WITCHCLIFFE

ECOVILLAGE

Sustainable Building Design Guidelines (REV C)

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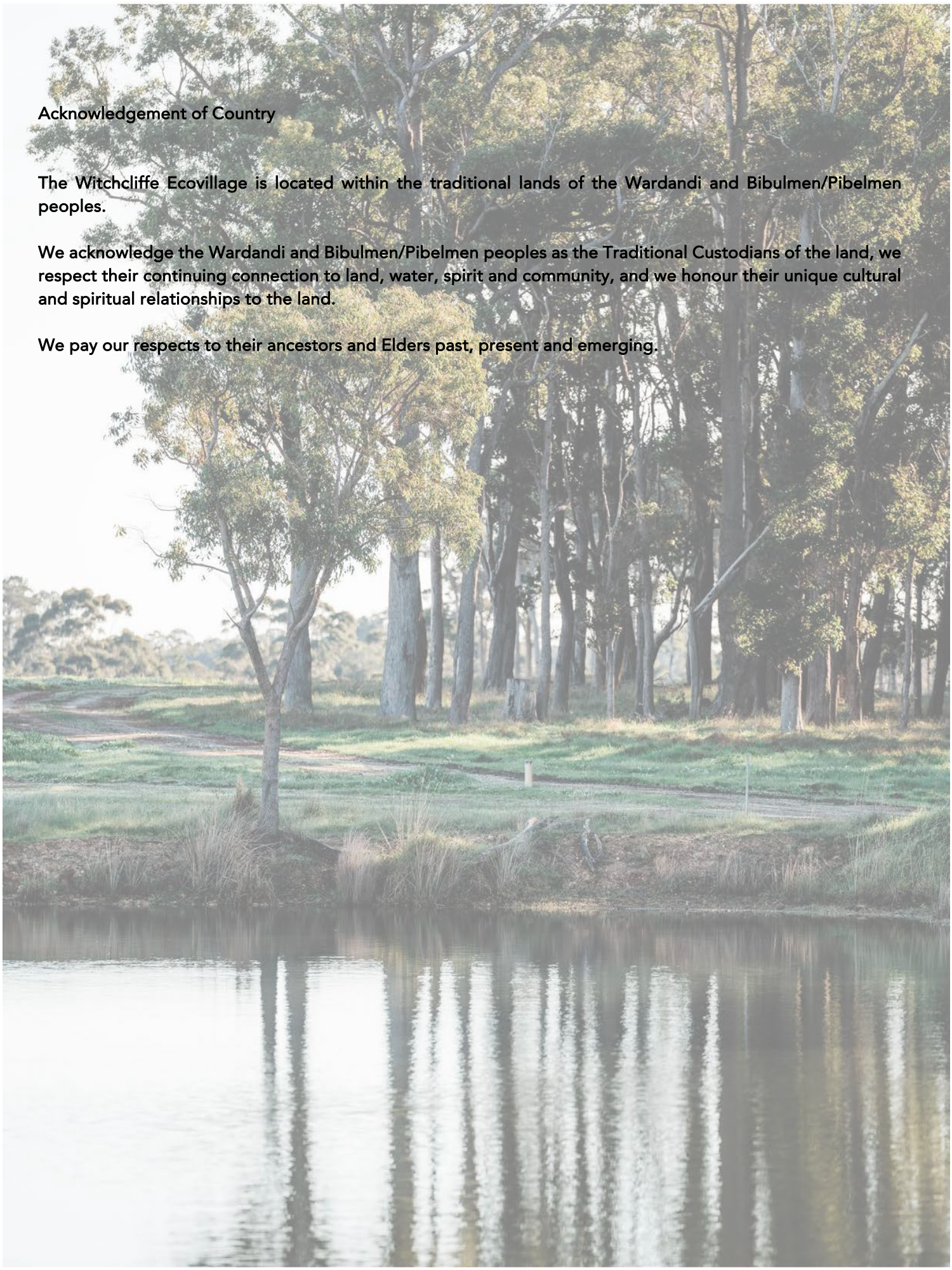

Acknowledgement of Country

The Witchcliffe Ecovillage is located within the traditional lands of the Wardandi and Bibulmen/Pibelmen peoples.

We acknowledge the Wardandi and Bibulmen/Pibelmen peoples as the Traditional Custodians of the land, we respect their continuing connection to land, water, spirit and community, and we honour their unique cultural and spiritual relationships to the land.

We pay our respects to their ancestors and Elders past, present and emerging.

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WITCHCLIFFE ECOVILLAGE

A. SETTING THE SCENE

"It's a revolution. But it's the sort of revolution that no one will notice. It might get a little shadier. Buildings might function better. You might [need] less money […] because your food is all around you and you don't have any energy costs. Giant amounts of money might be freed up in society so that we can provide for ourselves better. So it's a revolution."

~ Bill Mollison, co-founder of the Permaculture movement

1. Introduction

The Witchcliffe Ecovillage is a joint venture project between Sustainable Settlements Pty and Perron Developments Pty Ltd, and the culmination of a 20-year partnership focused on the design and development of small-scale, environmentally sensitive land developments. The Ecovillage is a unique development of multiple clustered survey strata schemes surrounding community gardens, united by joint custodianship of Ecovillage Common land, and bound by Ecovillage management statements and bylaws.

The Ecovillage has been master-planned to create a highly sustainable village that provides for as much of the community's day-to-day needs as possible. It responds to the site's location, topography and environmental features, and retains and conserves the land's remnant bush and creek lines. Working within local and State planning requirements and best practice sustainability outcomes, it provides for:

- Approx. 385 residential lots, ranging in size from 220m2 to 2000m2
- Optimum solar orientation to all residential lots, with guaranteed solar access to the living rooms of all homes
- A central public space – Wolghine Square - with café, tavern, nature playground and outdoor meeting places
- 11 community gardens with productive landscaping and shared amenities
- Organic market garden lots
- Aged and affordable housing
- Commercial lots for retail, hospitality, food processing and value adding
- Innovation hub (business incubator), childcare centre
- Tourism lots, holiday homes and backpackers' accommodation
- A playing field and community hall
- 27.9 ha of Ecovillage community owned land, including 3 dams for storage of stormwater for irrigation as well as 3 dedicated conservation areas
- Pathways connecting all community gardens and open spaces to promote an active healthy community.

An artist's impression of the Village Square showing the Tavern, Backpackers, Cafe and Mixed Use Cottages.

1.1 The Witchcliffe Ecovillage Vision

Our vision is to create a highly sustainable, self-reliant community in a regional village setting, incorporating the best of 21st century technology and human settlement design to enable Ecovillage residents to:

- be 100% self-sufficient in renewable energy;
- be 100% self-sufficient in water;
- grow their own organic fresh food;
- create less waste and reduce carbon emissions;
- care for the local environment;
- generate ongoing economic and social opportunities;
- foster creativity and innovation; and
- create an inclusive, active, cooperative, and resilient community.

The Witchcliffe Ecovillage is a place where people can live, work, socialise, and provide for their material needs sustainably; where most of what they consume on a daily basis can be produced within the Ecovillage; where built form, productive landscapes, natural environments, native flora and fauna, sustainable technology, and community exist in harmony and complement the existing rural character of Witchcliffe.

In time, the Witchcliffe Ecovillage will grow to be a model demonstration village where people can come to learn how to live more sustainably, with ample opportunities throughout for ecotourism, research and education.

1.2 The Cluster Garden Layout

"We're only truly secure when we can look out our kitchen window and see our food growing and our friends working nearby. "

~ Bill Mollison

The Ecovillage residential cluster layouts have been carefully designed to optimise solar access to all lots, manage the flow of stormwater via overland living streams to the community dams, and provide generous private and shared garden spaces. Each cluster surrounds a community garden that includes exclusive use areas adjacent to each home for productive allotment style veggie gardens, shared netted fruit orchards and chicken run, a community building/shed, nature play area, an electric vehicle charger, and a visitor parking area. A network of garden paths connects the clusters and provides safe pedestrian and bike trails throughout the Ecovillage. Each cluster has a range of lot sizes which fall into 3 types:

Groupies

Designed to provide an affordable option within the village, these 360m2 lots are oriented on the north / south axis, with living to the north. They are perfect to accommodate a small solar passive house (<100m2), similar to the weatherboard Group Settlement houses (affectionately known as "groupies" by locals) that were built throughout the South West in the 1930's.

Cottage

With garage and utilities to the south and living to the north, these 450 - 675m2 Cottage lots are designed to capture and maximise solar gain. There's room for easy care courtyard gardens and play spaces, with direct access into the community gardens and shared path networks.

Family

Opening directly into the landscaped community gardens and path networks, the 750-1200m2 Family lots are oriented east / west with building setbacks to the north to ensure each home has optimum solar access and plenty of room for gardens, play areas, chook pen and a garden shed.

Figure 1. Witchcliffe Ecovillage Cluster Plan

1.3 Living in Witchcliffe

The rural village of Witchcliffe is located just 8km south of Margaret River. It sits within the South West Boojarah, which are the traditional lands of the Wardandi and Bibulmun/Pibelmen peoples. The South West Boojarah encompasses the towns of Capel, Margaret River, Witchcliffe, Augusta, Windy Harbour, Northcliffe, Pemberton, Manjimup, Bridgetown and Nannup, and covers about 10,085 km2. For more information, visit https://www.noongarculture.org.au/south-west-boojarah/.

The Ecovillage is nestled in a rural and natural hinterland, immediately adjacent to the Witchcliffe village centre, with significant remnant bushland to the east, west and south. Witchcliffe is a sleepy village, with businesses on the main street offering an eclectic mix of farm services, bespoke and artisanal services and products, casual eateries, an electric bike shop, and up-cycling boutiques. It is 9 km east of Redgate Beach, a popular surfing, swimming and fishing spot, and the location of the famous 1876 wreck and rescue of the SS Georgette. The Ecovillage's winter creeks form the headwaters of 3 small tributaries which flow to the Chapman Brook, which then flows south east to join the Lower Blackwood River. Witchcliffe is also home to some of WA's most endangered species: Baudin's White-tailed Black Cockatoos; Western Ringtail Possums; and a tiny little froglet called *Geocrinia alba*, the White-bellied Frog, which is only found in the Witchcliffe area.

CLIMATE:

Witchcliffe has a mild temperate/Mediterranean climate with cold, wet winters and warm, dry summers. The Wadandi people recognise that there are six distinct seasons in the south west, and you can find information on the Noongar seasons here: http://www.bom.gov.au/iwk/calendars/nyoongar.shtml. Witchcliffe is rated as sub zone 54 (Mandurah) on the NatHERS climate zone map and is most closely represented by Zone 6 in the *YourHome* factsheet, "Passive Design: Design for Climate" (p.99-100).

Summer temperatures average 27° Celsius by day and 14° at night, with infrequent maximum temperatures of 38-40° degrees occurring between December and February. Hot days are generally cooled off with an afternoon sea breeze, and summer evenings are mild. The winter months average 16° by day and 8° at night, with frosty mornings reaching an occasional minimum of 0° between May and July. The maximum sun angle is 80° on December 22nd (summer solstice) and 34° on June 21st (winter solstice).

The average yearly rainfall is around 1000mm, with most rain falling in the winter months and the shoulders of autumn and spring, with isolated but not uncommon heavy rainfall events (max. recorded rainfall in 24 hours, 99.4mm). In summer, the wind is generally south to south-easterly in the morning, with cooling south westerly sea breezes in the afternoon. In winter, the prevailing winds are less predictable, with intermittent cold fronts and storms.

GROWING CONDITIONS:

Soils at the Ecovillage typically have a shallow sandy-loam topsoil layer with loam, sand and gravel composites in the upper soil profile to a typical depth of 0.5-1m. Lower soil profiles are typically white to orange/brown clays and gravels. The well-drained upper soils are excellent for productive gardening and the less permeable lower layer helps to retain water in the soil. The Witchcliffe Ecovillage farm and vineyard are currently certified organic by NASAA.

1.4 Witchcliffe Ecovillage Design Guidelines

The purpose of the Witchcliffe Ecovillage Building Design Guidelines ("Design Guidelines") is to ensure that the built form and landscaping of the Ecovillage reflects the **strong vision of sustainability** and the **rural village character** set for the development. They provide straightforward guidelines that apply to all residential buildings in the Ecovillage. They will help owners, designers and builders create aesthetically harmonious buildings that are solar passive, efficient, affordable, and comfortable to live and work in.

PART A, SETTING THE SCENE, gives an overview of the Ecovillage project, sustainable house design principles, carbon negative material choices and architectural character.

PART B, DESIGNING YOUR HOME, deals with specific design requirements and is structured into three elements:

- **Objective** — states the outcome that we are seeking.

- **Guidance** — provides non-mandatory suggestions to help residents achieve the highest possible sustainability outcomes in their building proposals.

- **Required** — designates the mandatory or minimum building standards required for building plans to achieve endorsement from the Witchcliffe Ecovillage Design Team (the "Design Team") prior to submission to the local government for building permit.

PART C, APPROVALS AND CONSTRUCTION, explains the design approval process and how the Design Team will ensure that all homes meet the Ecovillage's required sustainability, architectural and construction standards. This section includes the Ecovillage requirements for thermal performance assessment and negative carbon certification through life cycle analysis.

The Design Guidelines must be read in conjunction with the Augusta-Margaret River (AMR) Shire's *Local Planning Scheme 1*, State Planning Policy *7.3 Residential Design Codes*, and the *National Construction Code Volume 2*. The AMR Shire has adopted Local Development Plans (LDPs) for all lots in the Witchcliffe Ecovillage, to allow variations to R-codes as required to achieve sustainability and local character objectives (see section 9.1, Local Development Plans). Refer also to Local Planning Policy 22-Witchcliffe Ecovillage (AMRS).

