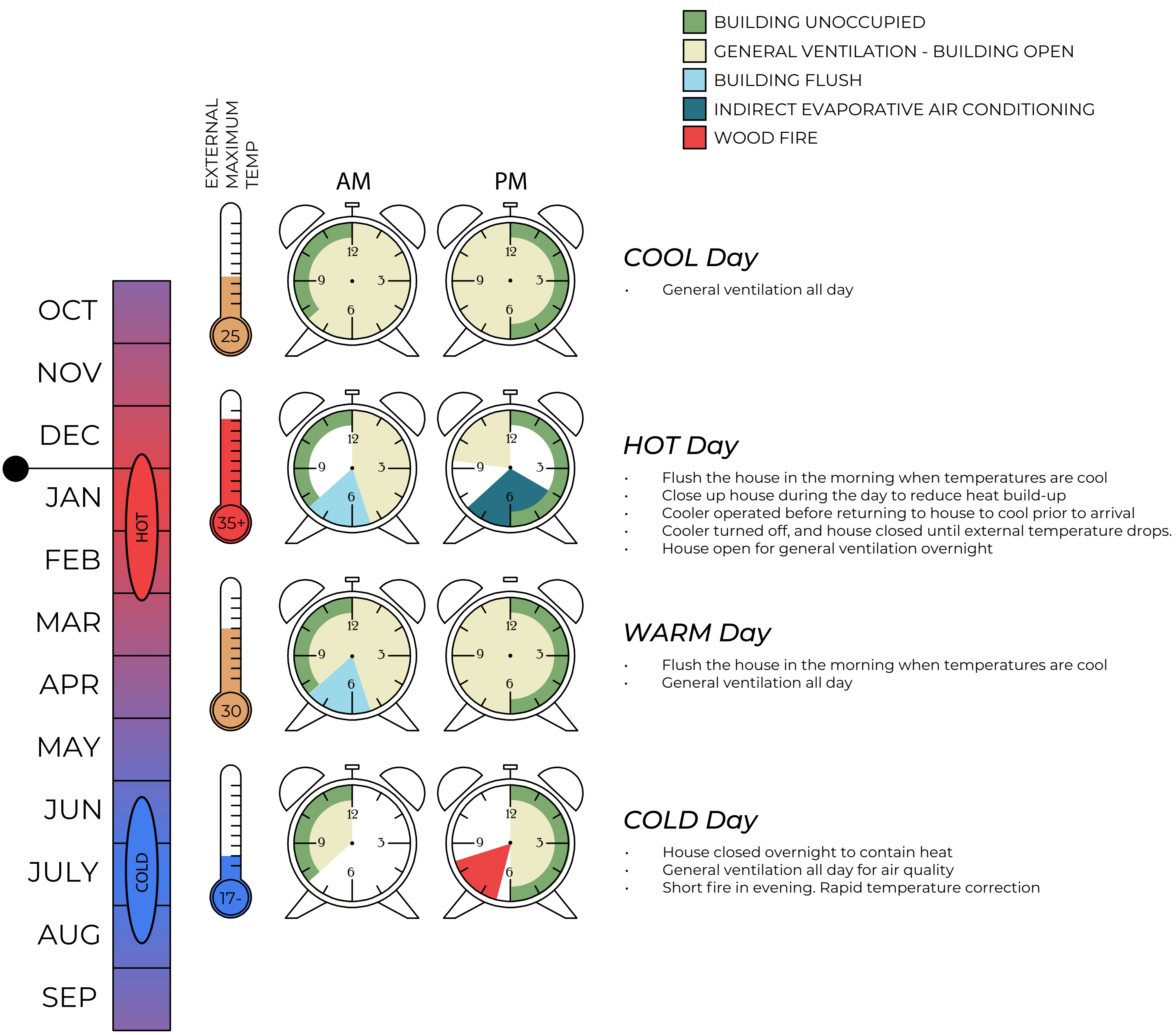


Figure 7 - Design Occupation Pattern

3 - ENERGY EFFICIENCY AND CONSUMPTION

3.3 Has the implementation of passive thermal design principles enabled the building's operational energy to be reduced across the seasons?

The house uses a range of passive thermal principles including:

- **High Insulation/Low thermal mass strategy**. Thermal mass is used sparingly and in targeted locations.. Low thermal mass does not require thermal maintenance when the building is unoccupied, When reoccupied, building temperature can be rapidly adjusted through fully passive or active systems with very little energy input. Conditioning is only necessary in extreme hot or cold. See Figure 8.4
- **Passive solar** with targeted thermal mass. Direct solar energy is controlled into the house via low (2.1m) and wide (1m) eaves. Where permitted into the structure in winter, solar energy falls on a paved, concrete thermal mass slab to absorb winter heat.
- **Stack ventilation**. Apex roof vents allow the building to exhaust heat build-up. Temperature recordings show a 5ºc differential over the 5.5m air column, which demonstrates the success of the stack. This phenomena passively draws cool air through the building at low level.
- **Cross ventilation**. The house is surrounded by openings at low level. To maximise airflow, windows are on winders with no insect screens. Cross ventilation combines with stack ventilation.
- **Infra-red reflectivity**. Infrared (low-e) glass, and an highly ir reflective aluminium ceiling distributes IR energy/heat over the entirety of the internal space. Minimum energy is wasted unnecessarily heating/cooling unproductive building elements.

3.4 Were energy audits or thermal modeling software utilised during the design process? Please state system used,

No energy audits were used. The design was intended to optimise energy performance in all aspects

Figure 8

BUILDING PERFORMANCE CHARTS

These charts are provided to show Temperature Performance against Power Usage and Power Consumption under different conditions. .

Single log used for entirety of household heating 26 june 2022

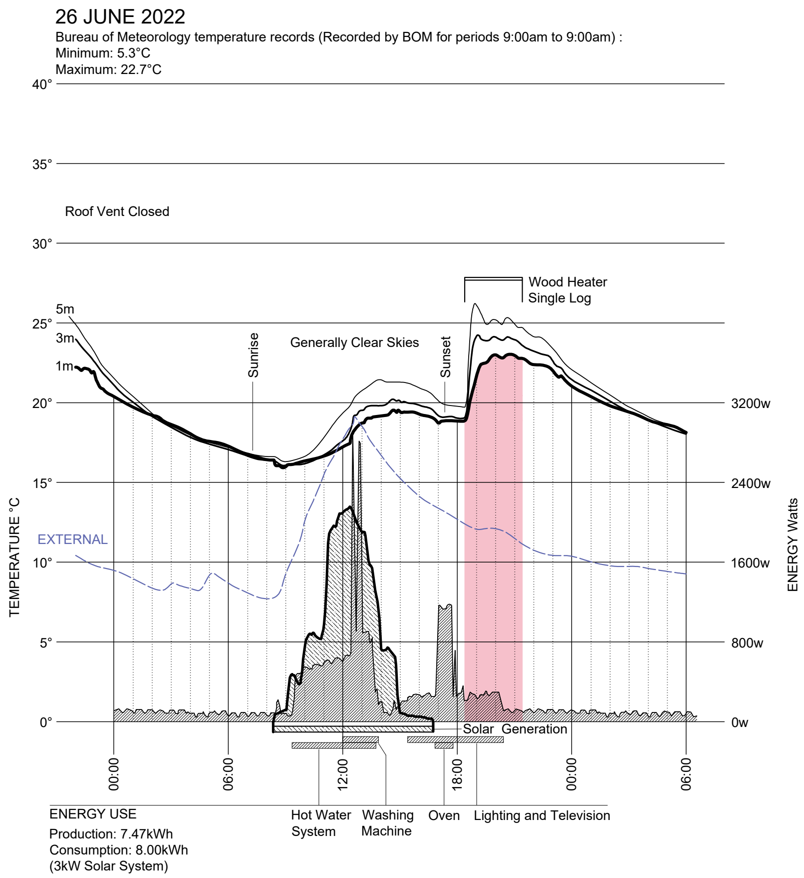


Figure 8.1

On an evening that dropped to 5*C, the house maintained comfortable temperatures with only a single log being consumed for heat.

The house is generally not occupied during daytime hours, and so the efficient and rapid heating of the space allows for comfortable occupation while not requiring heat input to offset thermal mass losses when the house is unoccupied.

3 - ENERGY EFFICIENCY AND CONSUMPTION

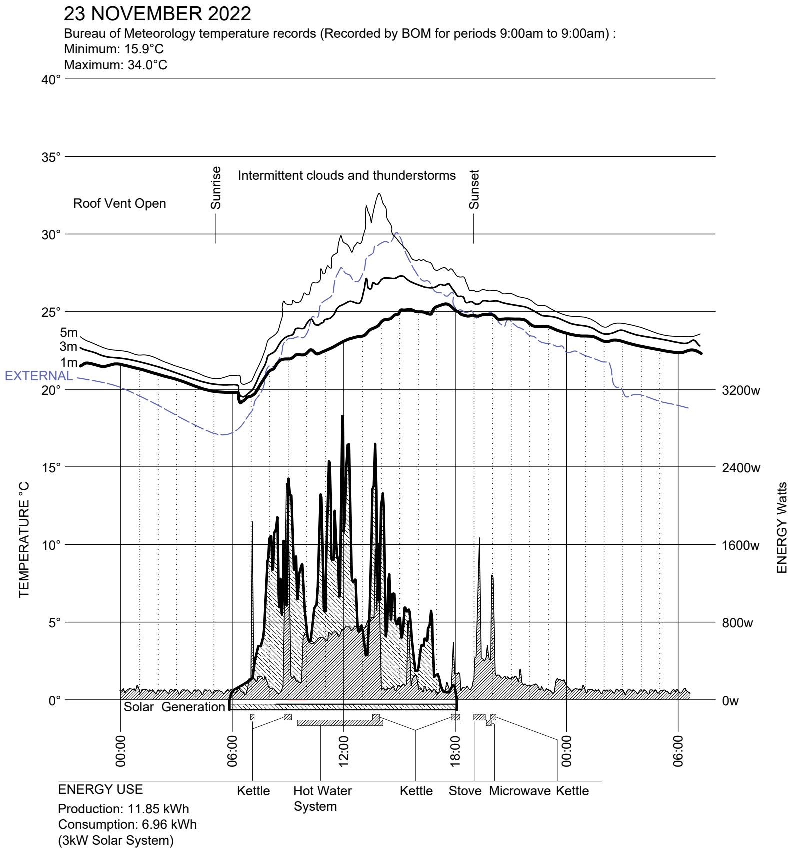


Figure 8.2

Here on a hot spring day after a hot night, internal temperatures stayed within the comfortable 19-26*c band without any thermal input. And with the roof vent left open.

The energy plot shows that even though solar collectors were obstructed by intermittent cloud, they were still able to produce almost twice the consumption of the house. Most house operational energy is timed to coincide with solar generation

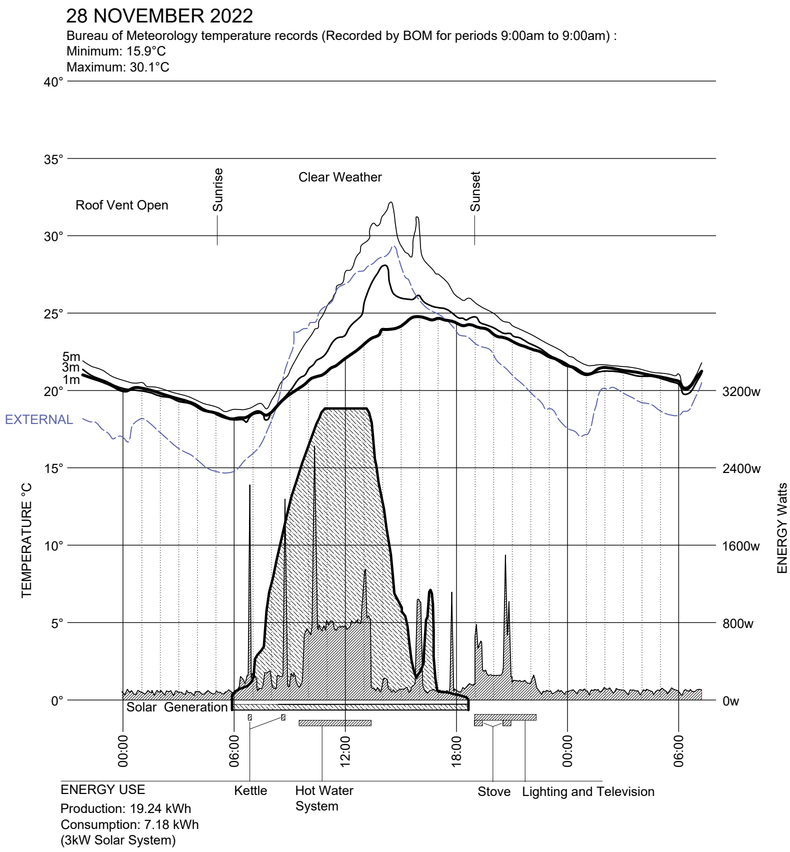


Figure 8.3

This plot shows a warm day with clear skies. The internal temperature stays within the comfortable band without any intervention, and with the roof vents left open.