While the Design Guidelines set out the requirements for building in the Ecovillage, any aspect of these guidelines can be varied on a merit basis at the discretion of the Design Team, **provided the outcome meets the objectives of the guidelines**.

All future renovations, additions or rebuilds will need to adhere to the Design Guidelines, and follow the same application process, with the respective strata body corporates replacing the Design Team as the approval body.

For more information on the design approval process and documentation requirements, see Section 9, Approvals.

1.5 Useful Resources

We strongly recommend *YourHome*, the Federal Government's excellent guide to sustainable building in Australia. It is available as a hardcopy from the *YourHome* website; however, the whole book is also accessible as factsheets on the website as well. "Passive Design: Design for Climate," (p 87-103) is an excellent starting place to familiarise you with designing a thermally efficient home (refer to the "mild temperate climate" information). The Low Carbon Cooperative Resource Centre's *Guide to Low Carbon Residential Buildings – New Build* is another useful free resource, with a focus on "reducing the carbon footprint (of new homes) in all phases of planning, design, construction and system (fixed appliance) selection."

We also recommend *The Smart Living Handbook*, by Melissa Wittig and Danielle King, which has a particular focus on creating healthy buildings, and provides detailed information on safe and efficient materials, finishes, appliances and products currently available in Australia. *Josh's House* is another excellent online resource which documents the build and occupation of a sustainable house project in Hilton, Perth, with informative factsheets and resources, videos and real time performance data.

When deciding on the built form outcomes for the Ecovillage, we referred to the Augusta Margaret River Shire's *Rural Hamlet Design Handbook* (2009) and *Patterns of Home: The Ten Essentials of Enduring Design* (2002). We have provided an excerpt from the *Rural Hamlet Design Handbook* at Appendix B, and we thoroughly recommend you read *Patterns of Home*—it is a very accessible condensation of some of the important architectural principles in Christopher Alexander's brilliant but daunting *Pattern Language* (1977).

Sustainable Settlements is a member of ReNew (formerly the Alternative Technology Association) which produces two excellent magazines, *Sanctuary* and *ReNew*, and facilitates the Sustainable House day events around Australia each September. ReNew is great sources of inspiration and information for anyone planning or designing a sustainable home. We recommend you explore their website at https://renew.org.au/ to access articles and factsheets and subscribe to the magazines.

2. Sustainable Housing

"… up to 80% of a building's efficiency can be traced back to the design. If you get the design right, you're well on your way to an efficient, sustainable home."

~ Melissa Wittig and Danielle King, The Smart Living Handbook.

The Witchcliffe Ecovillage has been masterplanned from the outset to allow households to be 100% self-sufficient in renewable energy and rainwater for household use. In addition, we expect all houses in the Ecovillage to:

- **Operate as carbon negative homes on an annual basis**—i.e., they will produce substantially more renewable energy onsite each year than the energy required to operate them; and
- **Be carbon negative over the lifetime of the building**—i.e., the house will produce more renewable energy over the 80-year life span of the building than its total embodied and operational energy consumption.

These objectives will be achieved through:

- the active generation of renewable power by the PV array on your roof;
- the passive energy efficiency achieved through designing a thermally efficient home with full solar access; and
- the embodied energy saved by choosing sustainable construction materials.

2.1 Sustainable Design Principles

Follow these 8 simple principles to design a comfortable sustainable home to provide you and your family with a low carbon, healthy lifestyle in the Witchcliffe Ecovillage.

1. REDUCE YOUR DWELLING'S CARBON FOOTPRINT

Australia has the largest average new house size in the world, and the largest residential floor space per capita. The **embodied** energy of the average Australian house is equivalent to approximately 15 years of its normal operational energy use (YourHome). Reducing overall house size and keeping your house shape and roof line simple also reduces the **operational** carbon footprint of your home, decreases construction costs and minimises the on-going running costs of heating and cooling your home every year. Reducing house size and choosing lower embodied energy construction materials wherever possible are the most cost-effective ways to reduce the embodied carbon footprint of your home (see Section 2.2, Choosing Sustainable Construction Materials and Products).

2. DESIGN A THERMALLY EFFICIENT HOME

There are four basic solar passive house design principles to follow in a temperate climate:

1. Allow winter sunshine to enter the house through appropriately sized and rated glazing to warm up thermal mass surfaces in living areas, and shade the house externally (glazing and walls) from the heat of summer sun (see Section 4.1, Thermal Performance, Section 6.8, Glazing, and Section 5.4, Shade Elements).
2. Provide sufficient correctly installed insulation to the outer shell of the house, including the roof cavity, to limit heat loss in winter and heat gain in summer. See Section 6.7, Insulation.
3. Place thermal mass or "phase change materials" strategically inside your home (e.g., concrete slab, internal brick or stone walls) to buffer your home from changes in external temperatures, (see Section 4.1, Thermal Performance).
4. Choose lightly coloured and reflective roofing materials and avoid thermal mass roofing materials (concrete, slate, or clay tiles) to reduce solar heat gain to your home in summer (see section 6.6, Roofing Materials).

3. SEAL YOUR HOUSE WELL

Ensure that your house is well sealed to exclude cold air in cold weather and prevent loss of warmth. Sealing your home is a very cost-effective way to prevent a significant 15-20% of heat loss in winter, and there are several common "leakage" points to pay attention to, such as doors, windows and exhaust fans. See Section 6.9, Vents and Sealing.

4. PROVIDE CROSS FLOW VENTILATION.

Provide effective ventilation and air flows via appropriately placed and specified windows, doors, vents, and ceiling fans to cool the house in hot weather and circulate warm air in winter. See Section 4.3, Passive Cooling.

5. PROVIDE NATURAL DAYLIGHT TO LIVING AREAS

Artificial internal lighting accounts for about 6% of average household energy consumption, so it is important to locate and design glazing to direct daylight into daytime living areas to provide a comfortable, inviting environment, and minimise energy use. You should aim to not require artificial lighting during daylight hours on a sunny day. See section 4.4, Natural Lighting.

6. PRODUCE YOUR OWN ENERGY, WATER AND FRESH FOOD

Energy:
The most efficient and environmentally responsible way to power your Ecovillage home (and offset the embodied energy used to construct it) is with renewable energy generated on site by rooftop solar panels, with shared battery storage and an independent microgrid in each strata cluster to provide renewable power at night. Households will have the potential to create significant excess energy to sell back to the Western Power grid or power an electric vehicle. For more information, see Section 8.1, Energy.

Water:
The supply of water to homes via a centralised provider like Water Corp creates significant carbon emissions and can place pressure on precious water resources, like the Yarragadee aquifer, one of the sources of Margaret River's mains water supply. By capturing and storing 100% of your water requirements onsite, reducing household water consumption through efficient appliances and fixtures, powering your rainwater pump with renewable energy from rooftop PVs, and connecting to the solar powered Ecovillage wastewater treatment service, you will reduce your water related carbon emissions, and enjoy sparkling clean un-chlorinated rainwater all year round. For more information, see Section 8.2, Water.

Food:
You can greatly reduce your food miles, carbon emissions, food waste and unnecessary packaging by growing the bulk of your fresh food requirements organically at home. Each Ecovillage household will have a generous exclusive use garden allotment in their strata's community garden, with irrigation water provided from the Ecovillage dams. The added bonus is that you will be socialising, exercising, improving your diet and enjoying fresh affordable organic produce at the same time.

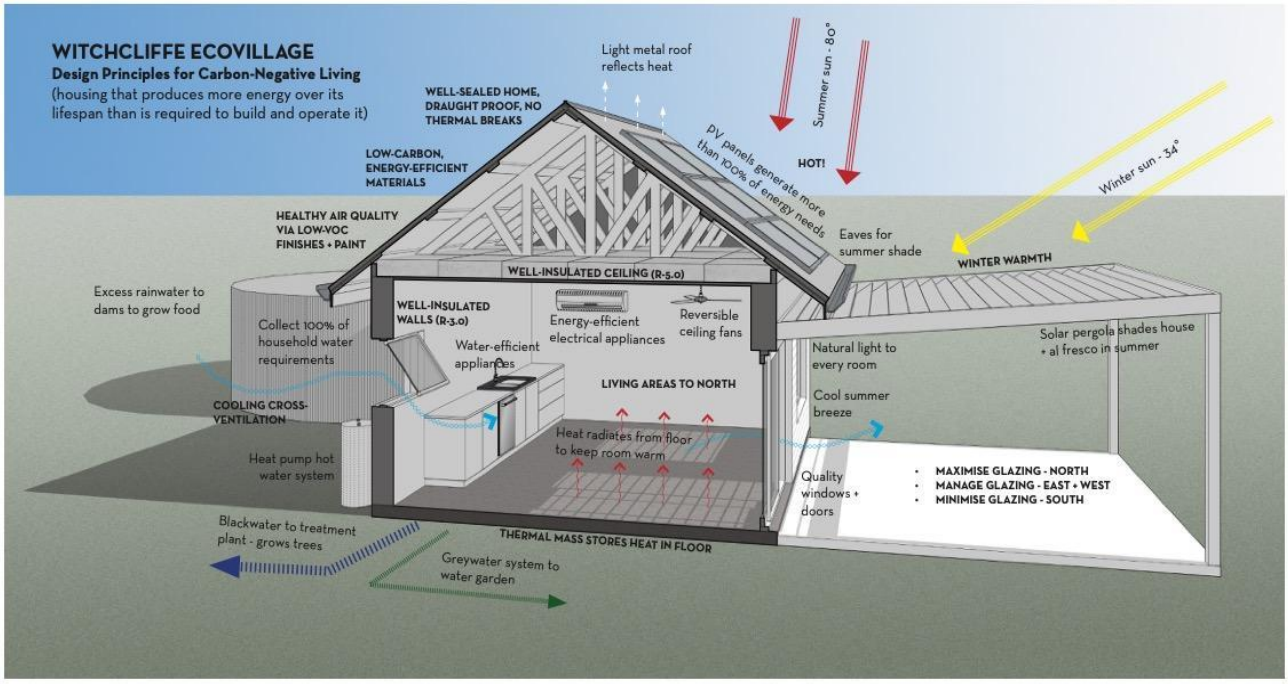
7. CHOOSE ENERGY AND WATER EFFICIENT FIXTURES AND APPLIANCES

To maximise carbon emission reduction and minimize rainwater tank storage requirements, homes are advised to install energy and water efficient fixtures (hot water systems, stoves and ovens, taps, etc.,) throughout the home (see Section 8, Services and Appliances). To deliver even more carbon savings, households should choose the most energy and water efficient free-standing appliances (fridges, washers, televisions, etc.,) wherever possible, and upgrade to the most efficient available whenever an appliance needs replacing (see Section 8.8, Free Standing Appliances). The more renewable energy that your house can send to the Western Power grid, the lower your home's operational carbon footprint.

8. CHOOSE POLLUTION FREE MATERIALS AND FINISHES

All houses in the Ecovillage should be constructed and finished with products that have low to zero volatile organic compounds. This not only provides pollution free air quality for residents and visitors, but also protects the health of on-site builders and off-site manufacturers, prevents off-site pollution, and promotes the wider availability and acceptance of VOC free products (see Section 7.5, Internal Air Quality).

Figure 2. WEV Negative carbon house design principles



2.2 Choosing Sustainable Construction Materials and Products

Choosing construction materials and products for your Ecovillage home is more involved that just deciding how you'd like the house to look. It is a process of weighing up all of the potential environmental impacts of various materials against the benefits of their thermal performance and their ability to reduce the on-going operational energy of your home, as well as achieving a great aesthetic outcome. Factor in the requirement to fit your choices within your budget, and it becomes a real balancing act!

To make this task easier for you, and to ensure your decisions will be based on the best available information, the Design Team commissioned Life Cycle Logic to create a detailed Life Cycle Analysis (LCA) report to assess the greenhouse warming potential and environmental impacts of a range of construction materials.

To accurately measure the carbon impact of homes, LCA can provide a global warming potential (GWP) metric measured in "kg CO2 e" (kg of carbon dioxide equivalent emissions). The GWP combines all of the carbon emission impacts of every material used in the construction of a building, including all manufacturing inputs, the transportation required to get materials to the house site, as well as the inputs needed to operate and maintain the house over the (80 year) life span of the building, and the energy required to demolish and either recycle materials or send them to landfill at the end of its life cycle.

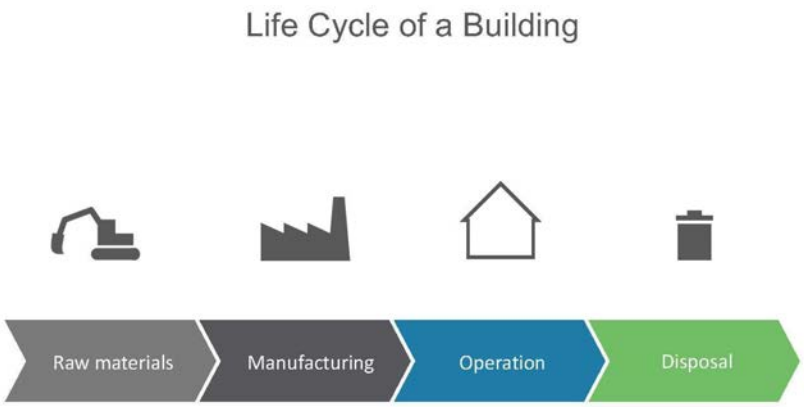


Figure 3. Life Cycle of a Building (image courtesy of Life Cycle Logic)

To enable accurate comparison of individual building elements, we had to assume a 'base-case' scenario that represented conventional construction materials and methods so we could understand the impacts of swapping out various materials. The 'base-case' house was modelled as having double-brick walls with air cavity, timber trusses, concrete slab foundation, single glazed aluminium windows, sand render exterior finish, zincalume corrugated roofing, synthetic carpets in bedrooms, tile in living spaces and wet areas, R6 ceiling insulation, cornices and skirting boards, standard wet plaster and paint on interiors. As all houses in the Ecovillage will be required to be solar passive and fitted with 6 kW of PV panels and rainwater tanks, the base case was also assumed to have these features to highlight just the impact of material and product choices. A separate LCA study investigated water heating options and assessed that certain heat pumps were the most efficient choice, so the base case also assumed a heat pump for hot water provision. These assumptions meant that the base case house design was already better than "business as usual."