Solar generation exceeds household consumption by 2.5x even with a minimal 3.0kW system.

Stratification of the air column demonstrates effective stack ventilation.

3 - ENERGY EFFICIENCY AND CONSUMPTION

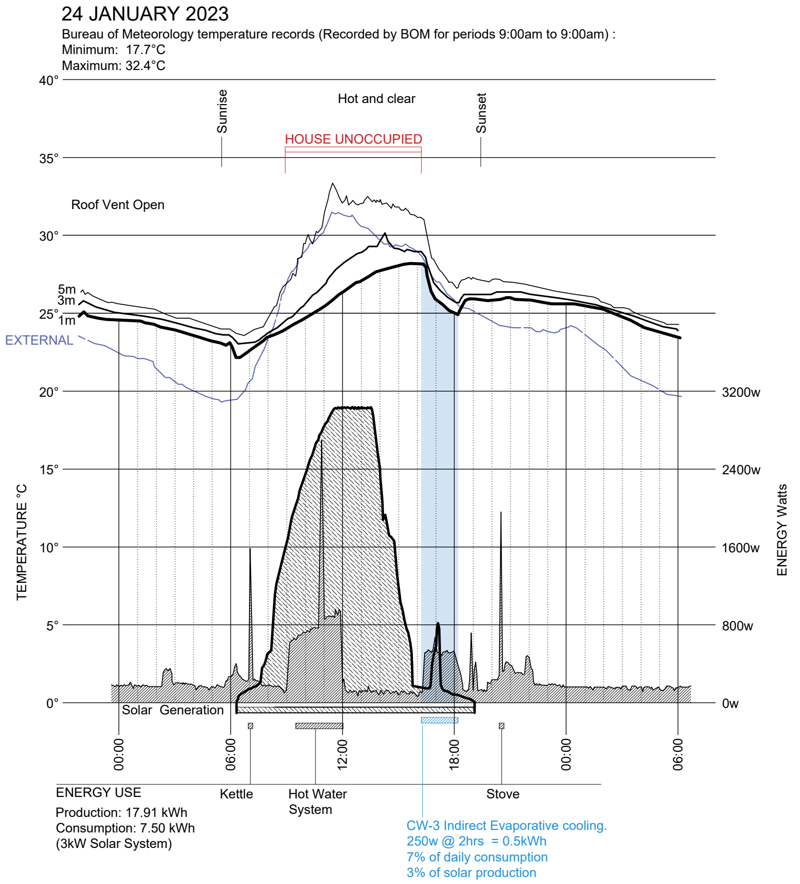


Figure 8.4

The vast majority of days require no conditioning. The house is also anticipated to be unoccupied during office hours.

This experiment was undertaken to demonstrate rapid correction of temperature when someone arrives back at the house. Here only 3% of the daily solar production is required to correct internal temperatures while the house is occupied.

In normal conditions correction is not necessary and would be more similar to Figure 8.3. But for demonstration purpose, this chart shows efficient cooling

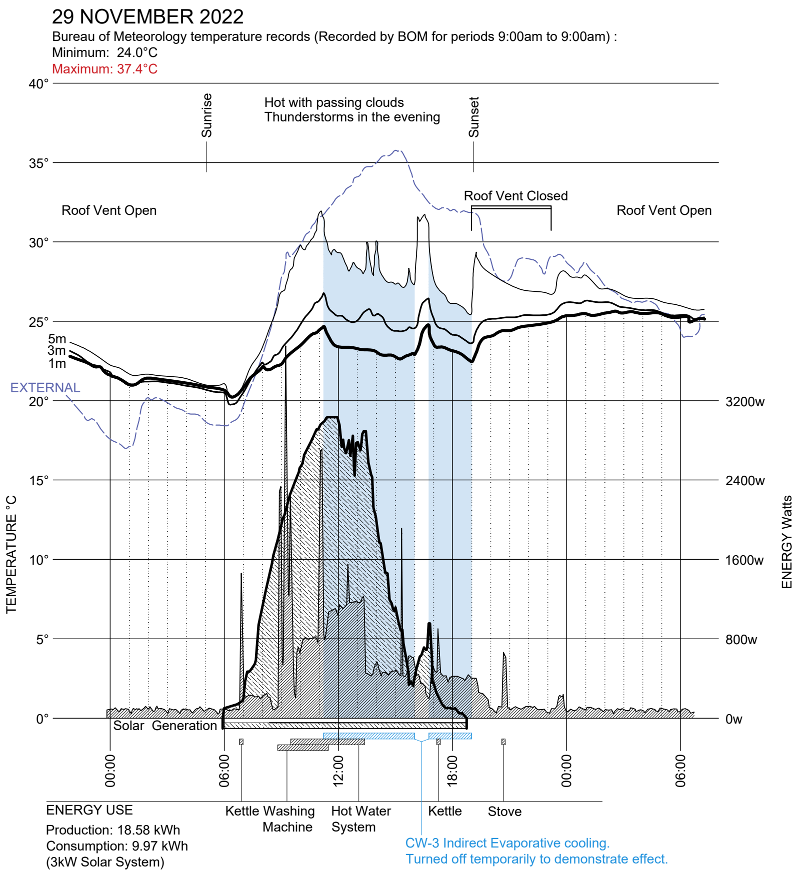


Figure 8.5

On a very hot day (exceeding 35 degrees) and leading into a hot night, the indirect evaporative system is operated. The system draws 200-300W and cools the house to 23*c while the solar system is generating up to 3000W.

The large stratification in the air column (7*c) demonstrates minimal mixing of air, and the effectiveness of the displacement strategy. Hot air is gathered at the top of the roof apex and expelled.

In this experiment the air conditioning was turned off while the windows remained open; showing a rapid ingress of hot air, and when the system was restarted, the rapid flushing of that air is demonstrated.

After the air conditioning was turned off at 7pm the heat advantage diminished over night as expected.

Power consumed by the indirect evaporative cooling system amounted to 2.8kWh or 14% of solar generation for the day.

3 - ENERGY EFFICIENCY AND CONSUMPTION

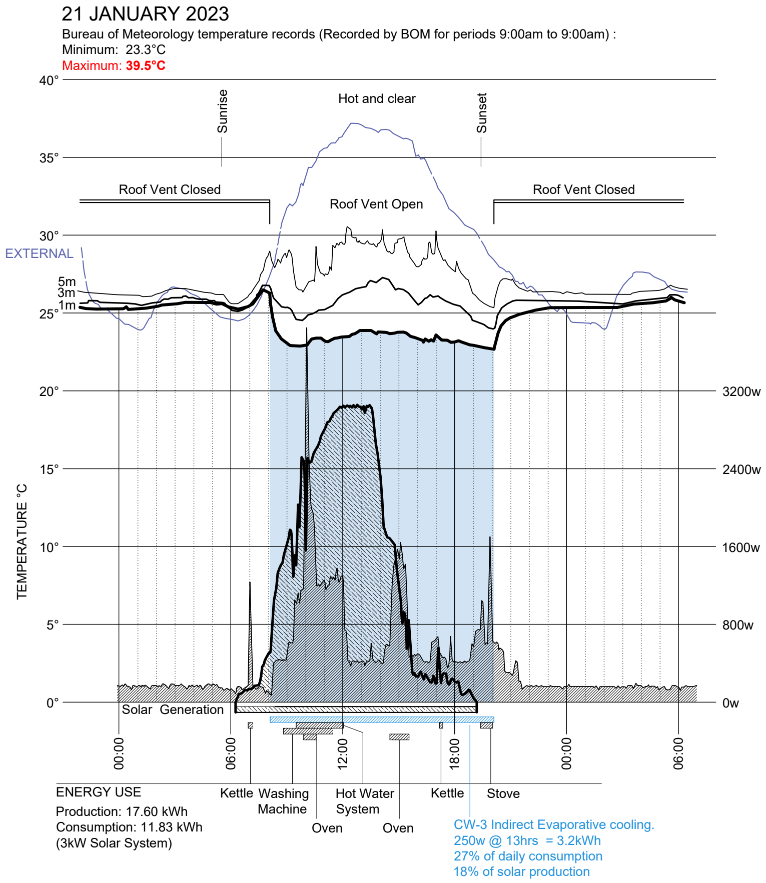


Figure 8.6

This experiment demonstrates full day operation of the indirect air-conditioning system on a day exceeding 39*C. On average there are only 4 days that exceed 40*c per year in Perth, so demonstrates an extreme circumstance.

This experiment shows internal temperatures in the comfortable range while consuming 3.2kW; only 18% of the solar production.

Erratic temperatures recorded at 5m shows the influence of wind at the apex. These fluctuations are not reflected at 1m. A benefit of the ceiling shape and height.

BUILDING PERFORMANCE SUMMARY

- The thermal performance of this house is specifically designed to suit this place, and to suit an occupational pattern where the house is primarily occupied before and after office hours.
- Data collected over the year demonstrates the effectiveness of the house in terms of thermal performance vs. energy balance.
- The house typically sits within the thermal comfort band without any intervention due to passive design.
- Where thermal intervention is required, such as long cold days in winter with persistent cloud cover, or runs of excessive summer heat with hot nights, the low thermal mass ensures short, sharp corrections of internal temperature can be achieved with only small amounts of energy consumption.
- Because The house is designed to be primarily un-occupied during the day. Rapid correction of internal temperature ensures comfortable occupation without the need to service a thermal mass during unoccupied hours.

3 - ENERGY EFFICIENCY AND CONSUMPTION

3.5 Has renewable energy technology been utilised to reduce the operational carbon footprint of this project? Consider system type and capacity (PV, wind, etc.), and battery type and capacity.

Solar system consists of 3.0kw inverter and 4kw of panels, coupled with timed appliances and low energy systems. The minimum sized solar system produces more power than the house consumes.
Batteries would have been wasteful due to very low nighttime energy consumption.

3.6 Is this project 'net zero' with respect to operational energy use?

Net Zero in terms of energy consumption producing 1212 kWh / year more than it consumes

3.7 Has air tightness been considered for this project and climate zone? If known, please include blower Door Test result for air exchange rate per hour (tested @50PA).

The house is fully sarked and taped for airtightness

Despite Passivhaus promoting air tightness as a major sustainability feature. Air-tightness is not a major part of this system - The house is designed to be constantly ventilated with natural air for health, and because the benefits of air-tightness are not substantial in a generally benign climate like Perth. HRV in a Perth context will use more energy to push air through the heat exchanger than the small amount of heat energy recovered from the exhaust air. In our climate, passivhaus theory does not achieve the outcomes we need.

In any case, Celilo Springs is fully sarked and taped using Proclima Enviroseal products. It can be closed up for limited air ingress for the small window where fully closing up the building provides some benefit

3.8 Does the façade integrate systems (or is a holistic system) designed to improve passive thermal design? Please include a breakdown of systems used including glass and framing types, Uw and/or SHGC values.

The façade includes an open ventilated steel panel system, with reflective foil insulation rainscreen.

Glass is Comfort Hush Low-e.

Uw=3.6

SHGC= 0.64

Infrared reflective glazing is part of the IR reflectivity strategy.

3.9 Does the insulation used exceed NCC 2019 minimum deemed to satisfy requirements? Please provide type, R or U value system values for each of the following: Roof (s) over conditioned spaces, Wall(s), Floor(s).

Insulation Systems see Appendix 4

Roof = R6.87
Walls = R5.09
Floor = R1.5

3.10 Have efficient fittings, fixtures and equipment been included in this project? Please describe these below or in adjacent spaces.

Energy efficient fittings and fixtures include:
- All lighting is LED. Lux levels are deliberately low for ambiance and reduced energy consumption
- Electric appliances chosen for energy efficiency.
- Heat pump HWS
- Indirect evaporative cooler which can cool the house to 22°c with only 250W draw

3 - ENERGY EFFICIENCY AND CONSUMPTION

THE WHOLE HOUSE AS A SYSTEM

The approach to sustainability in this house, is not a collection of independent technology systems, but an integrated approach where the whole house works together. Here the low eaves work with the vaulted aluminium ceiling, the IR Low-e glazing, the open volume, the solar and wind orientation, the low thermal mass, the air conditioner, and the heater. The whole is greater than the sum of its parts because all are designed to work in concert.

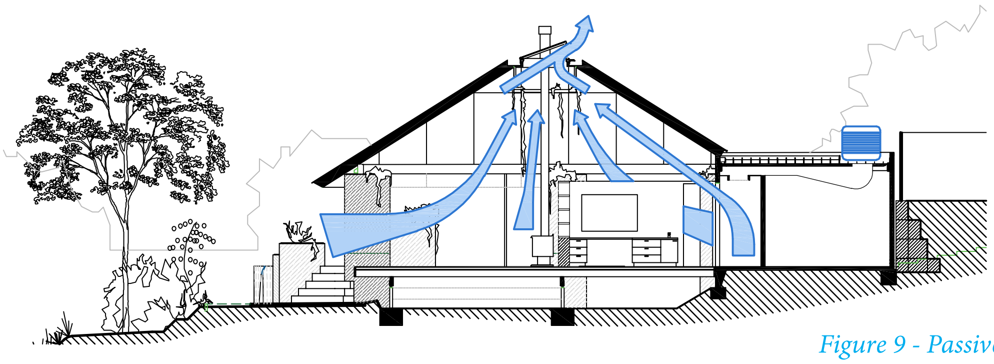


Figure 9 - Passive Ventilation Diagram

PASSIVE VENTILATION

The house uses a combined main living space (including the main bedroom) with openings on all sides to create opportunities for cross-ventilation. This is combined with a stack ventilation to draw air up through the apex of the building and exhausts through the roof vents. The stack effect has been measures at up to 5*c difference between the floor and the apex. This passively draws air through the building even when there is no effective breeze to power cross-ventilation.

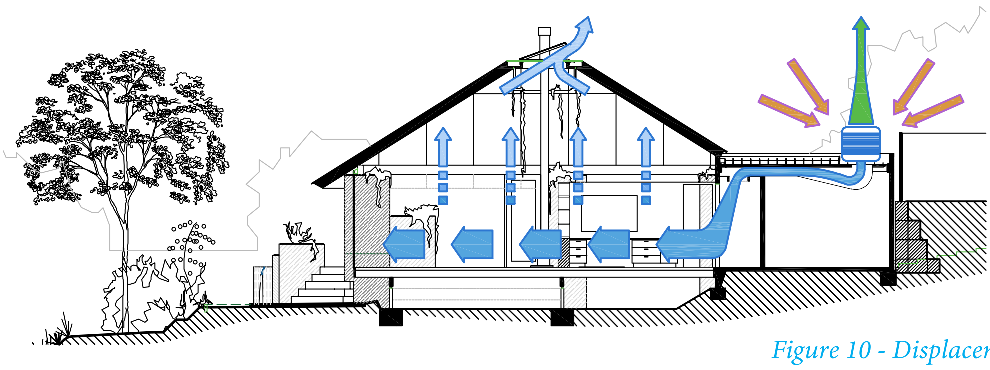


Figure 10 - Displacement Cooling Diagram

DISPLACEMENT COOLING

When temperatures exceed 35*c, The house uses a cutting edge indirect-evaporative cooling system developed by Seeley. This is one of the first houses in Western Australia to install this type of cooling unit. The Climate Wizard system is installed in a displacement arrangement where cool fresh air is supplied at low level, forming a pillow of conditioned air about 2m high. As more fresh air is pushed into the building, convection results in the warmer, stale being moved upward as it warms and is then exhausted through the roof vents. The direction of the roof vents and their position at the apex of the roof with scoops facing away from the prevailing wind is intended to assist convection with venturi suction.

INDIRECT EVAPORATIVE COOLER

The Climate Wizard by Seeley in Adelaide works by evaporating water through wet pads, but differs from traditional evaporative coolers in that it does not blow the cooled wet air into the building. Instead the cool wet air is passed through heat exchanges, allowing fresh dry air on the other side of the exchanger to be cooled and delivered into the building without increasing indoor humidity. The heat exchanger in the Climate Wizard is also backed on itself to pre-cool intake air before it is run through the wet pads. This allows the system to drop the wet-bulb temperature below that of the prevailing conditions.

When installed in the displacement arrangement, the unit can deliver enough air at fan-speed 1 to keep the house at 23*c when outside temperatures exceed 40*c. It does this only using 500W of power - half that used by a hairdryer.

3 - ENERGY EFFICIENCY AND CONSUMPTION

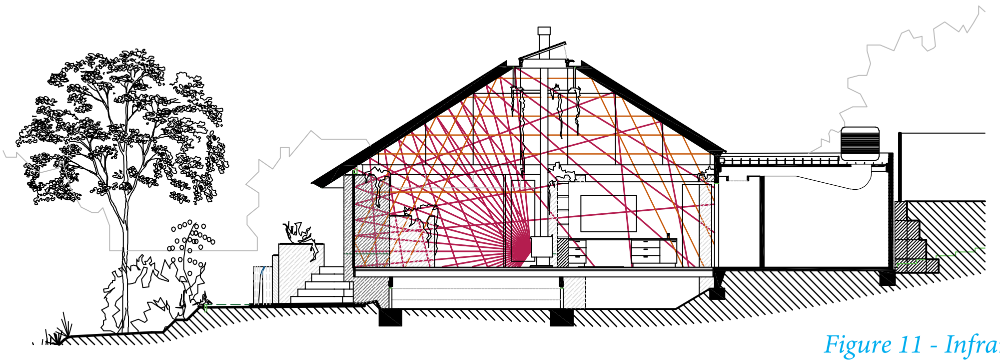


Figure 11 - Infrared Heating Diagram

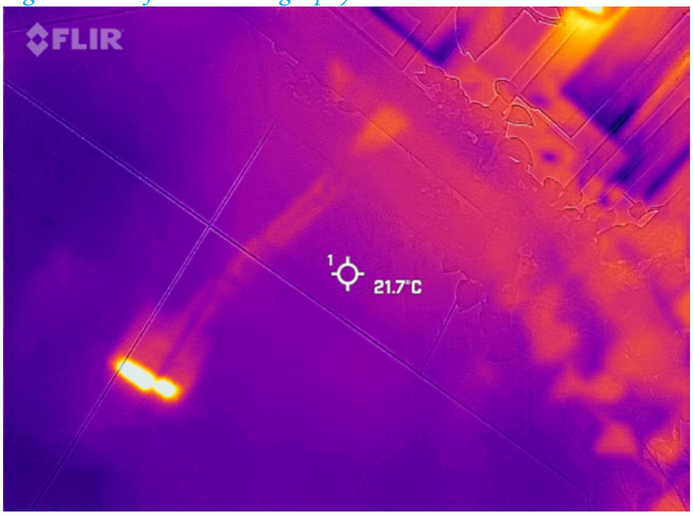
INFRARED HEATING

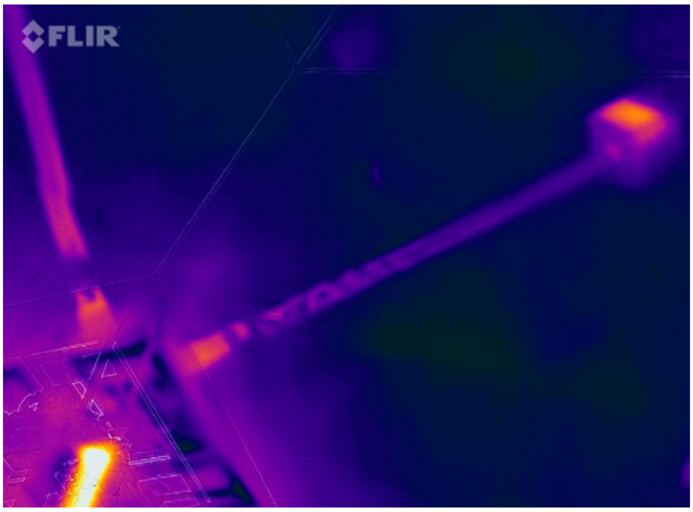
The house uses a combined main living space that accommodates all the main living areas including the kitchen, living room, activity room and the bedroom. All are heated with a centrally located wood heater. The house uses a lightweight roof structure that doesn't absorb heat, and infra-red reflective materials such as aluminium composite ceiling panels and low-e/infra-red reflective glass.

Maximum distribution is spread around the living area and kitchen where higher temperatures are desirable. Less infrared heat is distributed to the bedroom and activity rooms where cooler temperatures are desirable.

The system can achieve comfortable internal temperatures (20*c) with just a single log. See *Building Performance Charts*

Figure 12 - Infrared Photography





INFRARED REFLECTIVITY

Infrared photography of the ceiling during heating mode shows a perfect reflected image of the wood heater and flu. This demonstrates near total reflection of IR, and proves effectiveness of IR reflectivity/distribution.

3 - ENERGY EFFICIENCY AND CONSUMPTION

13.11 Is there a hot water service? If so, what type of system and power source is used?

HWS is a small capacity heat pump timed to use only solar power. Sized to ensure no unnecessary heating of water.

13.12 Is there space heating? If so, what type of system and power source is used?

Space heating is via the recycling convection wood stove only. Wood is collected from branches collected from local golf courses. No timber has ever been purchased.

3.13 Is there space cooling? If so, what type of system and power source is used?

Space Cooling is via an indirect evaporative cooler; Seeley Climate Wizard 3. This unit is installed in a displacement arrangement where fresh cooled air is delivered at low level, and the hot, stale air is exhausted at the apex of the building. This combined system never needs to exceed fan speed #1 to maintain the house at 23°c when outside temperatures reach 40°c. It does this with an electrical draw of 500W; equivalent of half the amount of a hair dryer.

3.14 Are cooking appliances included? If so, what type of systems and power sources are used?

The all electric appliances include an induction cook-top, 600mm oven.

4 - SELECTION OF BUILDING MATERIALS AND PROCESS

500 words

4.1 "Embodied Energy and Materials:
Has a WLA (Whole Life Assessment) or LCA (Life Cycle Assessment) been completed for this project? If not, please describe how you considered WLA or LCA. List any reclaimed, recycled, recyclable, local or sustainable materials. "

LCA has been completed using the eTool LCA platform. The LCA is accurately modeled based on actual receipts and actual material, time and energy usage, including power receipts and feed-in tariff information. See Appendix 2

4.2 If yes, have you achieved a carbon neutral or negative outcome with respect to project embodied carbon?

The house achieves a carbon negative life-cycle performance. With a lifetime saving of -26.7 tonnes of CO_2 See Appendix 2

4.3 What is the total amount of embodied carbon in the project (in Kgs of CO_2e)?

Embodied carbon = 76,993kg (31% of Average WA per occupant) See Appendix 2

4.4 Has selection of materials and processes considered a wide-range of environmental impacts? Including but not limited to: environmental degradation, embodied carbon, supply chain slavery.

All materials have been selected with environmental impact, embodied carbon or operational carbon being a major factor in selection.

- Where possible recycled materials have been used (Wandoo floor from Subiaco Markets, recycled jarrah cabinetry, etc.)
- Materials from Western Australia selected first, and Australia second to reduce transport CO_2 and supply chain risks
- Sequestration of CO_2 in the building structure/ timber frame.
- Minimisation of CO_2 intensive materials such as concrete, steel, bricks (single leaf, from WA clay)
- Utilisation of operationally efficient materials such as high IR reflectivity aluminium ceiling, Also very recyclable.

Figure 13 - Recycled floor installation photograph

Family and friends installing Wandoo floor from Subiaco Markets. Culturally significant, and recycled

4 - SELECTION OF BUILDING MATERIALS AND PROCESS

4.5 Does the project include strategies for maximisation of renewable and/or recyclable materials and components?

Recycled materials have been used where possible:

- Floor is recycled Wandoo from the Subiaco Markets.
- Bookshelf and cabinetry are recycled jarrah.
- Feature air-conditioning diffuser is recycled Marri.

Highly recyclable materials have also been chosen:

- The aluminum ceiling is almost 100% recyclable.
- Pavers were selected in standard format so they can easily be lifted and reused.

4.6 Where the use of a non-renewable resource has been unavoidable (e.g.: marble, coal powered steel etc), have there been any strategies for its minimisation or substitution?

- Where non-recyclable materials are required they have been minimised.
- Steel is used only for primary structure, with timber used everywhere else.
- Brick walls are single skin.
- Concrete has been limited to pad footings, a small wet area slab and retaining walls. There is some concrete used in the landscaping. In total it is a small quantity, and has been chosen because of durability.
- Paints and finishes have been minimised. Most materials are left in their natural forms.

4.7 Does the project include strategies to promote improvements in indoor air quality and reduction of off-gassing? Consider material toxicity, allergens, contribution to oxygen generation or filtration, include applicable active systems as required.