The LCA assessed the incremental changes to GWP when swapping out particular elements with all other elements staying the same as the base-model. The elements investigated were:

- Wall types
- External cladding
- Window frames and glazing
- Ceiling insulation batts
- Flooring
- Foundations

The LCA also provided preliminary thermal performance assessments of the different materials, and investigated hot spots in the embodied and operational energy of the base case design that were not controlled by building material choices, e.g., water consumption and household appliance use. Table 1 shows the proportionate distribution of global warming potential across the major elements of the base model building's footprint. Heating and cooling, refrigeration, household appliances and water heating together account for over 60% of the building's embodied and operational carbon footprint.

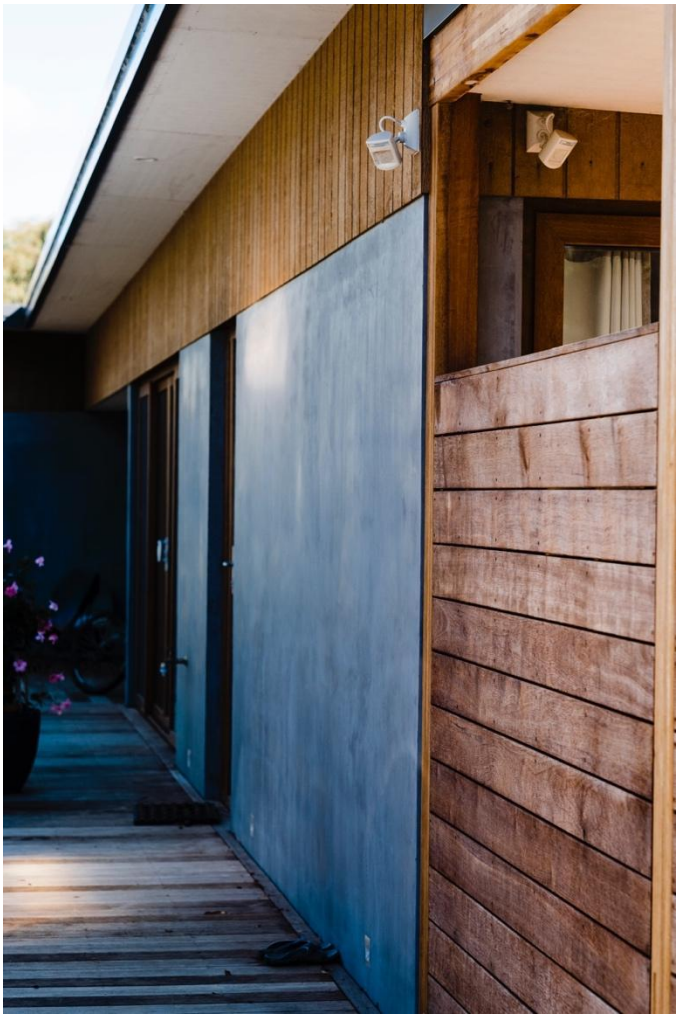
Table 1. Proportionate distribution of GWP across the base model building

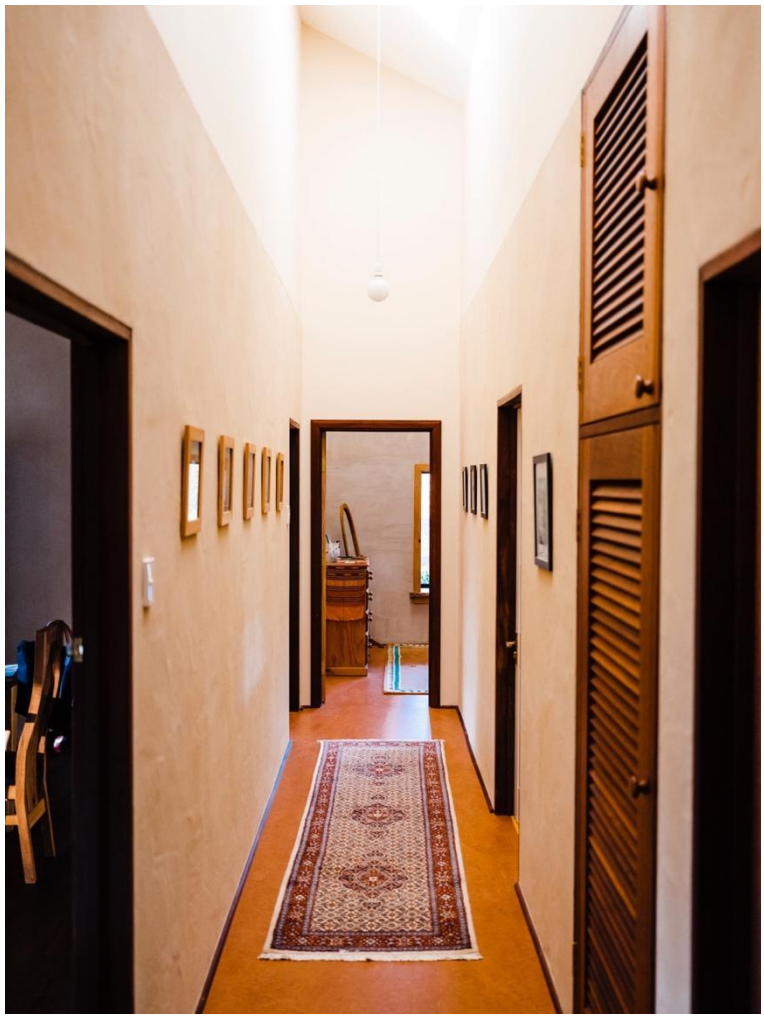
Building Elements	Share of Global Warming Potential (Embodied and Operational)
Heating and cooling (HVAC)	25%
Refrigeration	14%
Appliances (high efficiency)	13%
Hot water system (heat pump)	10%
Rainwater tanks and pumps	6%
UV Water treatment system	5%
Masonry wall external	5%
Masonry wall internal	4%
LED Lighting	4%
Wastewater treatment (1kL/ year WEV)	3%

Based on these outcomes, the LCA Report made the following 9 recommendations to reduce the carbon footprint of Ecovillage dwellings and achieve negative carbon outcomes:

1. Maximise the electricity production of household solar PV—this is the single most effective way to reduce the carbon footprint of Ecovillage buildings.
2. Use high energy-efficiency appliances and equipment, both fixed and freestanding.
3. Use external wall types with high insulation values (timber with insulation, straw bale with earth render, etc.,) and internal walls with high thermal mass (mud brick, fast brick, rammed earth, stone). All Ecovillage proposed wall materials significantly reduced global warming potential over the base case double brick wall.
4. If using external cladding, use timber over fibre cement.
5. Use double glazed timber and uPVC windows where suitable (thermal modelling on individual houses will optimise thermal performance of glazing combinations).
6. Provide well insulated ceilings (but avoid the use of wool insulation).
7. Use polished concrete, timber, marmoleum or earth flooring, avoid wool carpets.
8. Include local supplementary cementitious materials in slab foundations (e.g., 30% Boral fly ash) as this lowers the GWP, and avoid slab edge insulation as this led to an overall increase in GWP.
9. Reduce household water consumption to 100 L p/person, p/day to reduce the carbon footprint of buildings (through reducing the electricity required for pumping and UV treatment, reducing the size of rainwater tanks, and reducing the global warming potential of wastewater treatment).

Tables summarising the LCA findings in relation to specific design and material/appliance/fixture choices are included where relevant throughout Section 6, Construction and Detailed Design.





2.3 Ecovillage Architectural Character

"Quite often when we are attracted to an area, we forget the very reason why we made that commitment. Clean air, beaches, bush, small town feel, food, wine – the sweet life. Yet so often we then impose change. Create a sameness. Very soon it looks like the last place we lived…"

Rural Hamlet Design Handbook, 2009.

While the Witchcliffe Ecovillage's building design principles are strongly focused on sustainability, we also aim to create a village that is welcoming and beautiful, sits lightly and respectfully in the local environment, and reflects the history and rural character of the Witchcliffe townsite. Historic timber buildings contribute a strong presence in the Witchcliffe village centre: Druids Hall, the CWA building, the former Sundance Health Food Shop, and Darnell's General Store all contribute to its cherished "sense of place." Rammed earth, mud brick, reclaimed timber, weatherboards and other recycled elements are featured in homes along Shervington Avenue and Mammoth Road; and steeply pitched or skillion roof lines in corrugated iron add rustic character. Witchcliffe was part of the historic WA Group Settlement programme of the 1930's, and "groupie" houses still stand in the area today—simple jarrah weatherboard and iron houses, which, despite their tiny size, often housed large families.

Witchcliffe Ecovillage buildings should generally reflect the rustic aesthetic of a small South West village, without needing to replicate or mimic existing building forms. Attention should be given to simplicity of form, expression of natural materials, harmonious proportions, and careful rendering of details and finishes on building facades.

The Augusta Margaret River Shire's *Rural Hamlet Design Handbook* (RHDH) provides architectural direction for developing a "sense of place" in new developments that reflects and enhances the values and aesthetics of this unique and beautiful region. (See extract, Appendix B.) This approach accords with our vision for the Witchcliffe Ecovillage, where the architectural place making should complement and consolidate the character and natural beauty of the existing village and natural environment, instead of imposing an "out of place" sprawl of suburban project homes.

Figure 4. Example North facing streetscape, *Rural Hamlet Design Handbook*

We have taken the *Rural Hamlet Design Handbook's* list of "key architectural elements" (Appendix B, p.186), and adapted them for contemporary application in the Ecovillage, making changes to prioritise sustainability features and materials. The following list should provide a starting place for your building's external expression and design:

- Simple geometric volumes and vertical elements
- A mixture of natural earth rendered and timber wall external elements
- Use of local, natural and sustainable materials wherever possible in construction and landscaping, such as plantation and recycled timber, straw bale and render, rammed earth, hempcrete, clay, recycled bricks, limestone and granite
- Zincalume metal sheeting for roofs and rainwater tanks
- Creative and artistic use of recycled and sustainable materials
- Predominantly steep (30°-45°) double pitch roofs with overhanging eaves at gable ends
- Skillion roofs with lower pitches, lean to elements and clerestory windows
- Loft spaces and dormer windows
- Deep overhangs of roof structures

- Larger building volumes broken up into parts using design elements
- Small punctured openings and double volume openings
- Recessed window and doors with proportionate frames
- Windows typically vertical or square rather than horizontal
- Balconies and verandahs to provide shade, shelter and legible entry statements
- Shutters, awnings, solar pergolas, and other seasonally adaptable shade elements
- Creative use of garden fencing, stone / rammed earth walls, and landscape features to complement buildings, gardens and streetscapes
- Attention to detail in materials, finishes and transitions
- Integration of sustainability features into building design, e.g., solar panels
- Consideration given to the presentation of all elevations of the home, not just the street façade
- Avoid overtly expressed period or regional styles (e.g., Federation, Balinese)

For more information, see Section 5, Building Form, and Section 6, Construction and Detailed Design.

Figure 5. Witchcliffe timber outbuilding

WITCHCLIFFE ECOVILLAGE

B. DESIGNING YOUR HOME

A new house is an opportunity; not only to ensure affordability and the best possible liveability for future occupants, but to create high-performance dwellings that actively 'give back' by generating more power than they use, collecting and recycling water, and reducing the built environment's carbon footprint.

Guide to Low Carbon Residential Buildings – New Build, 2019.

Figure 6. Melbourne hempcrete house, image courtesy of OZHemp (https://www.ozhemp.com.au/)

3. Site planning

3.1 Site Analysis

Objective

Undertake a detailed analysis of the site prior to beginning the design process to provide a solid basis for design.

Guidance

- Key background information would include review of climate data such as prevailing winds, sun angles, rainfall amounts, and soil quality (see Section 1.3, Living in Witchcliffe).
- Important drawings would include a site feature survey of your block showing:
  - the extent and location of slope;
  - cadastral boundaries;
  - relevant Local Development Plan requirements, (e.g., nominated crossover location and building setbacks);
  - access to services (NBN, electricity microgrid, stormwater drainage) and
  - interface with the concept designs for the adjacent communal space or neighbouring lots (if available).

Required

- Compile and review relevant background information and drawings (see example Site Analysis, Fig. 7) prior to attending your Concept Review meeting with the Design Team (see Section 9.3, WEV Design Review Process).

3.2 Setbacks

Objective

Setbacks ensure that buildings are appropriately spaced apart to guarantee access to sunlight, ventilation, privacy and to create landscaped streets.