The condition of internal air quality is a major design consideration.

The house is designed as a platform in a garden and is completely porous to air movement; continuously flushed of internal air. The arrangement of the apex ventilation allow the vents to be open year-round. Stack ventilation ensures that air continues to flow through the house even when there is no wind. The house has no screens to limit airflow. (Mosquitoes are managed by fans instead)
Other initiatives include:

- An indirect evaporative cooler supplies 100% fresh outdoor air, with no air recycled.
- The house uses Low VOC paint, Latex mattresses and tatami grass floor mats.
- Large large volumes of internal planting, and a site that is heavily vegetated provides air cleaning

The absence of mechanical life support systems such as HRV or necessary recycled air filtration is deliberate. These types of systems are wasteful in a climate that is generally benign and where clean natural fresh air is so plentiful.

5 - SOCIAL ISSUES

500 words

5.1 Does the design consider the improvement of human connections through developing community and improving the quality of people's lives?

The connection between the house and its community is critical to the design.

The house is completely transparent. No fences front or rear, no gates, no window treatments. Everyday life is a part of a community of gardens and neighbours.

The architecture also addresses social context; forms, history, memories and materials, deployed to connect to place. Such as:

- Traditional roof pitch
- Floor recycled from the culturally important Subiaco Markets,
- Western Australian timbers throughout,
- Enough lawn length to kick a football.

Hand built by family and friends. Stories are wound through the building.

Figure 14 - Showing context - respectful connection to neighbours yards

5.2 Does the project include strategies to support utilisation of locally supplied and manufactured resources and skilled labour?

To establish a deeper connection to place, all materials were sourced and prioritized in a hierarchical fashion:

1. Western Australian
2. Australian
3. International

Western Australian materials are expressed and celebrated

5.3 Does the project team (design, construction, maintenance) include Indigenous businesses?
No

5 - SOCIAL ISSUES

5.4 Is there a strategy in place to prevent, as much as possible, the promulgation of modern slavery?

Use of almost exclusively Australian materials ensures suppliers are covered under the Modern Slavery Act 2018. This is our best way to minimize the risks of modern slavery. Review of reporting documents where available provides confidence.

5.5 Does this project exceed minimum industry standards for universal design?

The house is on a single level flat with minimal doors and good turning access. Unavoidable site gradient issues have resulted in a consistent low gradient stair.

5.6 Does this project demonstrably improve the users wellbeing through methods including but not limited to: improved comfort and amenity, connection to the environment/ biophilic design, personal safety?

The intention for the house was to submerge the occupants in cultural and environmental place. Research shows that both connections to environment and to community have significant benefit to occupants. Some benefits include:

- Unobstructed natural light; better promotes natural diurnal pattern
- Deliberate breaking down of the architectural form to stretch space into the garden.
- Complex natural garden (research shows 'natural' type gardens have greater benefits.

- Biophilic components:
    - Natural light: Skylights, perimeter glazing.
    - Indoor planting, overhead and at eye level. Garden below
    - Green roof
    - Views to nature: to natural garden, arranged for immersion
    - Natural materials: native wood. Raw materials like brick, concrete. All carried through the glazing line.
    - Water features: Visual, audio, kinetic. The pond is immediately present in the primary room. Reflects light onto the ceiling. Continuously flowing waterfall for sound. Visually flowing creek. Noise of frogs and birds.
    - Ventilation – through unscreened open windows and skylights
    - Gardens for different conditions; depending on prevailing conditions. Dichondra terrace, gravel terrace, grass terrace.
- Comfort and amenity
    - Only fresh air – natural ventilation and fresh air cooler. Not recycled.
    - Lighting minimized and at 3000k
    - External lighting for security and transparency.
    - Sounds of wind, birds and frogs.
    - Connected and open neighbourhood gardens
    - Property open to rear lane-way for neighbourhood conversations.

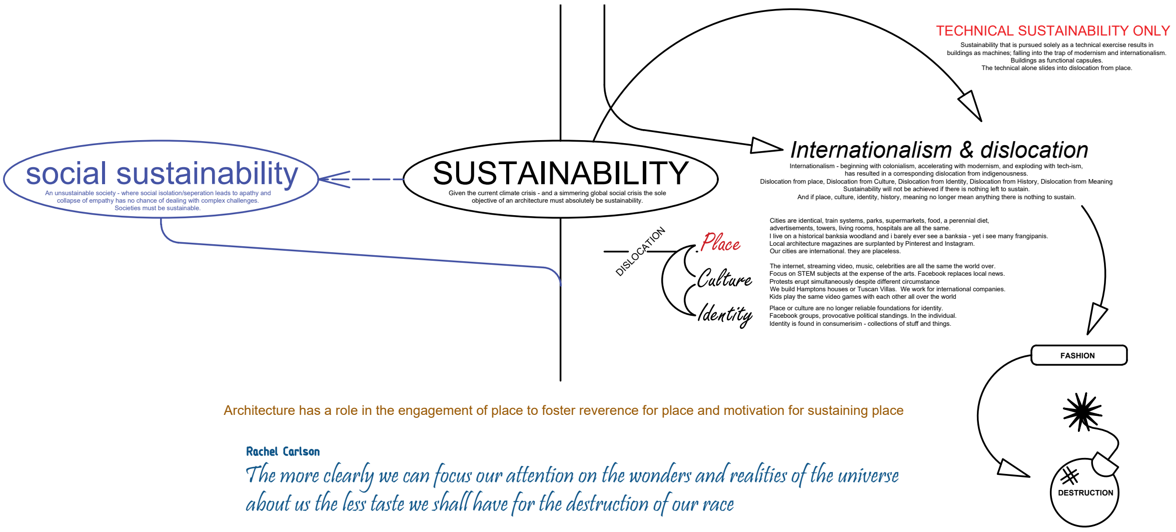
5.7 Does the project demonstrate economic sustainability? For instance, does the project represent a high level of value for the investment of funds without negatively impacting social, environmental, and cultural aspects of the community.

This is a 3 person house for $310,000 including GST. It is neighborly and contributes to the local community. It is carbon negative house with minimal water and electricity use. The very low cost is achieved in some part by being an owner builder, but mostly it is achieved through the small rational (square) footprint, and by careful internal planning that allows for more efficient space usage.

5.8 Does the design proposal contribute to local community in terms of economy, education, training, transport, etc?

The house contributes to local education through continued open houses (Emagn, AIA, Universities and Sanctuary Magazine green house open day), and through publication (HOUSES, Sanctuary)

APPENDIX 1 - Theoretical Framework

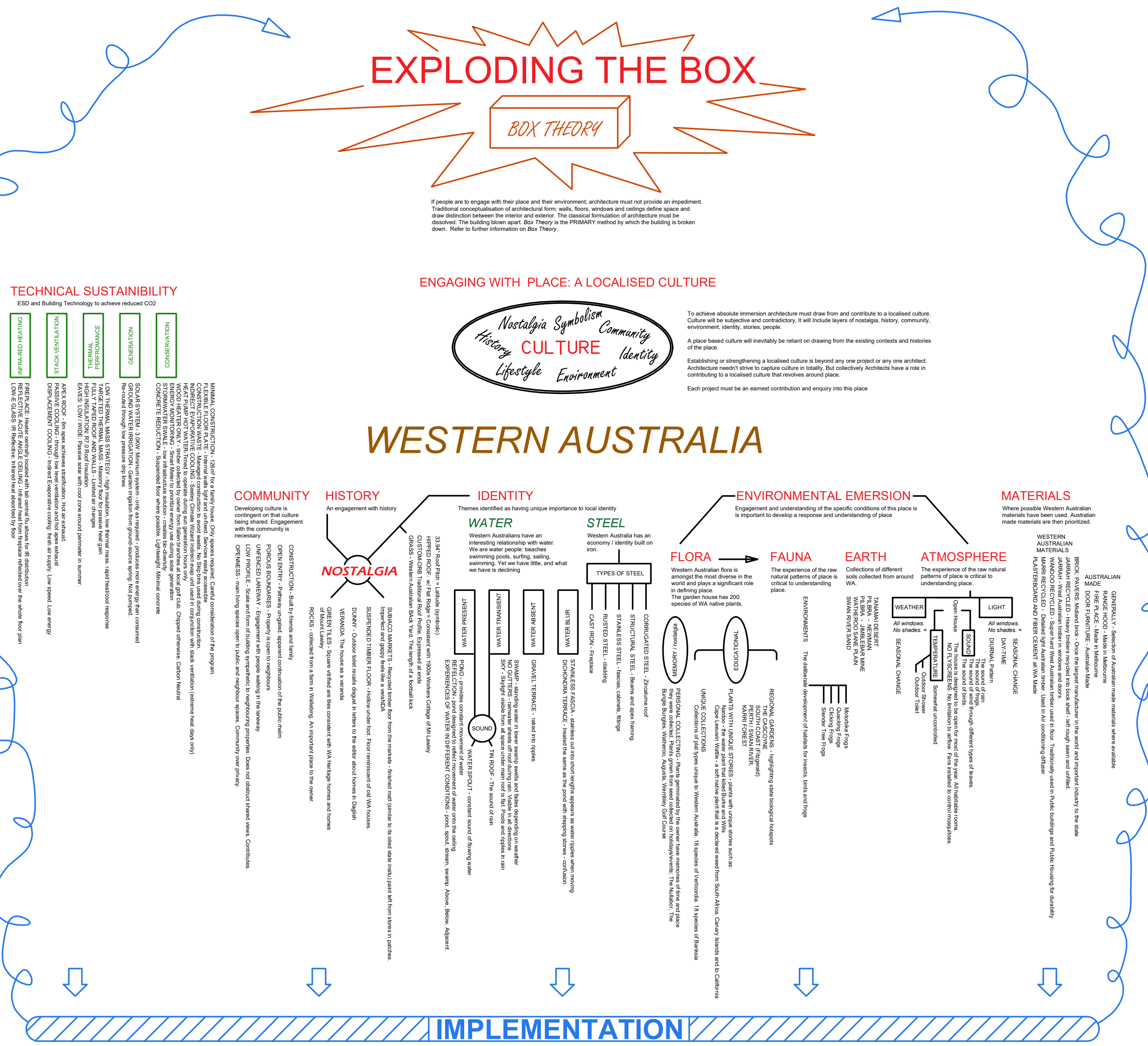


Architecture has a role in the engagement of place to foster reverence for place and motivation for sustaining place

Rachel Carlson

The more clearly we can focus our attention on the wonders and realities of the universe about us the less taste we shall have for the destruction of our race

Sustainability cannot be achieved without a culture that values the things that will be lost.



Every decision, every selection falls through the cascade to arrive at a solution that is sympathetic to the overall submersion of the occupants in place. The choices are then recycled again back through the cascade to inform their implementation through detail and application. The cascade is repeated over and over across all scales of the building and across all decisions. The recycling of the cascade eliminates arbitrary decision making. It removes the role of taste and fashion in informing the design process. The building becomes consistent and integral. It becomes immersed.

APPENDIX 2 - LCA Documents

LCA

LIFE CYCLE ASSESMENT SUMMARY

This LCA has been completed using ***eTool LCA***.

Inputs are based on **actual** delivery receipts and **actual** energy generation and consumption records.

This is a very high accuracy as-built LCA. (*significantly better than a design based LCA)*

Embodied Carbon	**76,993 kg**	• **39%** of WA Average House • **31%** of WA Average per person
Operational Carbon	-104,063 kg	• Life Cycle Carbon negative
Life Cycle Carbon	-27,070 kg	• Life Cycle Carbon negative

Additional Energy Data:

Heating/Cooling Electrical energy consumption	• 143 MJ
Other operational energy consumption (including all appliances, lighting, water heating)	• 8,136 MJ
Solar Generation	• -15,419 MJ
Net Operational Energy	• -7,140 MJ

APPENDIX 2 - LCA Documents

Life Cycle Assesment

11a pakenham st, mount lawley

eTool® CERTIFIED

A Life Cycle Assessment has been carried out on the proposed design calculating the greenhouse gas emissions over the whole life of the project as per EN 15978 scope and system boundary. The benchmark chosen to compare against is the **AU WA Res Ave Code Compl CZ 5 (10 dwellings)**. The results are summarised below:

Design Embodied Carbon
76,993 kgCO2e per Dwelling. Saving of 61%

Design Operational Carbon
-104,063 kgCO2e per Dwelling. Saving of 135%

Total Design
-27,070 kgCO2e per Dwelling. Saving of 106%

eTool PLATINUM

The Ratings Explained:

- Bronze: 0 – 30% Greenhouse gas emissions saving against the applicable benchmark
- Silver: 30 – 60% saving
- Gold: 60 – 90% saving
- Platinum: 90% saving plus gold in all categories for overall Platinum rating.