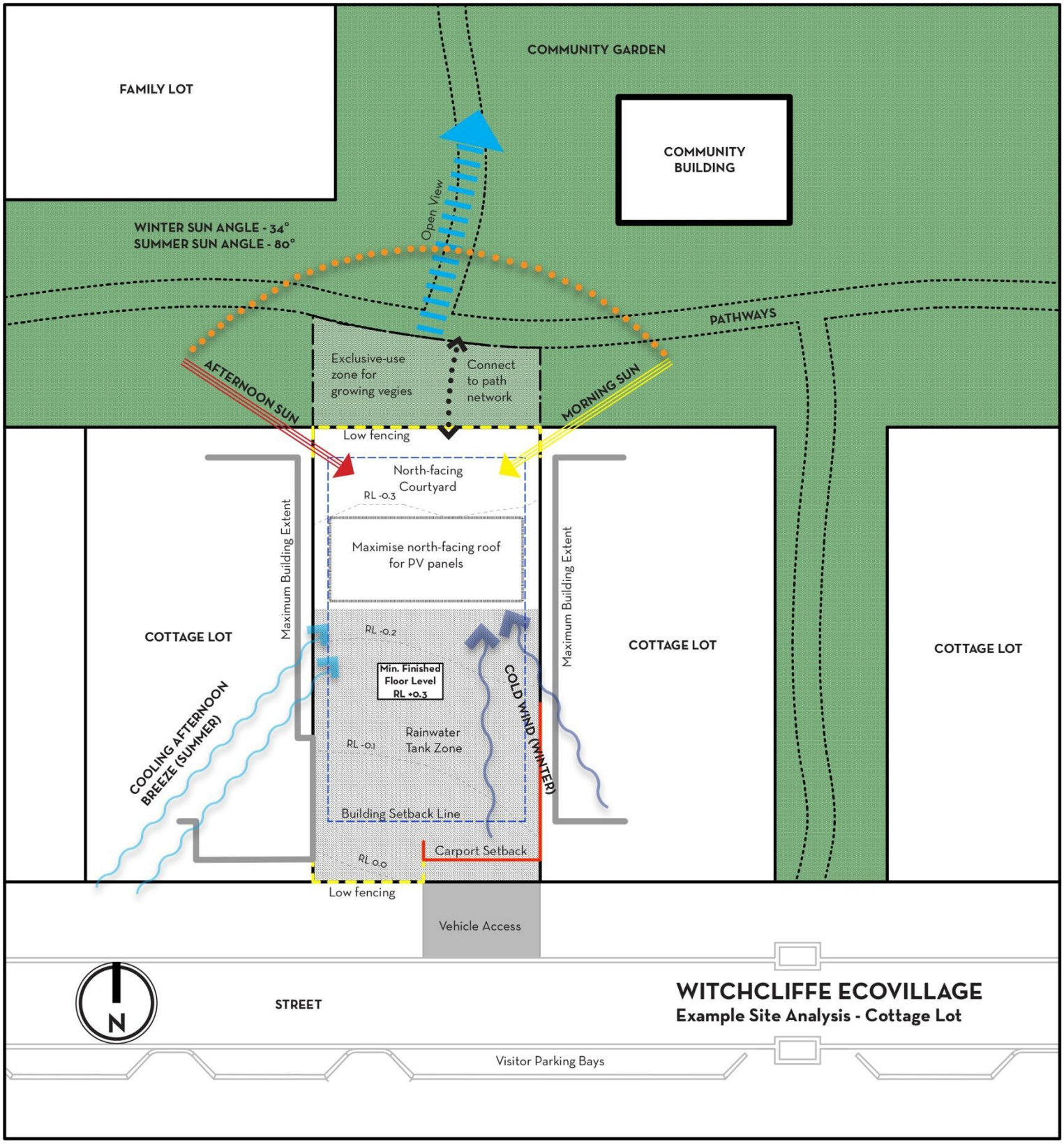
Guidance

- Carefully review the applicable Local Development Plan based on your lot type to understand the specific setbacks for your block.
- Additional setback requirements apply to carports and rainwater tanks (see Section 5.5, Garages and Carports, and Section 3.7, Service Infrastructure).

Required

- Adhere to all setbacks specified by the Local Development Plan for your lot.

Figure 7. Example Cottage lot site analysis plan



3.3 Site Works

As the development footprint of the Ecovillage is largely located on flat land with natural undulations to the east and south of the residential area, roads, lots and stormwater drainage have been constructed to follow the natural lay of the land. Most lots in the Ecovillage will require minimal site works to provide a level building pad, while some more sloping lots will provide opportunities for split level building forms.

Objective

To minimise the extent of earthworks and retaining to reduce the impact on neighbouring properties and the streetscape.

Guidance

- In general, buildings and garden spaces should be designed to work with the prevailing slope of the block. This suggests the potential of stepping the ground plane of the building, with different rooms on different levels (split level).
- Homes built on elevated footings (stumps) to avoid retaining on sloping lots will need to provide sufficient thermal mass and under floor insulation to achieve efficient thermal performance (see Sections 4.1, Thermal Performance, and 6.7, Insulation).
- Where there is significant level change on the block down to the street, consider incorporating 'tuck-under' parking at ground level with the house above. This may facilitate a more direct interface with the communal space and offer better views on the street side.
- Integrate benched areas with natural landform by using landscaped batters in preference to retaining walls (see also Section 5.7, Fences and Retaining Walls). If installing batters, show on site plans how the associated surface water runoff will be managed on site without impacting neighbouring properties.
- Any retaining walls higher than 0.5m above Natural Ground Level (NGL) will require Planning Approval from the Shire of Augusta-Margaret River.

Required

- To reduce impact of a large flood event, homes must be built to specific minimum Finished Floor Levels (FFLs), which are noted for each lot on the relevant Local Development Plan (https://www.ecovillage.net.au/library/document-library/).
- Side boundary retaining walls are allowed on the following lot types: Groupie, Cottage, and Short-Stay. The heights of these walls are limited to the difference between the lot's min. FFL and the NGL along the relevant side boundary.
- Where allowed, any side boundary retaining walls must be fully within the owner's lot boundaries (including footings) and may be subject to the provisions of Section 89 of the Building Act 2011. If retaining on the boundary, consider how boundary fencing will be integrated.
- On Family Lots, retaining walls are not allowed within 1.5m of a side boundary (unless otherwise noted in the relevant Local Development Plan).
- No cut and fill within 1.5m of any front or rear lot boundary, excepting planter beds not exceeding 0.5m height.

3.4 Orientation

Every lot in the Ecovillage has been designed to guarantee maximum solar exposure and ensure that all houses can be designed to take advantage of passive solar design opportunities (see Section 2.1, Sustainable House Design Principles, Section 4.1, Passive Solar Heating) and north facing outdoor living spaces (see Section 3.8, Outdoor Spaces).

Objective

To achieve effective solar orientation of the house on site, with internal and external living spaces generally located to face north, and service areas to the south (see Figure 8, Temperate Climate Orientation).

Guidance

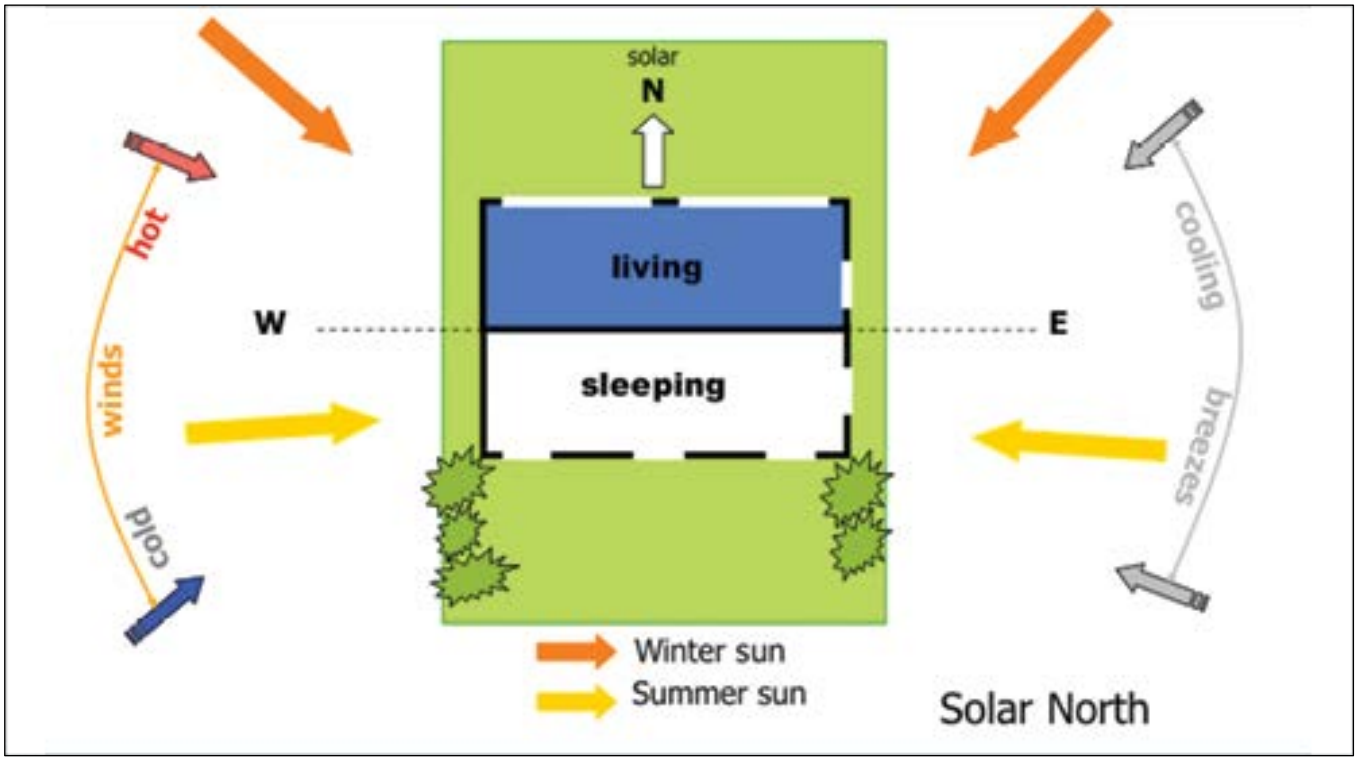
- Smaller lots are positioned on a north/south axis with vehicle loading and services to the south and living to the north. Optimal building footprint on north-south oriented lots will maximise the northern built edge, with tall windows or raked ceilings with glazing to maximise solar penetration into living areas located to the north.

- Larger blocks are positioned on an east/west axis, with setbacks provided on each lot to ensure winter solar access is guaranteed to the living rooms of all homes. The most effective building footprint on east/west lots maximises the northern facade, with the north and south-facing facades 1.5 to 2.0 times the length of the east and west facades.

Required

- Building floorplans must demonstrate effective solar passive building orientation for your lot.

Figure 8. Temperate climate orientation. (*YourHome*, Suntech Design).



3.5 Outdoor Spaces

…a house by its very presence on a site, creates outdoor rooms as well as indoor rooms. And the outdoor rooms should be as well-considered and well-proportioned as the indoor rooms. In a well-designed house, there is a lively balance of indoor and outdoor rooms, and the two types of spaces form a kind of interlocking checkerboard on the site.
Patterns of Homes: The Ten Essentials of Enduring Design, 2002.

Objective

Encourage indoor-outdoor living that takes advantage of solar orientation, promotes social interaction, and integrates exterior spaces into the overall design concept of the dwelling.

Guidance

- Maximise northern exposure into principal outdoor spaces.
- Consider function and best time of day/season, e.g., east facing breakfast courtyard, south facing verandah to provide a cool summer space, deck to north with clear sheeting for winter protection and solar pergola for summer shade, etc.).
- Plant deciduous trees north of the principle courtyard to provide summer shade.
- Ensure landscaping doesn't impact on your or your neighbour's solar access.
- Design outdoor areas adjacent to the community garden to facilitate easy access and neighbourly interaction.
- Design landscaping to provide wind protection.
- Where space permits, locate a habitable outdoor space at street frontage, e.g., porch or verandah, to assist with passive surveillance, and provide a cool outdoor space to sit on a hot summer day.
- Consider providing an undercover-clothes drying area for all year use.
- AMR Shire provides households with three wheelie bins for general, compostable and recyclable waste streams. Provide a convenient and discreet area to enable efficient waste management.

Required

- At least one usable open space (minimum dimension 4m) must have direct northern exposure and be located adjacent to an indoor living area.
- Shade structures over outdoor spaces to be designed and located to maximise winter sun access to the dwelling (see section 5.4, Shade Elements).
- Locate clothes drying in an area that is screened from street and community garden view.

Figure 9. Margaret River straw bale home

3.6 Views

All Ecovillage homes will have the ability to make the most of pleasing nature-based outlooks. Some blocks will have views of dams, conservation bush, or agricultural plots. Others will have more immediate views looking out to landscaped streets, public open space, community gardens or their own private gardens and courtyards.

Objective

Maximise the impact of attractive views from your block without diminishing the thermal efficiency of your building.

Guidance

- Design your house to emphasise and take advantage of views.
- Windows facing east will also let in morning sunlight. Consider placing the kitchen or breakfast nook in this location.
- Windows facing west will receive late afternoon sun and will require a design intervention to prevent overheating in summer (see Section 5.4, Shade Elements).
- Buildings with views looking north are optimally placed to benefit from large amounts of glazing which captures the view and lets in winter sunlight. Size your eaves and shade structures carefully (see Section 5.4, Shade Elements).
- Buildings with views to the south must strike a careful balance between capturing the view and not making windows too large (as this could lead to a poor thermal outcome). One solution to this predicament is specifying high performance windows in this location (see Section 6.8, Window Frames and Glazing).