APPENDIX 2 - LCA Documents

Life Cycle Assesment

11a pakenham st, mount lawley

A Life Cycle Assessment has been carried out on the proposed design calculating the greenhouse gas emissions over the whole life of the project as per EN 15978 scope and system boundary. The benchmark chosen to compare against is the **AU WA Res Ave Code Compl CZ 5 (10 dwellings)**. The results are summarised below:

Design Embodied Carbon
25,664 kgCO2e per Occupant. Saving of 69%

Design Operational Carbon
-34,688 kgCO2e per Occupant. Saving of 128%

Total Design
-9,023 kgCO2e per Occupant. Saving of 104%

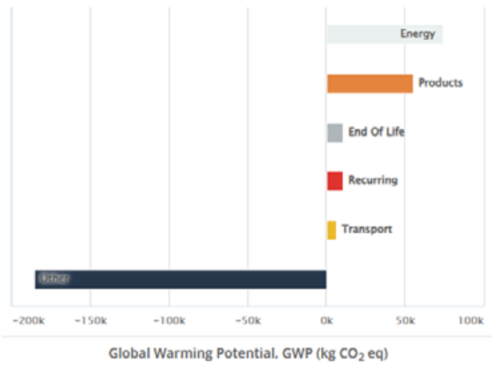
The Ratings Explained:

- Bronze: 0 – 30% Greenhouse gas emissions saving against the applicable benchmark
- Silver: 30 – 60% saving
- Gold: 60 – 90% saving
- Platinum: 90% saving plus gold in all categories for overall Platinum rating.

APPENDIX 2 - LCA Documents

Impact Summary

Global Warming Potential, GWP

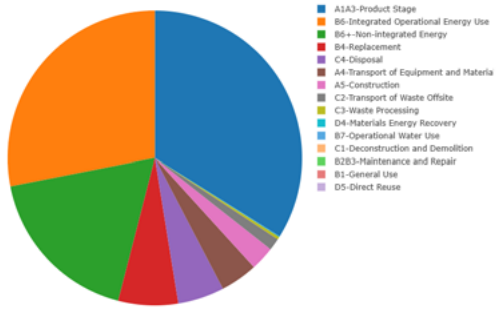


Products	55,276.5
Transport	6,665.8
Construction	4,317.4
Recurring	10,706.3
Energy	74,618.5
Water	54.4
End of Life	10,977.5
Energy Export	-178,735.9
Product Reuse	-10,950.6
Total	**-27,070.0**

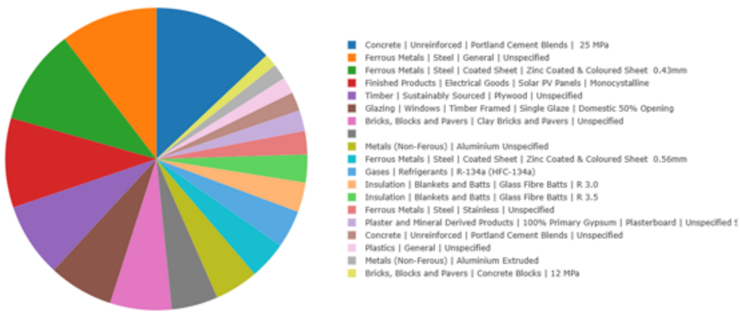
Sum of Global Warming Potential (kgCO2e), by Life Cycle Module

Design Function	A1A3 Product Stage	A4 Transport of Equipment and Materials	A5 Construction	B1 General Use	B2B3 Maintenance and Repair	B4 Replacement	B6 Integrated Operational Energy Use	B6+ Non-integrated Energy	B7 Operational Water Use	C1 Deconstruction and Demolition	C2 Transport of Waste Offsite	C3 Waste Processing	C4 Disposal	D1 Operational Energy Exports	D2 Closed Loop Recycling	D3 Open Loop Recycling
EPDs	3,425.44	372.88	34.76	0.00	0.04	0.00	0.00	0.00	0.00	6.04	81.15	0.15	57.89	0.00	0.00	0.00
House	51,851.11	6,292.93	4,282.65	0.00	0.00	10,706.28	45,415.69	29,202.78	54.44	0.00	2,079.50	490.52	8,262.25	-178,735.85	-4,040.40	-6,985.41
Totals	55,276.55	6,665.81	4,317.41	0.00	0.04	10,706.28	45,415.69	29,202.78	54.44	6.04	2,160.65	490.67	8,320.15	-178,735.85	-4,040.40	-6,985.41

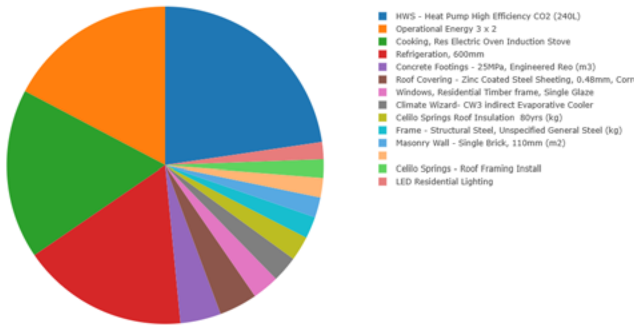
Sum of Global Warming Potential (kgCO2e), by Life Cycle Module



Sum of Global Warming Potential (kgCO2e), by Material



Sum of Global Warming Potential (kgCO2e), by Function



APPENDIX 2 - LCA Documents

2023.01.25 Top Global Warming Potential, GWP Impacts in CELILO SPRINGS

Top 50 Materials By Total Impact

Material	Initial (kg CO_2 eq)	Transport (kg CO_2 eq)	Recurring (kg CO_2 eq)	Recycling (kg CO_2 eq)	Waste Processing (kg CO_2 eq)	Disposal (kg CO_2 eq)	Total (kg CO_2 eq)
Concrete | Unreinforced | Portland Cement Blends | 25 MPa	9,300.097508	212.732625	0.000000	0.000000	143.997722	579.617945	11,096.805070
Ferrous Metals | Steel | General | Unspecified	5,349.122246	133.752750	4,304.421975	-982.464673	4.764729	5.856741	8,904.891605
Ferrous Metals | Steel | Coated Sheet | Zinc Coated & Coloured Sheet 0.43mm	4,389.421810	59.498148	4,673.084014	-431.291352	1.717676	2.971949	8,726.783826
Finished Products | Electrical Goods | Solar PV Panels | Monocystalline	1,967.832482	76.568745	4,500.049112	1,434.974772	0.000000	0.000000	8,185.048441
Timber | Sustainably Sourced | Plywood | Unspecified	1,064.532738	126.834737	3,070.882282	-159.383280	273.121390	2,319.151481	6,790.796834
Glazing | Windows | Timber Framed | Single Glaze | Domestic 50% Opening	2,901.871959	21.468530	2,957.122870	0.000000	0.662400	0.000000	5,914.245739
Bricks, Blocks and Pavers | Clay Bricks and Pavers | Unspecified	4,800.221359	297.887951	0.000000	0.000000	25.380632	198.671153	5,631.102574
Metals (Non-Ferous) | Aluminium Unspecified	1,671.099631	65.628034	3,643.453972	-1,421.816313	0.336979	0.566122	3,992.400168
Ferrous Metals | Steel | Coated Sheet | Zinc Coated & Coloured Sheet 0.56mm	3,546.602730	48.069935	0.000000	-170.732053	1.350818	1.660408	3,452.307796
Gases | Refrigerants | R-134a (HFC-134a)	29.656081	2.305615	3,010.473866	0.000000	7.806000	390.300000	3,440.541561
Insulation | Blankets and Batts | Glass Fibre Batts | R 3.0	1,331.984946	14.814360	1,358.120454	0.000000	0.221983	4.467623	2,716.240908
Insulation | Blankets and Batts | Glass Fibre Batts | R 3.5	1,258.568453	7.613426	1,276.879026	0.000000	0.209748	4.221376	2,553.758052
Ferrous Metals | Steel | Stainless | Unspecified	619.932578	4.910695	1,626.607021	-110.951336	0.172997	0.302766	2,144.131898
Plaster and Mineral Derived Products | 100% Primary Gypsum | Plasterboard | Unspecified Sheets	592.851637	17.809594	1,271.368752	0.000000	3.263889	8.758511	1,907.053128
Concrete | Unreinforced | Portland Cement Blends | Unspecified	1,307.505962	196.753742	1.946036	0.000000	19.092777	76.852023	1,716.226290
Plastics | General | Unspecified	189.609049	2.230529	1,307.164137	0.000000	0.296754	0.597246	1,500.784242
Metals (Non-Ferous) | Aluminium Extruded	1,766.239551	27.931490	0.000000	-410.162691	0.298715	0.501839	1,414.178521
Bricks, Blocks and Pavers | Concrete Blocks | 12 MPa	752.322558	309.777440	0.000000	0.000000	0.000000	45.731572	1,178.945967
Ferrous Metals | Steel | Reinforcement bar | Unspecified	986.020677	8.565805	0.000000	124.304926	1.039844	1.050654	1,140.728129
Timber | Sustainably Sourced | Plywood | Outdoor	134.173584	15.986236	566.149993	4.978378	54.259588	355.743847	1,137.278363
Plaster and Mineral Derived Products | 100% Primary Gypsum | Plasterboard | 12mm Sheets	501.824661	17.765497	540.771227	0.000000	2.762748	7.413721	1,081.542453
Plastics | Polypropylene | Injection Moulding	104.077734	11.358608	866.718598	0.000000	0.110292	0.221974	982.816695
Cementitious Binders | Mortars and Renders | 1 cement : 4 sand	771.767012	52.539335	0.000000	0.000000	6.144109	24.731196	891.891547
Carpets and Floor Coverings | Vinyl (PVC) | Unspecified	175.726204	44.064414	667.137615	0.000000	0.431431	0.844275	889.516820
Metals (Non-Ferous) | Copper Unspecified	252.371090	95.465849	952.048426	-469.608580	3.352054	1.153839	878.322900
Ceramics | Tiles | Ceramic Tiles	136.746816	92.972730	610.634347	0.000000	0.734992	1.972321	845.988831
Paints and Finishes | Unspecified | 1 Coat	134.010590	23.971653	670.245620	0.000000	0.185575	0.497982	829.650600
Plastics | Polystyrene | Expanded Polystyrene	85.428411	9.323299	673.307632	0.000000	0.090530	0.182199	768.602520
Bulk Aggregates Sands and Soils | Sand | Unspecified	289.539058	278.051279	0.000000	0.000000	24.052864	65.665846	751.995630
Paints and Finishes | Wood Stains and Finishes | General	43.445143	9.272356	585.974222	0.000000	0.072115	0.193518	639.244606
Rubber | Synthetic	122.107666	17.111022	446.121405	0.000000	0.088385	0.355768	586.312333
Plastics | Polyurethane | Unspecified	62.808893	6.692162	489.233410	0.000000	0.064905	0.130628	559.123898
Plastics | Polyvinyl Chloride (PVC) | Unspecified	89.369358	22.166448	472.277913	-47.572884	0.896148	0.355534	541.617720
Finished Products | Electrical Goods | Solar Inverters | Solar Inverter Commercial (20kW)	64.657353	1.731786	354.374038	70.334191	0.000000	0.000000	495.583037
Plastics | ABS | Unspecified	59.873284	0.574722	430.105463	0.000000	0.060065	0.102626	490.913860
Insulation | Blankets and Batts | Glass Fibre Batts | R 2.0	230.737550	1.395795	234.094488	0.000000	0.038454	0.773919	468.188976

APPENDIX 2 - LCA Documents

Material	Initial (kg CO_2 eq)	Transport (kg CO_2 eq)	Recurring (kg CO_2 eq)	Recycling (kg CO_2 eq)	Waste Processing (kg CO_2 eq)	Disposal (kg CO_2 eq)	Total (kg CO_2 eq)
Ceramics | Porcelain Sanitary Products | Bath	177.660268	36.330832	216.046282	0.000000	0.000000	0.762193	432.092565
Timber | Sustainably Sourced | Medium Density Fibreboard (MDF) | Unspecified	-654.201509	30.248238	237.325938	11.931804	101.191355	663.444072	401.104858
Ceramics | Porcelain Sanitary Products | Toilet	136.661745	26.810937	165.012150	0.000000	0.000000	0.586302	330.024299
Plastics | High Density Polyethylene (HDPE) | Unspecified	289.740703	34.246767	0.927873	0.000000	0.567343	0.640831	328.319397
Ferrous Metals | Steel | Coated Sheet | Galvanised (zinc coated)	346.362228	4.693449	0.000000	-30.137372	0.239637	0.294558	325.950675
Insulation | Blankets and Batts | Glass Fibre Batts | Unspecified	155.642965	1.731064	158.696910	0.000000	0.025939	0.522043	317.393819
Insulation | Rigid Foams and Boards | Polystyrene | Unspecified EPS	304.176294	2.913936	0.000000	0.000000	0.252266	0.676945	309.024267
Plastics | Nylon | Unspecified	58.820163	3.446394	252.165394	-23.486224	0.130063	0.051601	291.726106
Glazing | Windows | PVC Framed | PVC Only | Double Glaze | Commercial 50% Opening	102.120470	39.237453	143.679239	0.000000	0.045516	0.890710	287.358478
Resins and Adhesives | Melamine Resin	97.602602	9.773750	155.052944	0.000000	0.104492	0.193761	263.056247
Timber | Sustainably Sourced | General | Unspecified	-698.278817	45.752002	123.243786	12.178989	34.271692	718.785254	248.049191
Insulation | Rigid Foams and Boards | Polyurethane | Polyurethane	29.864670	0.282698	212.327757	0.000000	0.024152	0.064812	242.660293
Glazing | Glass and Films | Flat Glass	41.953498	2.067746	190.033839	0.000000	0.060059	0.445472	235.316317
Finished Products | Electrical Goods | Electronics | Electronics For Control Unit	17.878013	0.345763	182.237763	0.000000	0.000000	0.000000	200.461539

Top 50 Materials By Transport Impact

Material	Initial (kg CO_2 eq)	Transport (kg CO_2 eq)	Recurring (kg CO_2 eq)	Recycling (kg CO_2 eq)	Waste Processing (kg CO_2 eq)	Disposal (kg CO_2 eq)	Total (kg CO_2 eq)
Bricks, Blocks and Pavers | Concrete Blocks | 12 MPa	752.322558	309.777440	0.000000	0.000000	0.000000	45.731572	1,178.945967
Bricks, Blocks and Pavers | Clay Bricks and Pavers | Unspecified	4,800.221359	297.887951	0.000000	0.000000	25.380632	198.671153	5,631.102574
Bulk Aggregates Sands and Soils | Sand | Unspecified	289.539058	278.051279	0.000000	0.000000	24.052864	65.665846	751.995630
Concrete | Unreinforced | Portland Cement Blends | 25 MPa	9,300.097508	212.732625	0.000000	0.000000	143.997722	579.617945	11,096.805070
Concrete | Unreinforced | Portland Cement Blends | Unspecified	1,307.505962	196.753742	1.946036	0.000000	19.092777	76.852023	1,716.226290
Ferrous Metals | Steel | General | Unspecified	5,349.122246	133.752750	4,304.421975	-982.464673	4.764729	5.856741	8,904.891605
Timber | Sustainably Sourced | Plywood | Unspecified	1,064.532738	126.834737	3,070.882282	-159.383280	273.121390	2,319.151481	6,790.796834
Timber | Sustainably Sourced | Softwood | Unspecified	-1,304.669453	111.640122	41.537783	-179.363710	101.232045	1,194.961709	99.049426
Metals (Non-Ferous) | Copper Unspecified	252.371090	95.465849	952.048426	-469.608580	3.352054	1.153839	878.322900
Ceramics | Tiles | Ceramic Tiles	136.746816	92.972730	610.634347	0.000000	0.734992	1.972321	845.988831
Finished Products | Electrical Goods | Solar PV Panels | Monocystalline	1,967.832482	76.568745	4,500.049112	1,434.974772	0.000000	0.000000	8,185.048441
Metals (Non-Ferous) | Aluminium Unspecified	1,671.099631	65.628034	3,643.453972	-1,421.816313	0.336979	0.566122	3,992.400168
Timber | Sustainably Sourced | Particle Board | Unspecified	-1,799.583452	61.114428	0.000000	9.516021	0.000000	1,563.985697	-138.647321
Ferrous Metals | Steel | Coated Sheet | Zinc Coated & Coloured Sheet 0.43mm	4,389.421810	59.498148	4,673.084014	-431.291352	1.717676	2.971949	8,726.783826
Cementitious Binders | Mortars and Renders | 1 cement : 4 sand	771.767012	52.539335	0.000000	0.000000	6.144109	24.731196	891.891547
Ferrous Metals | Steel | Coated Sheet | Zinc Coated & Coloured Sheet 0.56mm	3,546.602730	48.069935	0.000000	-170.732053	1.350818	1.660408	3,452.307796
Timber | Sustainably Sourced | General | Unspecified	-698.278817	45.752002	123.243786	12.178989	34.271692	718.785254	248.049191
Carpets and Floor Coverings | Vinyl (PVC) | Unspecified	175.726204	44.064414	667.137615	0.000000	0.431431	0.844275	889.516820
Glazing | Windows | PVC Framed | PVC Only | Double Glaze | Commercial 50% Opening	102.120470	39.237453	143.679239	0.000000	0.045516	0.890710	287.358478
Ceramics | Porcelain Sanitary Products | Bath	177.660268	36.330832	216.046282	0.000000	0.000000	0.762193	432.092565
Plastics | High Density Polyethylene (HDPE) | Unspecified	289.740703	34.246767	0.927873	0.000000	0.567343	0.640831	328.319397
Timber | Sustainably Sourced | Medium Density Fibreboard (MDF) | Unspecified	-654.201509	30.248238	237.325938	11.931804	101.191355	663.444072	401.104858

APPENDIX 2 - LCA Documents

Material	Initial (kg CO_2 eq)	Transport (kg CO_2 eq)	Recurring (kg CO_2 eq)	Recycling (kg CO_2 eq)	Waste Processing (kg CO_2 eq)	Disposal (kg CO_2 eq)	Total (kg CO_2 eq)
Metals (Non-Ferous) | Aluminium Extruded	1,766.239551	27.931490	0.000000	-410.162691	0.298715	0.501839	1,414.178521
Ceramics | Porcelain Sanitary Products | Toilet	136.661745	26.810937	165.012150	0.000000	0.000000	0.586302	330.024299
Paints and Finishes | Unspecified | 1 Coat	134.010590	23.971653	670.245620	0.000000	0.185575	0.497982	829.650600
Plastics | Polyvinyl Chloride (PVC) | Unspecified	89.369358	22.166448	472.277913	-47.572884	0.896148	0.355534	541.617720
Glazing | Windows | Timber Framed | Single Glaze | Domestic 50% Opening	2,901.871959	21.468530	2,957.122870	0.000000	0.662400	0.000000	5,914.245739
Plaster and Mineral Derived Products | 100% Primary Gypsum | Plasterboard | Unspecified Sheets	592.851637	17.809594	1,271.368752	0.000000	3.263889	8.758511	1,907.053128
Plaster and Mineral Derived Products | 100% Primary Gypsum | Plasterboard | 12mm Sheets	501.824661	17.765497	540.771227	0.000000	2.762748	7.413721	1,081.542453
Rubber | Synthetic	122.107666	17.111022	446.121405	0.000000	0.088385	0.355768	586.312333
Timber | Sustainably Sourced | Plywood | Outdoor	134.173584	15.986236	566.149993	4.978378	54.259588	355.743847	1,137.278363
Insulation | Blankets and Batts | Glass Fibre Batts | R 3.0	1,331.984946	14.814360	1,358.120454	0.000000	0.221983	4.467623	2,716.240908
Plastics | Polyvinyl Chloride (PVC) | PVC Pipe	52.866681	13.112621	0.000000	-5.584171	0.530118	0.210317	63.575842
Timber | Sustainably Sourced | Recycled | Unspecified	90.279030	12.383631	90.799527	-74.353158	0.512151	0.000000	170.836305
Plastics | Polypropylene | Injection Moulding	104.077734	11.358608	866.718598	0.000000	0.110292	0.221974	982.816695
Resins and Adhesives | Melamine Resin	97.602602	9.773750	155.052944	0.000000	0.104492	0.193761	263.056247
Plastics | Polystyrene | Expanded Polystyrene	85.428411	9.323299	673.307632	0.000000	0.090530	0.182199	768.602520
Paints and Finishes | Wood Stains and Finishes | General	43.445143	9.272356	585.974222	0.000000	0.072115	0.193518	639.244606
Ferrous Metals | Steel | Reinforcement bar | Unspecified	986.020677	8.565805	0.000000	124.304926	1.039844	1.050654	1,140.728129
Bulk Aggregates Sands and Soils | Aggregate | Recycled Building Rubble (Compacted)	26.728563	8.521792	0.000000	19.540251	0.000000	0.000000	88.215740
Plant Based Products (non Timber) | Mulch | Green Waste	-974.099080	8.003596	-37,677.723879	0.000000	0.000000	0.000000	-38,643.819363
Insulation | Blankets and Batts | Glass Fibre Batts | R 3.5	1,258.568453	7.613426	1,276.879026	0.000000	0.209748	4.221376	2,553.758052
Resins and Adhesives | Epoxy Resin	86.747348	7.351203	94.098551	0.000000	0.000000	0.000000	188.197101
Plastics | Polyurethane | Unspecified	62.808893	6.692162	489.233410	0.000000	0.064905	0.130628	559.123898
Ceramics | Porcelain Sanitary Products | Bathroom Sink	32.798819	6.162019	39.320364	0.000000	0.000000	0.140713	78.640729
Paints and Finishes | Water Based | 1 Coat	34.080116	5.894528	40.336459	0.000000	0.047193	0.126641	80.672918
Ferrous Metals | Iron | Unspecified	9.187899	5.788411	111.006731	-14.077229	0.292797	0.038161	116.102566
Resins and Adhesives | Urea Formaldehyde	26.415865	4.946437	118.312062	0.000000	0.046661	0.086525	149.954333
Ferrous Metals | Steel | Stainless | Unspecified	619.932578	4.910695	1,626.607021	-110.951336	0.172997	0.302766	2,144.131898
Ferrous Metals | Steel | Coated Sheet | Galvanised (zinc coated)	346.362228	4.693449	0.000000	-30.137372	0.239637	0.294558	325.950675

Top 50 Materials By Recurring Impact

Material	Initial (kg CO_2 eq)	Transport (kg CO_2 eq)	Recurring (kg CO_2 eq)	Recycling (kg CO_2 eq)	Waste Processing (kg CO_2 eq)	Disposal (kg CO_2 eq)	Total (kg CO_2 eq)
Ferrous Metals | Steel | Coated Sheet | Zinc Coated & Coloured Sheet 0.43mm	4,389.421810	59.498148	4,673.084014	-431.291352	1.717676	2.971949	8,726.783826
Finished Products | Electrical Goods | Solar PV Panels | Monocystalline	1,967.832482	76.568745	4,500.049112	1,434.974772	0.000000	0.000000	8,185.048441
Ferrous Metals | Steel | General | Unspecified	5,349.122246	133.752750	4,304.421975	-982.464673	4.764729	5.856741	8,904.891605
Metals (Non-Ferous) | Aluminium Unspecified	1,671.099631	65.628034	3,643.453972	-1,421.816313	0.336979	0.566122	3,992.400168
Timber | Sustainably Sourced | Plywood | Unspecified	1,064.532738	126.834737	3,070.882282	-159.383280	273.121390	2,319.151481	6,790.796834
Gases | Refrigerants | R-134a (HFC-134a)	29.656081	2.305615	3,010.473866	0.000000	7.806000	390.300000	3,440.541561
Glazing | Windows | Timber Framed | Single Glaze | Domestic 50% Opening	2,901.871959	21.468530	2,957.122870	0.000000	0.662400	0.000000	5,914.245739
Ferrous Metals | Steel | Stainless | Unspecified	619.932578	4.910695	1,626.607021	-110.951336	0.172997	0.302766	2,144.131898
Insulation | Blankets and Batts | Glass Fibre Batts | R 3.0	1,331.984946	14.814360	1,358.120454	0.000000	0.221983	4.467623	2,716.240908