Figure 10. Views over the Witchcliffe Ecovillage dams and vineyard

3.7 Service Infrastructure

Conventional land subdivisions rely on external provision of services like power, water and wastewater; at the Ecovillage, providing all of those services on site is key to meeting our sustainability objectives. Some of the sustainability features required in the Ecovillage will also set it apart visually—notably the infrastructure supplying every household with water and power. We envisage that the shining rainwater tanks and grids of rooftop PVs will distinguish the Ecovillage as a model for the future. Considering all of your required sustainability features from the beginning of your design process will ensure optimal efficiency and functionality, as well as achieving integrated design outcomes.

Objective

To ensure an efficient layout of service infrastructure that will minimise visual impact on the streetscape.

Guidance

- Configure optimal locations for essential service infrastructure including solar panels, inverter, rainwater tanks, monitoring interfaces, reticulation controller, bin storage, etc. Consider access, setbacks, visual amenity and functionality.
- Locate solar panels to optimise solar collection (see section 8.1, Energy, and section 5.3, Roof Forms).
- Calculate the water demand of your household and size your rainwater tanks accordingly (see section 8.2, Water).
- If you plan to provide household batteries to supplement your lot's shared strata battery allocation, batteries must be located to comply with safety regulations and provide practical access (see Section 8.1, Energy).
- Make provision for stormwater flows and rainwater tank overflows.

Required

- Provide location and specifications for all service infrastructure on detailed Infrastructure Plan.
- Aside from solar panels, solar hot water systems and unpainted metal rainwater tanks, all external fixtures must be screened from the street and pedestrian walkways.
- Locate your rainwater tanks in a suitable location that addresses LDP setback requirements and doesn't interfere with solar gain to indoor and outdoor living spaces.
- Situate rainwater tank to facilitate overflow to stormwater drainage and indicate the method (piped or overland flow) and destination (street or community garden drainage).

Figure 11. Rainwater tanks, Margaret River Econcepts house.

3.8 Bushfire Protection

Living and building anywhere in rural Western Australia requires attention to bushfire management and planning, and all development in the State is assessed against State government bushfire regulations.

Objective

To ensure all homes within the Ecovillage meet State Planning Policy requirements for bushfire protection.

Guidance

A detailed Bushfire Management Plan (BMP) was developed during the structure planning of the Ecovillage, and it specified a range of bush protection measures to provide a safe environment for Ecovillage residents, including:

- 3 x 328,000L rainwater tanks for firefighting purposes (in addition to the 3 Ecovillage dams on site);
- 3m perimeter firebreak around the whole Ecovillage;
- 2 access roads for emergency egress;
- 6m wide roadways to allow emergency vehicle access to all lots; and
- fire sensitive landscaping.

The BMP identified that most lots in the Ecovillage are located in areas with low bushfire risk and will therefore not require additional bushfire management strategies. However, as the regional has some risk of future bushfire, it is recommended to design all homes to BAL 12.5 standards. Some lots on the eastern and western edges of the village are located in areas of moderate bushfire risk (BAL 12.5 - 19). Development on these lots may require additional construction requirements and limitations and fire-sensitive landscaping planning and management.

For more information, please refer to your applicable LDP, the BMP map (Appendix C) and *State Planning Policy (SPP) 3.7, Planning in Bushfire Prone Areas* (https://www.dplh.wa.gov.au/information-and-services/state-planning/bushfire-planning-reform/state-planning-policy-3-7-and-guidelines)

Required

- Plans must specify the BAL rating of lot and address all requirements of State Planning Policy 3.7 if applicable, or any other subsequent State fire regulations.

3.9 Driveways and Crossovers

Objective

Minimise the impact of crossovers and driveways on the streetscape, and provide low maintenance, functional design.

Guidance

- Design the driveway and crossover width based on your on-site parking configuration.
- Consider single or tandem parking on smaller lots, as it allows more space for landscape and a stronger building presentation to the street.
- Consider creative integration of turf or ground cover into driveway design using dispersed pavers or paved strips.
- Crossovers constructed of *in situ* concrete must include 30% min. supplementary cementitious materials (e.g., Boral fly ash).
- Crossovers constructed of *in situ* concrete and comply with the Shire of Augusta-Margaret River's 'Standard Crossing' specifications and are eligible for a Shire subsidy.

Required

- Design vehicle access and parking based on the nominated crossover location on the applicable Local Development Plan.
- Single vehicle crossovers min. 2.8m, max. 3.5m in width.
- Double vehicle crossovers maximum 6m in width.

- Driveway material must be paved, bitumen, concrete or compacted gravel.
- Bitumen paving is to be red-brown in colour, with red oxide added, rather than black.

3.10 Fencing and Retaining walls

Lot boundary fencing is the interface between private lots and the Ecovillage landscape. How you fence your boundary will impact on the streetscape, the adjacent community garden, and your neighbours' gardens. The Building Design Guidelines provides guidance to help households achieve aesthetic outcomes that promote community activation, while also providing privacy and security.

Please note that side and rear boundary fencing is also regulated by the *Dividing Fences Act 1961*, which defines your rights and responsibilities when it comes to replacing, maintaining and repairing shared fences.

Objective

To ensure appropriate heights and materials of fencing to balance privacy requirements and community interaction and create aesthetically pleasing streetscapes and community garden outlooks.

Guidance

- Post and wire rural style fencing at 1.8m is recommended on side boundaries between lots. Using these structures for growing plants and vines is recommended for privacy. Sections can be filled in or blocked to create more privacy in desired locations.
- Timber fencing may be stained, sealed or painted in line with Ecovillage aesthetic or left unsealed to weather naturally.
- Gates, archways, and thresholds are opportunities for creative expression.
- Creative configurations and clever uses of recycled materials are encouraged.
- Natural limestone (not reconstituted) and granite for walls can be sourced locally.

Figure 12. Recycled timber and iron fencing, Margaret River

Required

- Fencing height and design must comply with applicable LDPs and Table 2, Witchcliffe Ecovillage Fencing Requirements.
- Submit a fencing design concept for assessment during the formal design approval process. This is not required for side boundaries between lots.
- Fencing is to be made of natural materials that are compatible with the intended rustic aesthetic such as timber, wire, brush, stone, earth, recycled Zincalume panels, etc., NOT Colourbond steel sheeting or fibre cement boards.
- Retaining walls to be constructed of granite or natural limestone stonework, recycled masonry or rammed earth using local clay, or reconstituted limestone blocks NOT in situ concrete, concrete blocks or post and panel configurations.
- A functional gate / accessway must be provided and maintained between the private lot and the Exclusive Use gardening area, and the boundary must be clearly defined with a fence or landscaping.

Table 2. Witchcliffe Ecovillage Fencing Requirements

Lot Types	Within primary street setback	Rear boundary	Side boundary
Groupies	1.5m	• 1.8m max. • 1.5m max. on portion of rear fence adjacent to community garden. • Any change in fence height is required to step immediately rather than gradually sloping to the new height.	• 1.8m max. • Side boundary fencing adjacent to the street verge or community garden must match the height of the adjacent primary street or rear fence. • Any change in fence height is required to step immediately rather than gradually sloping to the new height and must occur at or prior to front/rear setback lines.
Family and Cottage	1.2m max.	• 1.2m max.	• 1.8m • Side boundary fencing adjacent to the street verge or community garden must match the height of the adjacent primary street or rear fence. • Any change in fence height is required to step immediately rather than gradually sloping to the new height and must occur at or prior to front/rear setback lines.
Additional requirements			
Side fencing in "sensitive" locations (e.g., adjacent to street frontage, community garden or public accessway)	Side fencing in sensitive locations to be a maximum height of 1.8m, with either: • 50% visual permeability above 1.5m along its entire length; or • maximum of 1.5m along 50% of its length		
Dog fencing to front and rear (if required for larger dogs)	1.5m max., set back at least 6m from front or rear boundary. Ideally incorporated into the building edge.		

3.11 Additional Buildings

Objective

To ensure that buildings additional to the primary dwelling are complementary to the exterior presentation of the property and do not negatively impact neighbours, and that habitable additional buildings address sustainable building design principles.

Guidance

- Consult R-Codes and applicable LDPs for maximum shed size.
- Any outbuilding (non-habitable Class 10 A structure, e.g., shed) exceeding 10m2 or 2.4m in height is required to have a Building Permit (see Section 9.5, Building Permit).

Required

- Additional buildings on site are to be visually compatible with the primary residence.
- Outbuildings may not be placed within the primary or secondary street setback.
- Outbuildings must maintain a 1m setback from all boundaries.
- Lots with Ancillary Dwellings must provide sufficient additional rainwater tank storage and PVs to meet the calculated demand of both homes.
- Ancillary Dwellings must be appropriately located and designed to meet passive solar and ventilation requirements, and not impact the solar access of the main dwelling.
- Ancillary buildings that are unable to orient living spaces to solar north must adhere to Passive House principles.
- Ancillary Dwellings facing the street or communal open space must provide at least one window at sight level to provide passive surveillance.

Figure 13. Modern rustic shed, Margaret River

3.12 Pools and Spas

Figure 14. Biological swimming pool, Margaret River

Objective

Minimise negative impacts on neighbours and the environment from residents' private pools or spas.

Guidance

- Conventional pools and spas (including "saltwater pools") are not encouraged at the Ecovillage. The three large dams will provide excellent opportunities for swimming and water sports in a communal setting, and Redgate Beach is just a short 10-minute drive away, so individual pools may be redundant.
- Non-chlorinated and biological pools will be considered, provided there is surplus roof area / tank storage provided to fill and top up pool/spa with rainwater over summer.

Required

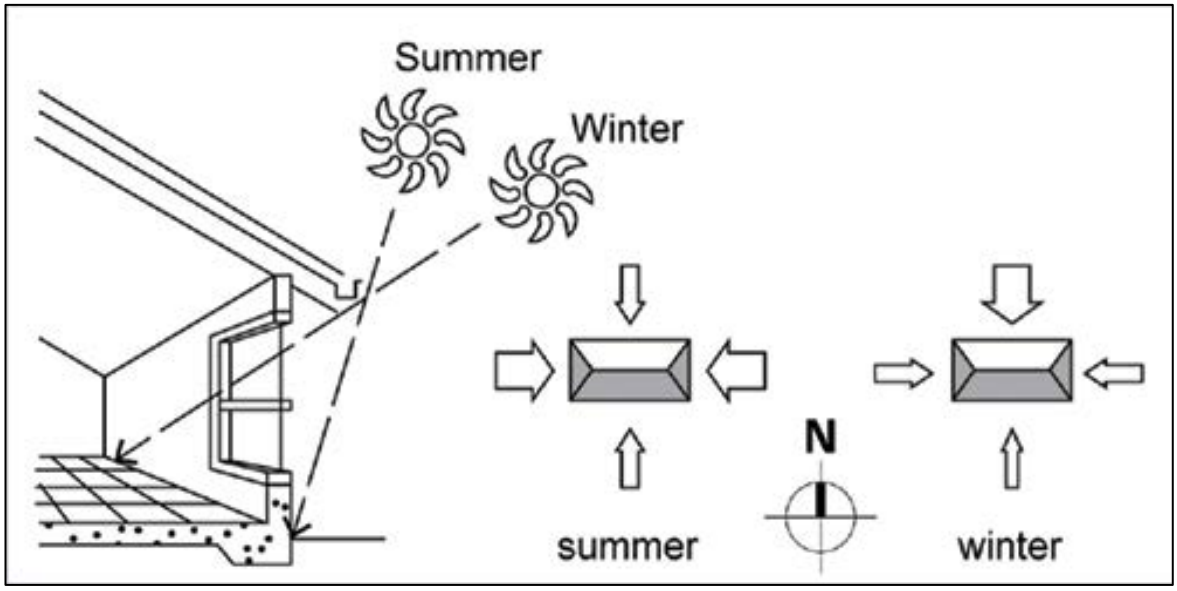
- Pools and spas must be non-chlorine or 'natural pools' only.
- Pools with filters and pumps must be run from 100% renewable energy.
- Pool must be located to minimise noise impacts on neighbours.
- Water budget must demonstrate provision of sufficient additional roof size / tank storage to provide for summer evaporation top up requirements.
- Ponds, pools and spas must be designed and managed biologically to control mosquito breeding.

4. Internal layout

4.1 Passive Solar Heating

Capturing and storing the heat of the sun is the cheapest, most environmentally sustainable way to heat your home. Passive heating requires careful placement of glazing, layout of rooms and incorporation of thermal mass, as well as a well-insulated and sealed building perimeter and roof, (see also Sections 6.7, Insulation; and 6.9, Sealing and Ventilation).

Figure 15. Average daily solar radiation on vertical surfaces. (YourHome.)



Objective

Design your house to take advantage of renewable solar energy from the sun to heat your house in winter without overheating in summer.

Guidance

SOLAR GAIN

- The maximum sun angle at Witchcliffe is 80° on December 22nd (summer solstice) and 32° on June 21st (winter solstice). Design windows to maximise sun exposure for one month on either side of the winter solstice, and to minimise direct sun exposure for one month on either side of the summer solstice.
- Solar gain during hot weather in the morning (east) and evening (west) must be carefully controlled because of the low angle of the sun. Consider vertical louvers, deciduous vines, adjustable external shades / shutters or deep verandahs.
- Efficient solar passive houses are generally no more than 2 rooms deep to allow warmth to penetrate to rooms on the south, and approximately 1.5 times longer on the east west axis.

THERMAL MASS

- The key characteristics of thermal mass materials are: high density, thermal conduction, appropriate thermal lag, low reflectivity, and high-volume heat capacity.
- Thermal mass materials have poor insulation (R) values, so are not recommended for external walls. Incorporate thermal mass materials in the interior of homes to provide temperature moderating benefits by absorbing heat from the sun (via solar access) during the day and then releasing it at night as temperatures cool.
- Materials that are considered good thermal mass include concrete, stone, rammed earth, brick, adobe, and water.
- Newer phase-change materials (PCMs) provide thermal mass that may be useful in light-weight construction. While currently more expensive, they take up less room and are lighter so less costly to support on an upper level. These materials include paraffin wax and a range of benign salts, with new products emerging every year.

- The WEV Life Cycle Assessment recommended the use of thermal mass wall elements for all internal walls (e.g., single brick, recycled brick, mud brick, stone, rammed earth, light earth construction, etc.) to maximise thermal performance.

Required

- Living spaces must generally be located on the northern side of buildings.
- Provide sufficient and appropriately located thermal mass to capture and store winter heat (e.g., thermal mass floor in northern living areas, internal rammed earth wall placed to absorb winter sunshine through glazing, single leaf internal brick walls).
- Thermal mass materials can only be used as part of an external wall (e.g., rammed earth) if insulated to Ecovillage R-value standards, see Section 6.7, Insulation.

4.2 Passive Cooling

Summers in Witchcliffe are generally milder than Perth, but still involve periods of hot weather, so houses must be designed to be cool and comfortable in the heat to avoid the need for energy intensive air conditioning.

Objective

To utilise the breeze and the dynamics of heat rising to naturally cool your house in summer and to provide fresh air to internal rooms.

Guidance

- See *YourHome,* "Passive Cooling" (p.135-48), for advice regarding air movement and cross ventilation, including best window and overhang designs for directing air flow.
- Provide appropriate shading to external walls and glazing, see Section 5.4, Eaves and Shade Elements.
- Provide reflective and bulk insulation in roof space as per Section 6.7, Insulation.

CROSS VENTILATION

- The prevailing summer winds at Witchcliffe are from the SE in the morning and SW in afternoon.
- To achieve effective cross-ventilation, houses should ideally be no more than two rooms deep, with an opening (window or door) allowing air into each room and another on an opposite wall to allow it to exit.
- To create higher velocity, the 'upwind' opening (south) should be smaller than the 'downwind' opening (north).
- Choose window types with large effective openings such as double-hung, sliding, casement or louvers (high-efficiency well-sealed louver units only).
- South facing windows should be thermally efficient and minimised in area to what is necessary to provide cross ventilation and satisfy National Construction Code requirements, to avoid heat loss in winter.
- Windows / doors located for cross ventilation should also provide insect screens.
- Consider installing an earth coupled heat exchanger system ("earth tube") in the slab to provide a low cost source of summer cooling (see https://en.wikipedia.org/wiki/Ground-coupled_heat_exchanger).
- We recommend that all living areas and bedrooms should be provided with ceiling fans to provide supplementary air flow when required, see Section 8.6, Heating and Cooling.

THERMAL MASS

- Provide thermal mass (e.g., concrete floor, single leaf brick walls, rammed earth feature wall) located internally to lose heat via breezes, ceiling fans or night venting in summer.
- Shade thermal mass from direct sun in summer (e.g., eaves, solar pergola, deciduous trees, etc.).

Required

- House designs must demonstrate adequate cross ventilation through primary living spaces and bedrooms with flow-path diagrams and appropriately located thermal mass.

- Two storey or homes with vaulted ceilings must provide a mechanism to vent heat in summer via 'stack ventilation' (e.g., clerestory windows, roof ventilators).

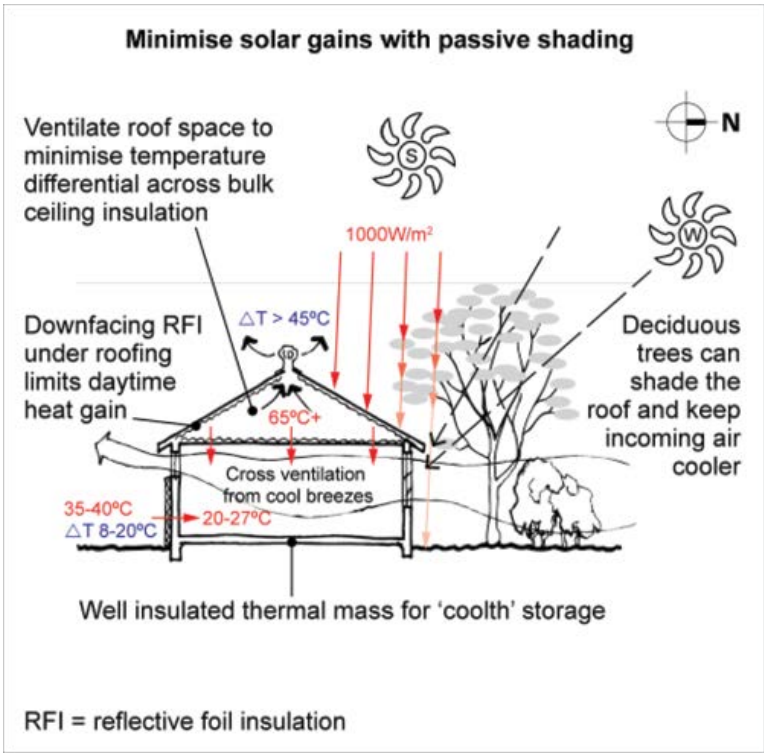


Figure 16, Cooling strategies, *YourHome*, (http://www.yourhome.gov.au/passive-design/passive-cooling)

4.3 Natural Lighting

When we build homes, it is important to locate and organise them in a way that allows all important spaces to receive abundant natural light. This single step probably has more effect on our perception of comfort than does any other aspect of home design.

Patterns of Home: The Ten Essentials of Enduring Design, 2002.

Objective

Design and locate glazing to direct natural sunlight to task areas where it is most useful to reduce the need for artificial lighting.

Guidance

- To enable sufficient natural lighting, the extent of glazing should be proportional to room size and volume. The general rule of thumb is that the glazing should be at least 10% of floor area of the room.
- Aim to provide light sources from at least two sides in all living spaces to create a balance of dispersed light in the space.
- Consider placing rooms on the east and west that would benefit from either morning or afternoon light.
- Windows placed higher on the wall allow for deeper light penetration into a room.
- For east-west oriented lots, keep building footprint 'skinny' to allow sufficient light to access centre of home from the north.
- Regular skylights should be used sparingly, as they cannot be easily shaded in summer, and allow heat loss in winter. Consider a dormer window or thermally efficient skylight instead.
- Lighter floor colours naturally bounce light around a room.

Required

- Appropriate glazing is provided so that tasks can be comfortably undertaken during the day without artificial lighting.

Figure 17. Margaret River timber house, image courtesy of Sorensen Architects (http://sorensenarchitects.com.au/)

4.4 Room Layout

Like ecological niches in a biocommunity, homes should provide a wide variety of settings for group and private life. And these settings should be interrelated, so that we are able to find a measure of privacy at the edges of a group space, yet still maintain connection to the common core when we're in the private places. The two needs are not exclusive; each arises within the frame of the other, and a good house helps us find comfortable places in this critical dimension, places that give a sense of balance to our lives.

Patterns of Home, The Ten Essentials of Enduring Design, 2002.

Taking the architectural patterns described in *Patterns of Home* (p179-205) into consideration when you design your internal layout can help you create a comfortable, welcoming home that "flows," encouraging social interaction at its heart, as well as providing for privacy and retreat. Simple, disciplined floor plans will help to keep building elevations balanced and roof lines uncomplicated, and have the added bonus of being more affordable to build.

Objective

To achieve internal room layouts that are thermally efficient, comfortable, and functional.

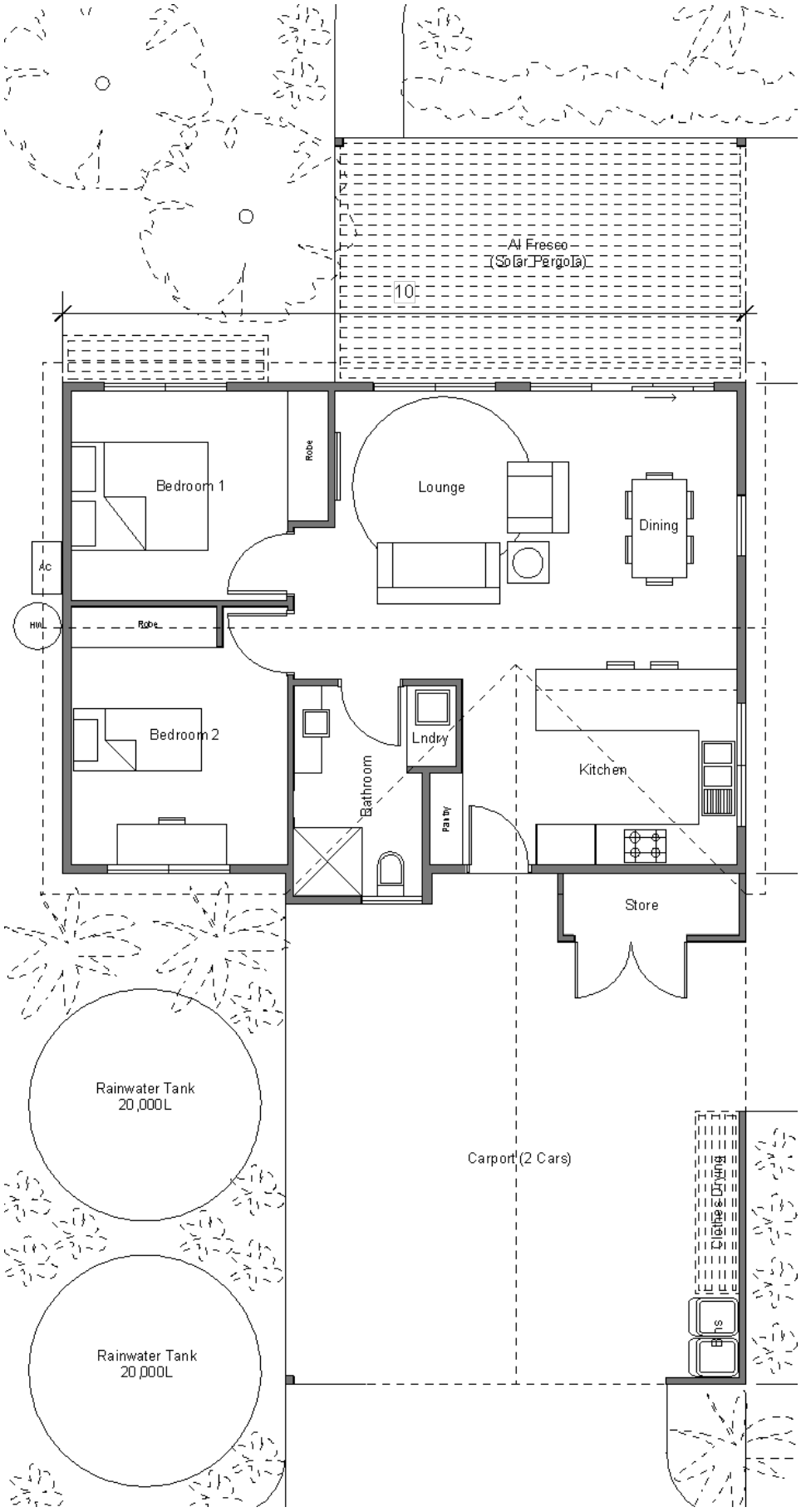
Guidance

- Design floor plan to maximise thermal efficiency (see Section 3.2, Orientation, 4.1 Solar Passive Heating and 4.2 Passive Cooling).
- Design floorplan with external expression in mind to create attractive and balanced elevations (see Section 5, Building Form).
- Begin with a simple rectangular shape and simple roof form, (see Section 5.3, Roof Forms) and be aware of the impact of any extruding rooms on roof form.
- In open plan and/or double storey houses, make provision for areas to be thermally isolated so that heating/cooling energy can be focused only on areas being used.
- Consider providing airlocks/mudrooms at commonly used entrances to help maintain a comfortable internal air temperature. These have the added benefit of helping to reduce clutter and keep the house clean.
- Consider layouts of existing or proposed furniture to provide functional flow.
- Design 'wet areas' (rooms with plumbing) so that they are clustered together and close to the location of the hot water system. Shared plumbing walls will help to minimise pipe runs, saving money and reducing heat loss for hot water.
- Consider reducing the number of bathrooms, and conveniently locate at least 1 bathroom with a separate toilet to avoid requiring an additional powder room.
- In small homes, consider combining a bathroom and concealed laundry to minimise wet areas.
- Locate kitchens and laundries close to each other and provide a convenient doorway to an outdoor service area to provide easy access to carport/garage/store, bin storage and washing line.
- Locate built in storage/bookcases in hallways to make use of an otherwise redundant space.
- Bedrooms are generally the least actively used rooms in a house, used mainly for dressing and sleeping. Consider reducing their size, or incorporating other elements, such as storage, craft or study spaces.
- Design guest bedrooms as multi-purpose spaces—yoga room, craft room, study, etc.

Required

- Internal room layout allows for effective solar passive design outcomes.

Figure 18. Example floorplan, WEV Groupie lot (72m2 house design)



4.5 Accessibility

All Australians benefit from homes designed with comfort, safety and ease of access as core design features. These features make the home easier for parents to manoeuvre prams, easier to carry the shopping into the house, easier for people with disability or temporary injury to get around and easier to move furniture. These same features enable key living spaces to be more easily and cost effectively adapted to meet the changing needs and abilities of home occupants such as ageing baby boomers and people who have or acquire disability.