APPENDIX 2 - LCA Documents

Material	Initial (kg CO_2 eq)	Transport (kg CO_2 eq)	Recurring (kg CO_2 eq)	Recycling (kg CO_2 eq)	Waste Processing (kg CO_2 eq)	Disposal (kg CO_2 eq)	Total (kg CO_2 eq)
Plastics | General | Unspecified	189.609049	2.230529	1,307.164137	0.000000	0.296754	0.597246	1,500.784242
Insulation | Blankets and Batts | Glass Fibre Batts | R 3.5	1,258.568453	7.613426	1,276.879026	0.000000	0.209748	4.221376	2,553.758052
Plaster and Mineral Derived Products | 100% Primary Gypsum | Plasterboard | Unspecified Sheets	592.851637	17.809594	1,271.368752	0.000000	3.263889	8.758511	1,907.053128
Metals (Non-Ferous) | Copper Unspecified	252.371090	95.465849	952.048426	-469.608580	3.352054	1.153839	878.322900
Plastics | Polypropylene | Injection Moulding	104.077734	11.358608	866.718598	0.000000	0.110292	0.221974	982.816695
Plastics | Polystyrene | Expanded Polystyrene	85.428411	9.323299	673.307632	0.000000	0.090530	0.182199	768.602520
Paints and Finishes | Unspecified | 1 Coat	134.010590	23.971653	670.245620	0.000000	0.185575	0.497982	829.650600
Carpets and Floor Coverings | Vinyl (PVC) | Unspecified	175.726204	44.064414	667.137615	0.000000	0.431431	0.844275	889.516820
Ceramics | Tiles | Ceramic Tiles	136.746816	92.972730	610.634347	0.000000	0.734992	1.972321	845.988831
Paints and Finishes | Wood Stains and Finishes | General	43.445143	9.272356	585.974222	0.000000	0.072115	0.193518	639.244606
Timber | Sustainably Sourced | Plywood | Outdoor	134.173584	15.986236	566.149993	4.978378	54.259588	355.743847	1,137.278363
Plaster and Mineral Derived Products | 100% Primary Gypsum | Plasterboard | 12mm Sheets	501.824661	17.765497	540.771227	0.000000	2.762748	7.413721	1,081.542453
Plastics | Polyurethane | Unspecified	62.808893	6.692162	489.233410	0.000000	0.064905	0.130628	559.123898
Plastics | Polyvinyl Chloride (PVC) | Unspecified	89.369358	22.166448	472.277913	-47.572884	0.896148	0.355534	541.617720
Rubber | Synthetic	122.107666	17.111022	446.121405	0.000000	0.088385	0.355768	586.312333
Plastics | ABS | Unspecified	59.873284	0.574722	430.105463	0.000000	0.060065	0.102626	490.913860
Finished Products | Electrical Goods | Solar Inverters | Solar Inverter Commercial (20kW)	64.657353	1.731786	354.374038	70.334191	0.000000	0.000000	495.583037
Plastics | Nylon | Unspecified	58.820163	3.446394	252.165394	-23.486224	0.130063	0.051601	291.726106
Timber | Sustainably Sourced | Medium Density Fibreboard (MDF) | Unspecified	-654.201509	30.248238	237.325938	11.931804	101.191355	663.444072	401.104858
Insulation | Blankets and Batts | Glass Fibre Batts | R 2.0	230.737550	1.395795	234.094488	0.000000	0.038454	0.773919	468.188976
Ceramics | Porcelain Sanitary Products | Bath	177.660268	36.330832	216.046282	0.000000	0.000000	0.762193	432.092565
Insulation | Rigid Foams and Boards | Polyurethane | Polyurethane	29.864670	0.282698	212.327757	0.000000	0.024152	0.064812	242.660293
Glazing | Glass and Films | Flat Glass	41.953498	2.067746	190.033839	0.000000	0.060059	0.445472	235.316317
Finished Products | Electrical Goods | Electronics | Electronics For Control Unit	17.878013	0.345763	182.237763	0.000000	0.000000	0.000000	200.461539
Ceramics | Porcelain Sanitary Products | Toilet	136.661745	26.810937	165.012150	0.000000	0.000000	0.586302	330.024299
Insulation | Blankets and Batts | Glass Fibre Batts | Unspecified	155.642965	1.731064	158.696910	0.000000	0.025939	0.522043	317.393819
Resins and Adhesives | Melamine Resin	97.602602	9.773750	155.052944	0.000000	0.104492	0.193761	263.056247
Glazing | Windows | PVC Framed | PVC Only | Double Glaze | Commercial 50% Opening	102.120470	39.237453	143.679239	0.000000	0.045516	0.890710	287.358478
Timber | Sustainably Sourced | General | Unspecified	-698.278817	45.752002	123.243786	12.178989	34.271692	718.785254	248.049191
Resins and Adhesives | Urea Formaldehyde	26.415865	4.946437	118.312062	0.000000	0.046661	0.086525	149.954333
Ferrous Metals | Iron | Unspecified	9.187899	5.788411	111.006731	-14.077229	0.292797	0.038161	116.102566
Resins and Adhesives | Epoxy Resin	86.747348	7.351203	94.098551	0.000000	0.000000	0.000000	188.197101
Timber | Sustainably Sourced | Recycled | Unspecified	90.279030	12.383631	90.799527	-74.353158	0.512151	0.000000	170.836305
Plastics | Polyvinyl Chloride (PVC) | PVC Injection Moulding	13.676577	3.392227	89.890127	-8.702600	0.137141	0.054409	99.079179
Timber | Unspecified Supply | Medium Density Fibreboard (MDF) | Unspecified	11.804319	0.717798	74.512846	0.296246	1.606369	10.531890	99.646708
Timber | Sustainably Sourced | Softwood | Unspecified	-1,304.669453	111.640122	41.537783	-179.363710	101.232045	1,194.961709	99.049426
Paints and Finishes | Water Based | 1 Coat	34.080116	5.894528	40.336459	0.000000	0.047193	0.126641	80.672918
Ceramics | Porcelain Sanitary Products | Bathroom Sink	32.798819	6.162019	39.320364	0.000000	0.000000	0.140713	78.640729
Finished Products | Electrical Goods | Light Fittings | Flourescent Globes	2.604009	0.916287	24.642072	0.000000	0.000000	0.000000	28.162367
Insulation | Blankets and Batts | Mineral Wool | Blanket | R 1.5	3.845626	0.042771	23.526496	0.000000	0.000641	0.012899	27.447579
Asphalt and Bitumen | Asphalt hot mix | 5.50% primary bitumen, (0% RAP)	0.891716	0.164602	10.844378	0.000000	0.027203	0.111397	12.199926

APPENDIX 2 - LCA Documents

Top 50 Equipment and People By Total Impact

Equipment	Energy Consumption (kg CO_2 eq)	Transport (kg CO_2 eq)	Recurring (kg CO_2 eq)	Deconstruction (kg CO_2 eq)	Total (kg CO_2 eq)
Front End Loader, Articulated, 25t, Diesel	1,967.354416	983.677208	0.000000	0.000000	2,951.031624
Crane, Diesel	536.650566	526.151167	1,150.538008	0.000000	2,213.339741
Electrical Equipment, Small with transport and tradestaff, Electricity	156.717854	564.014461	1,135.561738	0.000000	1,856.294053
Trench Digger / Miniloader, Diesel	187.991644	146.590368	434.275271	0.000000	768.857283
Electrical Equipment, Large with transport and tradestaff, Electricity	379.075296	130.753753	139.511560	0.000000	649.340609
Elevated work platform, Diesel	76.945417	26.522852	413.873077	0.000000	517.341346
Offsite Manufacturing / Prefabrication Process, Electricity	121.484601	0.000000	349.686670	0.000000	471.171271
Trade Staff (No Equipment, labour transport only), Electricity	0.000000	28.417342	338.166365	0.000000	366.583706
Concrete Pump, Diesel	12.777525	348.112434	0.000000	0.000000	360.889959
Laser Machining Metal Offsite, Electricity	24.420594	11.062235	0.000000	0.000000	35.482828
Professional Labour, Electricity	0.000000	1.420867	4.262601	0.000000	5.683468
Trade Staff (No Travel, no travel, cost only), Electricity	0.000000	0.000000	0.000000	0.000000	0.000000

Top 50 Operational Energy Categories By Lifetime Impact

Category		Annual Demand (MJ)	Annual Impact (kg CO_2 eq)	Lifetime Impact (kg CO_2 eq)
Domestic Water Heating		2,487.000000	589.507355	47,160.588429
Cooking and Food Preparation		1,882.976471	446.332320	35,706.585585
Refrigeration		1,540.000000	365.034711	29,202.776912
Miscellaneous		1,059.000000	251.020623	20,081.649838
Appliances | Laundry Appliances		464.000000	109.984484	8,798.758758
Appliances | Entertainment		464.000000	109.984484	8,798.758758
HVAC		201.818800	48.430630	3,874.450417
Lighting		200.000000	47.407105	3,792.568430
Power Generation and Storage		-15,419.000000	-3,263.880472	-261,110.437772

Top 50 EPDs

Name	LCI Source Portability	Product Life	Quantity	Units	Lifetime Impact (kg CO_2 eq)
Humes Reinforced Concrete Pipe - Spun pipe NSW/VIC/SA/WA/TAS - Class 2	Global	200	12640	kg	3,978.350711
Mitsubishi Alpolic	Global	120	149	m2	276.395000

The LCA predictions of embodied and operational impacts (including costs) conducted in eTool software, by their very nature, cannot be exact. It is not possible to track all the impacts associated with a product or service back through history, let alone do this accurately. The software has been built and tested to enable informed decision making process when comparing design options. Generic cost and environmental indicator coefficients do not necessarily correspond to those of individual brands of the same product or service due to differences within industries in the way these products and services are delivered. eTool PTY LTD cannot make assurances regarding the accuracy of these reports for the above reasons.

APPENDIX 3 - Synergy Energy Report

synergy

Account number: 000XXXXXXXX

Consumption History

Billing period end date	Number of billing days	Average daily usage	Total usage for period	Amount	Solar export (units)	CO2
21 Dec 2022	58	3.8	223	85.74	614.400	219
24 Oct 2022	61	5.9	359	144.92	401.304	351
24 Aug 2022	58	8.4	488	195.65	188.002	479
27 Jun 2022	61	7.1	435	177.72	194.244	426
27 Apr 2022	64	4.3	277	123.33	354.505	272
22 Feb 2022	64	7.3	468	145.39	827.253	458
20 Dec 2021	60	3.2	189	67.25	719.506	185
21 Oct 2021	59	3.6	213	93.22	439.087	209
23 Aug 2021	60	4.8	288	133.28	196.556	282
24 Jun 2021	62	3.4	213	104.43	293.468	208
23 Apr 2021	63	4.3	269	103.04	554.184	263
19 Feb 2021	65	3.4	218	67.78	873.578	214

Average Measured Annual Grid Consumption = 1820kWh
Average Measured Annual Grid Export = -2828kWh
Average Measured Net Energy Consumption = -1009kWh
Average Measured Net Energy consumption/m2 = -8kWh/m2/yr

NOTES:
Synergy data is provided over a 2 year period due to a number of unusal occurances that dont accurately reflect actual usage of the house under normal circumstances:

1) Baby born in March 2022 - As a result energy use in March and onward has included a lot of boiling for steralising bottles and equipment
2) January and February 2022 a heatwave occured. The house had not yet had the evaporative air conditioner installed.
A temporary portable air conditioner was brought into the house. The operation of which resulted in much higher energy usage than would have been observed had the permanent indirect evaporative air conditioning system been available.

For fair comparison a corrected calculation has been provided to represent probable energy usage.
This calculation is based on Feb through Dec 2021 + 10% + 25 days running indirect evaporative cooler @ 500W for 7 hours/day

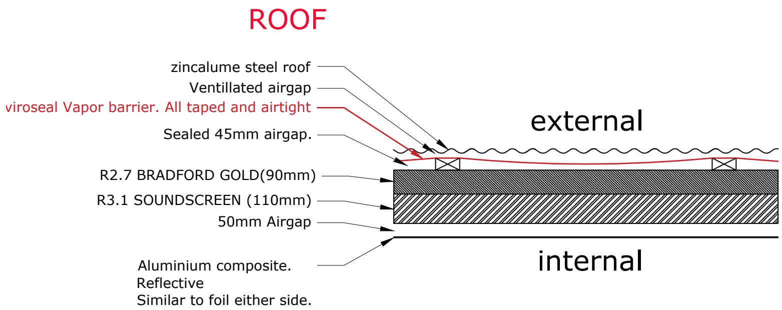
Corrected Average Annual Grid Consumption = 1616kWh
Corrected Average Annual Grid Export = -2828kWh
Corrected Average Net Energy Consumption = -1212kWh
Corrected Average Net Energy consumption/m2 = -9.7kWh/m2/yr

Corrected Average Net Energy Consumption Per Person= -404kWh

APPENDIX 4 - System R-Values

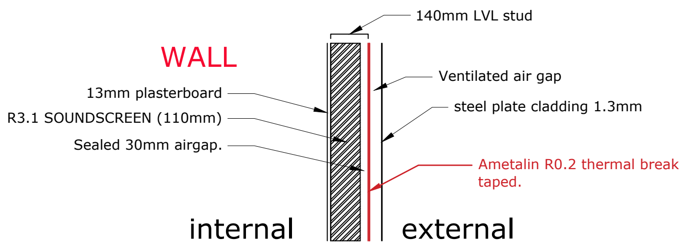
ROOF = R6.87

- Outdoor air film – 0.04
- Metal cladding – 0.00
- Vapour Barrier – 0.00
- 45mm air gap – 0.21 (downwards)
- Bradford Gold Soundscreen – 2.7
- Soundscreen – 3.1
- Air gap – 0.51 (still air reflective)
- Reflective composite layer – 0.15
- Indoor air – 0.16



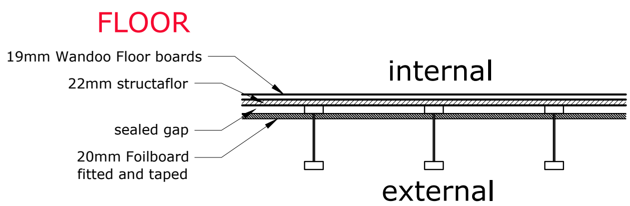
WALL = R5.09

- Outdoor air film – 0.04
- Airspace Reflective – 0.51
- Ametalin insulation – 0.2
- Airspace Reflective – 0.6
- Soundscreen – 3.1
- Plasterboard – 0.6
- Indoor air film – 0.12



FLOOR = R1.5

- Indoor air film – 0.16
- Floorboards – 0.12
- Structafloor – 0.15
- Air gap Reflective – 0.51
- Foilboard 20 – 0.52
- Outdoor air film – 0.04



APPENDIX 5 - NatHERS EQUIVALENCY CALCS.