Liveable Housing Guide, 2017

Objective

To design your house to suit your current needs while also allowing the flexibility to provide accessibility to all visitors and accommodate future needs.

Guidance

- As part of the design process, consider accessibility and changing spatial needs, which may include children, grandchildren or elderly parents, or relate to the mobility requirements of yourself or visitors.
- The *Liveable Housing Design Guidelines* (4th Ed.) provide dimensions and spatial requirements for three categories of accessibility (Silver, Gold and Platinum), which vary by the degree to which they accommodate those with mobility challenges. (For more dimensions and specifications, visit http://www.livablehousingaustralia.org.au/.)
- To achieve full Universal Access compliance inside and outside of the home, use the standards set out in AS1428.1.

Required

- At a minimum, adopt the requirements of *Liveable Housing Design Guidelines* Silver Category to provide future flexibility and ensure the basic accessibility of your home to visitors with differing mobility needs:
    1. A safe and continuous and step free path of travel from the street entrance and/or parking area to a dwelling entrance that is level.
    2. At least one level step-free entrance into the dwelling.
    3. Internal doors and corridors that facilitate comfortable and unimpeded movement between spaces.
    4. A toilet on the ground or entry level that provides easy access.
    5. A bathroom on ground or entry level that contains a hobless shower recess.
    6. Reinforced walls around the toilet, shower and bath to support the safe installation of grabrails at a later date.
    7. Stairways designed to reduce the likelihood of injury and also enable future adaptation.

5. Building Form

Wonderful homes always instruct us anew on the power of natural light on a wall, the truth of materials, the pleasures of outdoor rooms, the proportions of height to width in rooms, the sense of arrival, the feeling of shelter and refuge.

Jacobsen, et al, Patterns of Home: The Ten Essentials of Enduring Design, (2002).

5.1 Building Facades

Objective

To ensure that building facades visible from the street, community garden or pathways are well-composed, expressive, and balanced, with appropriate scaling, legibility, and use of compatible materials.

Guidance

- See Section 2.3, Architectural Character.
- Design the internal layout of the building with the external expression in mind (see Section 4.5, Room Layout).
- Harmonious proportions and the use of natural external materials are key considerations.
- Keep the main building volume simple and attach external elements to break up long walls or add shadowlines, such as verandas, balconies, louvres, shade structures, awnings, and bay or dormer windows.
- Arrange windows and doors to achieve a visually balanced composition (symmetrical or asymmetrical.)
- Windows should generally be rectangular with a vertical proportion.
- A separate window surrounded by solid wall tends to be more attractive in a vertical proportion (window panes with a minimum 1:1 height to width ratio) as it relates to human scale and proportion.
- Windows ganged together allow for greater flexibility in terms of shape/proportion where a 'window wall' is intended. These are often combined with sliding glass or French doors.
- "Punched" or recessed openings (to create external overhangs and window sills) are preferred to flush openings and can create visually interesting facades without adding cost.
- Avoid long blank walls (>5m) without openings facing the street or community garden. If unavoidable (for example, a west facing wall) explore the use of texture and pattern expressed in natural materials or features such as fences / walls, landscaping, shade structures, etc., to provide visual interest.
- Use landscaping features (walls, fences, shrubs) where possible to soften the visual impact of rainwater tanks and carports / garages on the streetscape.
- Design simple, high quality and well executed external finishes and details, including gable ends, use of colour, material transitions, etc., (see Section 7, Finishes and Details).
- Avoid overtly expressed period or regional styles (e.g., Federation, Tuscan, etc.,) as these are not considered consistent with the Ecovillage aesthetic or rural character of the region.
- Double storey porticos are not allowed.

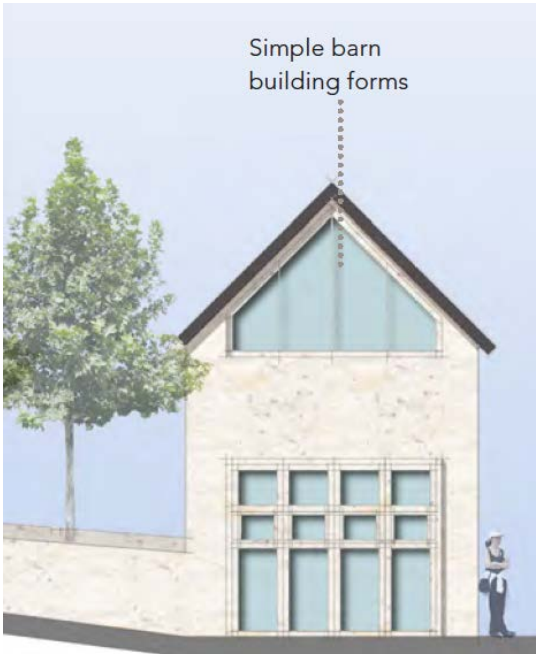


Figure SEQ Figure * ARABIC 19. Example building form, *Rural Hamlet Design Handbook*

Required

- Building form and facades must generally accord with the Ecovillage's adapted Rural Hamlet design principles, see Section 2.3, Ecovillage Architectural Character.
- Create a comfortable entry experience from the public street, including a separate pedestrian pathway, adequate lighting, and a clearly visible entry door.
- Ensure that building facades address and appear attractive from the streetscape, the community garden and pedestrian walkways (where applicable).

5.2 Building Height and Bulk

Each lot owner must check the applicable Local Development Plan for additional restrictions on the location of the upper building level relative to property boundaries to ensure all lots have guaranteed solar access. Building height is measured from natural ground level adjacent to the elevation in question.

Objective

To ensure that the height and bulk of buildings is compatible with the intended village scale and does not negatively impact the solar access opportunities on neighbouring lots.

Guidance

- On larger lots, buildings can be designed as a collection of smaller segments rather than one large mass. These segments can be used to effectively shape exterior space and create micro-climates. Typical configurations include footprints shaped like a U, T, or L. Overly complex shapes and rooflines will add cost to the build, and potentially increase the operational cost of heating or cooling your home.
- Ridge height is limited on Groupie lots but is more generous on Cottage and Family lots (see applicable LDPs). This height is slightly higher than the AMR Shire standard but takes into account the Ecovillage requirement for steeper pitches on gabled roofs.

Required

- Building walls are limited in height to 2 storeys (maximum 6.5 m plate height) unless site falls more than 2m, in which case additional building height can be supported.
- Ridge height maximum:
    - Groupie lots: 8m
    - Cottage and Family lots: 9.5m

Figure 20. Margaret river pitched roof, Pamela Forward Design

5.3 Roof Forms

One of the defining comforts of home is the feeling of being enveloped by a simple sloping roof…. More than any other single element, the form of the roof—as experienced both outside and in—carries the look and meaning of shelter, of home.

Jacobsen, et al, Patterns of Home: The Ten Essentials of Enduring Design, (2002)

Arriving at standardised requirements for roof form in the Ecovillage was surprisingly difficult. These guidelines aim to define a set of recommended roof forms that invoke a simple authentic "down south" aesthetic and the Pattern Language notion of a "sheltering roof," but at the same time provide functionality in terms of solar PV placement and rainwater collection. The roofing requirements also had to accommodate affordability, and the differing constraints of the various lot orientations and dimensions. Three roof forms met these requirements: the steep pitched barn style roof recommended by the Rural Hamlet Design Guidelines, and "modern pavilion" or "mid-century" inspired skillion and skillion with lean to roofs. Each style has pros and cons, dependent on your lot size and orientation. If you are having any difficulty interpreting the roof form requirements, please seek guidance from the Design Team at your initial briefing (see Section 9.3, WEV Design Review Process).

Objective

To ensure that buildings have roof types and configurations that fit with the intended character of the Ecovillage and provide for efficient placement of solar panel arrays.

Guidance

ECOVILLAGE CHARACTER

- Keep roof forms clear and simple, with one roof type / form clearly dominant and all others minor.
- Ensure roof forms generally adhere to Figure 21, WEV Roof Types.
- Hip roofs are not consistent with Ecovillage architectural character.
- The preferred and recommended Ecovillage roof forms are:
    - Steep (30°- 45°) symmetrical, double pitch gable roofs with overhanging eaves at gable ends;
    - Skillion (10°-15°) with overhanging eaves; and
    - Skillion (20°-25°) with lean to or split gable with overhanging eaves.
- Gable roofs take their cue predominantly from steeper pitched roofs as found in barns, using their form to create opportunities for useable loft spaces.
- A steep gable can look disproportionate in > 8m width at the gable end. Consider reducing building width, increasing plate height, adding loft or bay windows, verandahs / pergolas, or providing feature material transitions to achieve balance. A split gable may also be a solution over a wider span.
- For skillion roofs, ensure roof pitch and sheeting span are sufficient to provide adequate rainwater run-off, as well as achieve aesthetic outcomes. Skillion roofs can look disproportionate if the span is too short and steep, or if the span is too long.
- Butterfly, saw tooth, flat roof forms and other configurations with box gutters over internal spaces are not recommended due to the risk of leakage during heavy rain events.
- See also Section 5.4, Shade Elements, regarding eave requirements.

SOLAR PANELS

- Design your roof to accommodate your required solar panel array. The minimum 6.0 kW array will occupy approximately 40m2 roof area.
- Solar panels are most effective when positioned to face north at a 32° angle (Witchcliffe latitude) to maximise winter solar access, however, efficiency is adequate between approx. 15° and 45°. (See Table 3, Solar Panel Efficiency by Orientation and Plane Inclination.)
- North facing roof space for PV array can be located on carport if adequately sized and located if your home doesn't provide sufficient north facing roof surface (consider potential shading of carport PV panels by house roof on Cottage lots).

- East and west facing placement of PVs will lead to an approximate 15-20% reduction in PV performance (depending on roof angle) and is generally not recommended (see Table 3, Solar Panel Efficiency by Orientation and Plane Inclination). However, an exception may be considered on Cottage lots, where lot dimensions and house size/massing outcomes may necessitate a roof gable opening to the north. The reduction in PV efficiency would impact carbon footprint outcomes (see Section 9.2, Thermal Assessment and Life Cycle Analysis) and may necessitate the addition of extra PVs.

Table 3. Solar Panel Efficiency by Orientation and Plane Inclination

Solar Panel Efficiency (%)					
Direction (plane azimuth)	Solar Panel Plane Inclination (degrees)				
	12°	22°	32°	42°	52°
North (0°)	94%	98%	100%	99%	95%
East (90°)	88%	87%	84%	81%	77%
South (180°)	82%	74%	65%	55%	46%
West (270°)	88%	87%	85%	81%	77%
NB: Table is based on *Clean Energy Council GC Design Guidelines* figures for Perth latitude, optimising winter sun generation. Figures have been adjusted to roughly reflect 100% efficiency at 32° for Witchcliffe location. (https://solarcalculator.com.au/wp-content/uploads/solar-power/CEC-guidelines-direction-panel-angle.pdf)					

Required

- No hip roofs.
- Generally, gable roofs must be min. 30° pitch, though this can be reduced to min. 25° on gable roofs wider than 8m. Gable roofs must be 'generally symmetrical' which means gable roofs with different wall plate heights will be accepted but not gable roofs with different pitches.
- Skillion roofs are to be no steeper than 25° with max. 10m spans.
- Flat roofs or sections of flat roof will be considered only if house design can demonstrate that:
    - the design principles of Section 2.3, Ecovillage Architectural Character, have been addressed through built form and material selection;
    - all windows are provided with appropriate external shade elements; and
    - roof has sufficient slope / waterproofing to facilitate rainwater run-off and avoid leakage
- Gable dormers to loft spaces must have eaves and same slope roof as primary roof.
- Flat and skillion roofs must demonstrate aesthetic and functional accommodation of PVs and gutters for rainwater collection.
- Any box gutter over internal rooms must be sized to accommodate one in 50-year rain events.

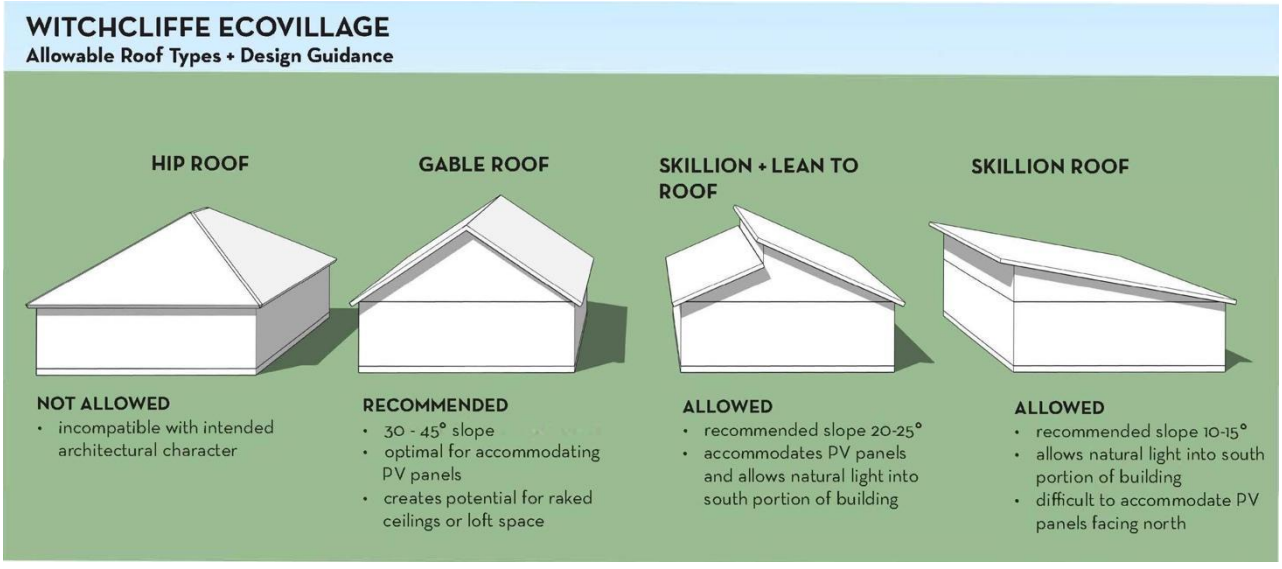


Figure SEQ Figure * ARABIC 21. Witchcliffe Ecovillage Roof Guide

5.4 Eaves and Shade Elements

Unprotected glazing and walls are a significant source of radiant heat gain to a house in summer. Effective shading can eliminate up to 90% of this heat gain (YourHome). Shading elements such as deep eaves, verandahs, balconies, pergolas and porches can also be used architecturally to provide interest to blank walls and create legible entry statements and outdoor living spaces.