NatHERS modelling software uses assumptions about how a building is occupied and operated. These assumptions are suitable for project homes (for which NatHERS is aimed), but are less suitable for houses with specific and customised occupation patterns or innovative sustainability features.

Celilo Springs uses innovations such as stack ventilation, displacement cooling, infrared heating, open plan/volumes, and it is designed with specific occupation patterns: intended to be unoccupied during office hours, with cooler nights and warmer days.

The standard NatHERS rating was never going to be reflective of the actual performance of the building, and so the building was assessed against the reference building.

NatHERS star ratings are models only, and do not reflect real-world performance of the building. They are not ideal well suited for determination of actual building performance.

It is however possible to compare actual energy consumption against the NatHers Star Band Criteria.

In the case of Celilo Springs, the wood heater is difficult to quantify – but all attempts have been made to develop a realistic and fair comparison based on actual performance records.

NOTE:
The Sustainability Checklist 3.2 asks for kWh/m2/yr – which is a measurement of electrical energy. Given that no electricity is used for heating, the heating/cooling electrical load represents the cooling electrical consumption only = 0.3kWh/m2/yr

CALCULATIONS

COOLING:
Records show that internal temperature remains comfortable when external maximums are below 37°c. BOM records only provide records for days exceeding 35°c. Days exceeding 35°c will be used for calculations

Climate Wizard measured energy consumption:	250W
Average days over 35°c per BOM records:	26.4
Average hours of operation / day	6
Annual Cooling Energy Consumption	39.6 kWh/yr = **143 MJ /yr**

HEATING:
House uses a wood heater. By definition combustion of biomass is carbon neutral. For energy calculation we will calculate Mj of timber burned. Records show that internal temperature remains comfortable when external maximums exceed 20°c. BOM records provide monthly averages.

Average days over 20°c per BOM records:	90- Approx 50% of days are heated
Volume of timber burned per day	0.007m³
Mass of Jarrah burned per day (835kg/m³)	5.87kg
Energy per 1kg of hardwood timber	10MJ/kg

But electrical MJ of the fuel is not the same as MJ at the plug/appliance. To create an equivalent we will use the percentage of the energy of coal delivered to the appliance.

Comparative correction:	
Embodied energy in mining and transport of fuel coal	15%
Energy delivered through generation and transmission from fuel coal	40%
Annual Heating Energy Consumption	2630 x 0.85 x 0.4 = **894 MJ/yr**

Heat/cooling = 894MJ + 143MJ =	1037MJ / 125m²
Heating/Cooling Energy Loads	**8.296 MJ/m²/yr**

NatHERS Equivalent: 9.5 Stars

APPENDIX 5 - NatHERS EQUIVALENCY CALCS.

Heating/Cooling Energy Loads **8.296 MJ/m²/yr**

Star Band Criteria

Within NatHERS, unique Star Bands are set for each Climate Zone to allow fair comparisons of buildings despite extreme regional variability in weather conditions across Australia. This table shows the maximum Energy Loads (thermal) corresponding to these Star Bands (shown in half star [0.5] increments) in each Climate Zone.

NatHERS Star Band Criteria (Energy Loads [thermal] in MJ/m^2.annum)

Climate Zone	Location	Energy Rating (stars)																			
		0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10
1	Darwin	853	773	706	648	598	555	516	480	446	413	381	349	317	285	253	222	192	164	140	119
2	Port Hedland	643	569	507	455	411	373	340	310	284	260	237	215	194	172	151	131	111	93	76	62
3	Longreach	654	550	465	396	340	294	257	226	200	178	159	141	124	107	90	74	58	43	29	18
4	Carnarvon	209	181	157	137	120	105	93	82	73	66	59	53	47	41	36	31	27	22	18	14
5	Townsville	337	309	283	259	238	218	200	183	168	153	140	127	114	103	92	81	71	61	52	44
6	Alice Springs	681	562	464	385	321	269	228	196	170	148	130	113	99	84	70	56	43	29	17	7
7	Rockhampton	344	295	255	222	194	171	152	136	122	110	99	90	80	71	63	54	46	38	31	24
8	Moree	597	481	388	315	258	214	180	155	135	119	106	94	83	71	60	47	35	24	14	7
9	Amberley	407	334	275	226	187	157	132	113	97	85	75	67	59	52	45	38	31	24	18	12
10	Brisbane	245	203	167	139	116	97	83	71	62	55	48	43	38	34	30	25	21	17	13	10
11	Coffs Harbour	286	232	188	153	125	103	86	73	63	55	49	44	39	34	29	24	19	15	11	7
12	Geraldton	349	285	233	191	158	132	112	96	83	73	64	57	50	43	36	29	22	16	10	5
13	Perth	483	387	311	251	204	167	139	118	102	89	79	70	61	52	44	34	25	17	9	4
14	Armidale	801	661	545	451	375	314	266	227	195	169	147	128	110	93	76	60	43	27	13	1
15	Williamtown	429	349	284	232	191	159	133	114	98	86	76	67	58	50	42	34	26	19	12	6
16	Adelaide	584	480	394	325	270	227	192	165	143	125	109	96	83	70	58	46	33	22	11	3
17	Sydney East	286	230	184	148	120	98	81	68	58	50	44	39	35	30	26	22	17	13	9	6
18	Nowra	517	423	346	284	235	195	164	140	121	105	92	81	70	60	50	40	30	20	12	5
19	Charleville	525	434	359	298	249	209	177	151	131	114	100	87	76	66	56	45	35	26	17	9
20	Wagga	804	663	548	455	380	321	273	235	204	178	156	137	118	100	82	64	47	30	15	3
21	Melbourne	676	559	462	384	321	271	230	198	171	149	131	114	98	83	68	54	39	25	13	2
22	East Sale	791	653	541	449	376	317	269	231	201	175	153	133	115	98	80	63	46	30	15	2
23	Launceston	895	740	615	513	431	366	314	272	237	208	183	160	138	117	95	74	53	33	15	1

THIS EQUIVILENCY IS BASED ON ACTUAL MEASURED BUILDING PERFORMANCE - AND NOT ON SPECULATIVE MODELLING

NatHERS Equivalent: 9.5 Stars

APPENDIX 6 - Notes on Solar Offsetting

NOTES ON SOLAR

Solar power generation is a critical technology in the move to carbon neutral energy. But its implementation in buildings can be used as a crutch to justify unsustainable practice.

In general, a dollar spent on rooftop solar produces only 30% of the energy than a dollar spent on a utility scale solar farm. This is because of the inefficiencies of rooftop solar; including sub-optimal orientation, trees, dirt and maintenance, tiny inefficient inverters. By comparison solar farms are sun tracking, free of shade, well maintained and use large, highly efficient inverters (transmission losses in the grid are only about 5%).

A panel installed on an energy efficient building provides 70% less power to that building than if the same panel had been installed in a solar farm.

In a world of limited resources it seems curious that we are celebrating such a low output.

There are reasons that roof-top solar has been supported by governments. Governments here pay a third of the cost of the system, and get a third the amount of power; dollar for dollar invested they come out even, but when private individuals pay the other two thirds, they also take on maintenance, administration, and provide roof space. The government then gets the same power for the same investment, but almost none of the costs. It's a good deal for governments, but a bad deal for the community and the environment. We are only getting a third the power for our national investment.

As superannuation funds now buy up utility scale renewable energy projects with much higher efficiency, rooftop solar looks more and more like a temporary stop-gap measure.

Solar panels are not part of the architecture, they are off-the shelf products, developed by engineers and scientists. and electrically connected to buildings. Remove the panels from a building and install them some place else, and the building performs no better or worse. The same energy is used in the building for heating and cooling, the same society wide greenhouse gasses are produced. The only place there is a change is on the corresponding meters,... you wouldn't say this of roof eves..... We wouldn't say that a hairdryer plugged into a grid connected solar system is all of a sudden net-zero or astonishingly carbon negative?

The problem with rooftop solar being included in LCAs, Green Building Challenge, Greenstar etc. as offsets is how easily they can apparently offset wilful embodied CO_2. A 15kW system costs about $15000, and will produce more than 11x the average household annual energy consumption, and apparently offset more than twice the embodied CO_2 of an average Western Australian brick house.

Pay $15,000 and you can make pretty much anything carbon negative.

This is greenwashing.

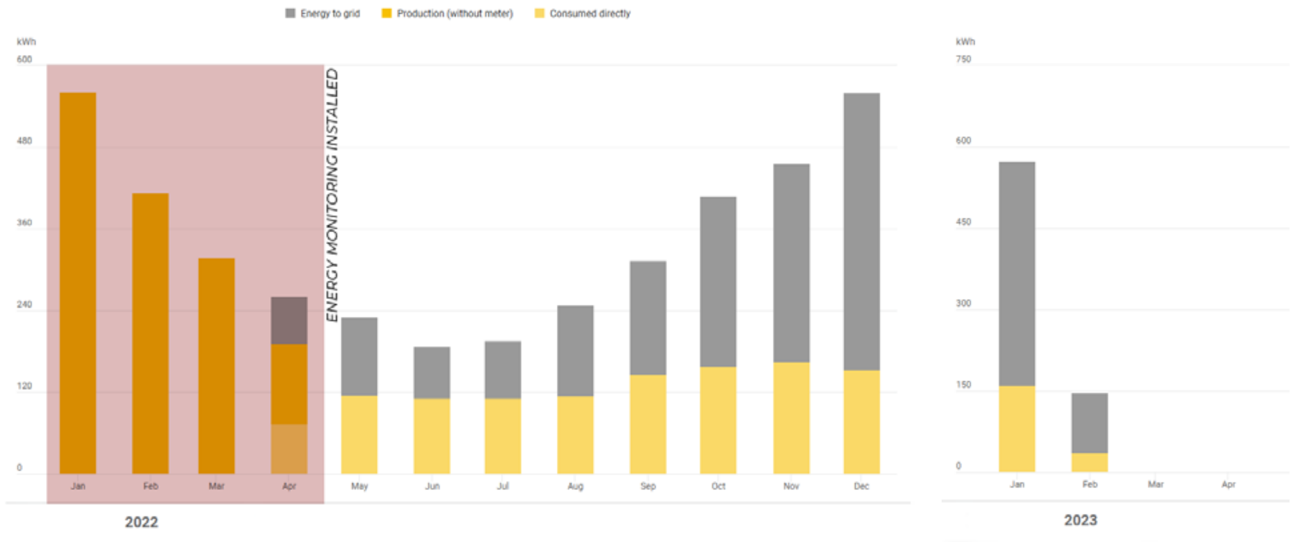
We need to acknowledge what roof-top solar is: It is an expensive and inefficient political stop-gap until highly efficient utility scale solar is connected to the grid. Roof-top solar is currently necessary, but does not make a building better performance. It does not make a building sustainable. It is not part of the architecture.

Sustainable buildings must have low embodied CO_2, be highly efficient, and be environmentally responsible.... Regardless of what equipment is installed on the roof...

APPENDIX 7 - Solar Production Records

Records taken from Fronius Smart Meter

SOLAR ENERGY CONSUMPTION



ENERGY BALANCE