Objective

To design visually integrated shading that allows solar gain in winter but protects walls and glazing from summer heat transfer.

Guidance

EAVES

- North-facing gable eaves should be sized so they allow maximum solar penetration for one month on either side of the winter solstice, and are fully shaded for one month on either side of the summer solstice.
- All other gable eaves to be minimum of 300mm (see Section 7.4, Gable Ends and Eaves). Ideally eaves will be symmetrical and balanced across building elevations visible to the street or community garden, as well as sized to provide shading to walls and glazing as required.
- Skillion roofs facing north and clerestory windows to north will require case by case assessment of windows and eaves to achieve effective winter solar access and summer shade, and may require additional shade structures (e.g., solar pergola).

WINDOW SHADING

- North-facing windows should maximise winter solar access, using external shading (eaves, solar pergola, deciduous trees) to minimise heat gain in summer.
- West facing windows require deep eaves, verandahs or additional shade structures to diminish late afternoon sun in summer.
- East facing windows are a valued source of morning sunshine to living areas in winter, and are best protected with seasonally adaptable external shading (awnings, fins, deciduous plantings, etc.)
- Ensure that fixed shading structures over west and east facing windows still allow lower angled winter sun penetration to living rooms.

EXTERNAL SHADE STRUCTURES

- Individual external window shades can augment eaves in protecting key windows (gable end to west or flat roof).
- Balconies, porches and verandahs should be designed as integral parts of the façade, complement the style and construction materials of the building, and only provide beneficial shading impacts on rooms below.
- Balconies and verandahs may project into boundary setbacks areas as identified in the applicable LDP.

Required

- Adequate roof eaves/overhangs (responsive to orientation) must be provided over all external walls of the dwelling (unless a parapet wall and flat roof is specified, in which case all glazing must be separately and adequately shaded).
- All other gable overhangs and eaves to be minimum of 300mm.
- Verandahs, pergolas, patios and other external shade structures over outdoor spaces on the north must not exclude winter solar access to northern glazing.
- Balconies and verandahs must be supported by posts or columns of at least 120mm x 120mm (or ground floor of house).
- Balconies may cantilever no more than 750mm without visible support structures such as brackets.
- Balconies and verandahs are to be no less than 1.8m deep to provide a functional sitting area.

5.5 Carports and Garages

The Ecovillage masterplan differs from conventional subdivision layouts by prioritizing pedestrians and sustainability outcomes over the automobile. Each house interfaces with both the street and strata cluster community garden. All footpaths run through the community gardens (rather than along the streets) to maximise community interaction and amenity. To minimize the visual impact of garages and carports on the streetscape, it is important that the placement of carports and garages is carefully regulated and that they complement main building in materials and form.

Objective

Minimise the impact of vehicle parking on the streetscape and encourage social interaction.

Guidance

- Consult the applicable LDP for your lot for crossover locations and garage and carport setbacks.
- Carports are not subject to side setback requirements and may be located on the side boundary of the lot (subject to *National Construction Code, Vol.2* fire separation standards).
- Free standing carports (steep gable or skillion roofed) are the preferred design outcome as they have less visual impact from the street than an attached garage with double doors, and the open design encourages neighbourly interaction as residents come and go.
- The design of the carport should complement the main structure either by mimicking the roof configuration (same roof slope and type) or by 'deferring' to the primary building by keeping the profile low to minimising visual impact. In both cases, streetscape impact is the primary consideration.
- Gabled carports can easily incorporate a loft storage space for surfboards, etc., and lockable storage at ground level.
- If carport gable is to be filled in, keep finish and detail simple.
- On Family Lots, double garages which adjoin the dwelling can be approved but must address LDP requirements to ensure that the garage does not dominate the house façade.
- Garages can incorporate an upper floor studio (with window to the street frontage) or covered outdoor living area to maximise space and (where applicable) take advantage of views.
- Roof decks (uncovered) over carports may be possible subject to visual privacy setbacks.
- Preferred garage doors are sectional or tilt doors in timber.

Required

- Carports and garages must meet all setback requirements of the applicable LDP.
- Garage and carport construction and roofing materials to reflect and / or complement main building.
- Gable roofs to carports must reflect the pitch of the main house (if main house has gable roof).
- Carports are required to have min. 300mm eaves for non-boundary wall.

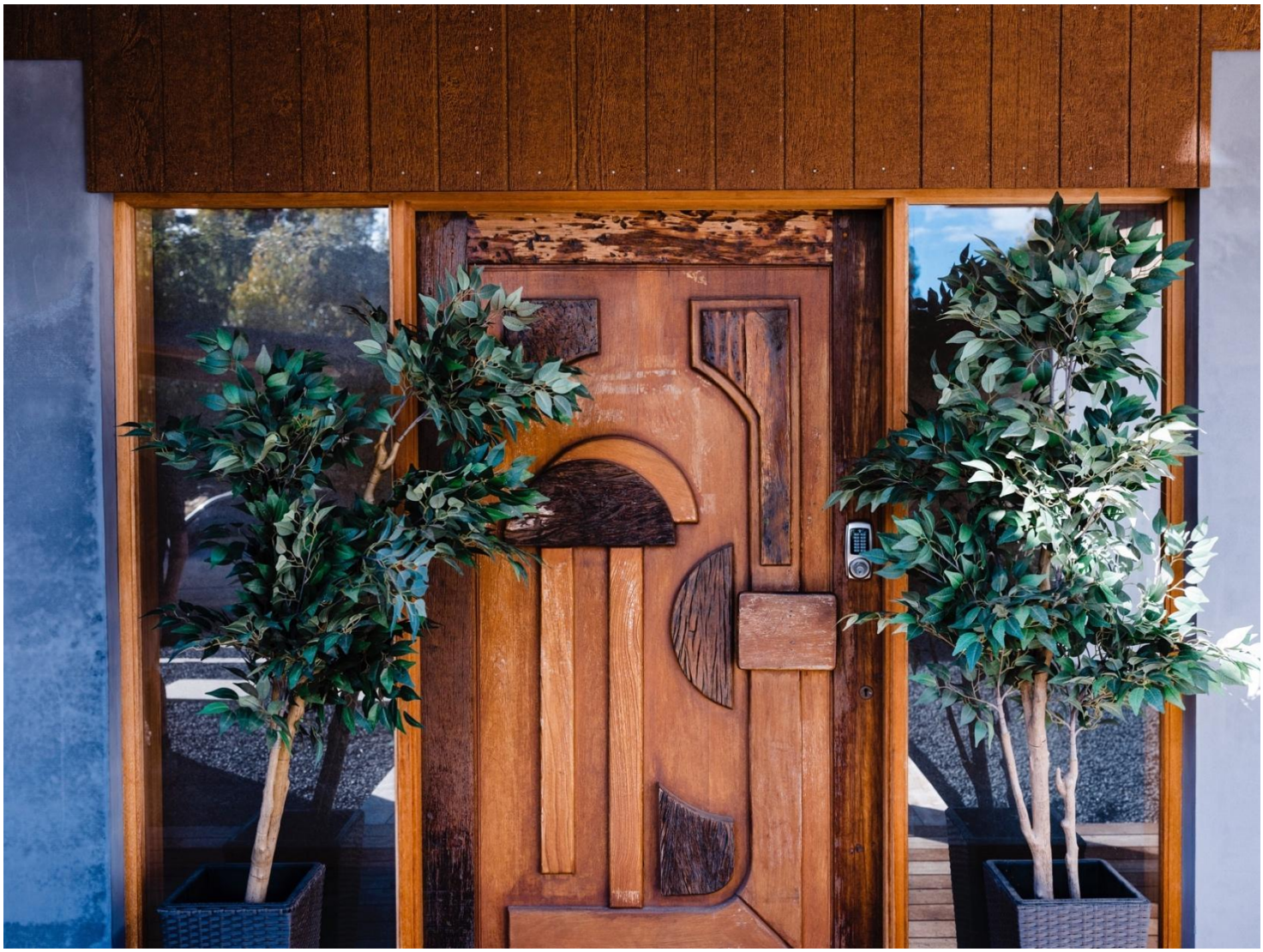
Figure 22. Single gable carport

Figure 23. Single skillion carport

6. Construction and Detailed Design

The power to make buildings beautiful lies in each of us already.

Christopher Alexander, The Timeless Way of Building, (1979).



6.1 Sustainable Materials

Any fossil-fuel energy used in manufacturing and transporting construction materials leads to carbon emissions. This is known as "embodied energy." 26% of the energy use of a typical house over its lifetime is contributed by the embodied energy of the materials used in its construction (*YourHome)*. With the use of life cycle analysis tools, it is possible to significantly reduce the carbon emissions associated with building your home. In addition, life cycle analysis weighs up all other negative environmental impacts associated with the manufacture of construction materials, as well as the material's thermal performance, allowing you to make evidence-based choices to achieve a carbon negative, sustainable house.

Objective

To minimise the carbon emissions and environmental impacts associated with the construction and life cycle of buildings in the Ecovillage.

Guidance

- Consult Table 4, WEV Life Cycle Analysis – Wall Sections, and choose materials that will assist you to achieve the thermal performance and carbon negative objectives required by Section 9.2, Thermal Assessment and Life Cycle Analysis.
- If material you want to use is not included in Table 4, please contact the manufacturer and request life cycle analysis data (if available) to assist with eTool Life Cycle Assessment of your building plans (see Section 9.2, Thermal Assessment and Life Cycle Analysis).

Required

- Provide a detailed schedule of all construction materials and finishes with building application.
- All timber must be Australian certified plantation, FSC certified, locally milled from fallen paddock or verge trees, or recycled timber.

6.2 Unconventional Construction Materials / Methods

Objective

To ensure non-standard construction methods comply with building standards and conform with Ecovillage sustainable design requirements.

Guidance

- Innovative sustainable construction methods will be considered by the Design Team; however, house plans will need to comply with National Construction Code (NCC) requirements to gain Augusta Margaret River Shire development approval. If you are considering using a non-conventional building method, it is recommended that you check with the AMR Shire Planning Department prior to beginning design work. Tiny houses on wheels, shipping container buildings, and earth ships, etc., would fall into this category.

Required

- All plans for unconventional building construction methods must demonstrate ability to comply with AMR Shire and NCC requirements, as well as Witchcliffe Ecovillage Building Design Guideline requirements, including meeting LCA minimum carbon emissions and thermal performance targets (as per Section 9.2, Thermal Assessment and Life Cycle Analysis) and adequate roof space for solar PV array and rainwater collection.

6.3 Walls

Objective

To use sustainable wall construction materials which provide excellent insulation values and provide internal thermal mass.

Guidance

- In order to achieve carbon negative outcomes, you should choose low carbon, thermally efficient wall construction materials wherever possible (see Table 4, WEV Life Cycle Analysis – Wall Sections). These figures relate specifically to the WEV LCA of the base case house model but give a reasonable indication of the relative thermal and GWP performance of the materials in a Witchcliffe context.
- Exterior wall assemblies must meet the insulation requirements of these design guidelines (see Section 6.7, Insulation). R-values of common wall types are included in Table 4, WEV Life Cycle Analysis – Wall Sections.
- Internal walls that add thermal mass (e.g., rammed earth, fast brick, mudbrick, stonework) can help moderate temperature swings if located correctly (see Section 4.1, Passive Solar Heating, and 4.2, Passive Cooling).
- Timber framing should comprise studs, appropriate moisture barrier, battens, and then external cladding to ensure that moisture can evaporate and not condense behind cladding.
- SIPs that are sealed to Passive House standard will require a mechanical ventilation system, (see Section 6.9, Sealing and Ventilation) which will need to be factored into the building's life cycle assessment.

Required

- Wall framing to be constructed from timber or recyclable light-gauge steel.
- Walls must be constructed of locally sourced, low carbon, and/or renewable materials wherever possible.

Table 4. WEV Life Cycle Analysis – Wall Sections

Wall Sections (NB: All NatHERS and GWP metrics are specific to the WEV LCA of the base case house design with 6 kW PV)	NatHERS Star Rating Impact (higher is better)		GWP (kg CO2e) Compared to Base Case	Insulation R- value (higher is better)
Wall Structures	With internal timber/plaster-board walls	With internal brick walls	With internal timber/plaster-board walls	
Double brick, no insulation	-	(Base Case)	0%	0.46
300mm Hempcrete (imported) / Exterior Lime Plaster	+0.9 stars	+1.5 stars	-98%	4.10
300mm Hempcrete (local) / Exterior Lime Plaster	+0.9 stars	+1.5 stars	-120%	4.10
90mm Timber Frame / R3 Batts / 25mm Battens	+0.8 stars	+1.2stars	-132%	3.08
Steel Frame / R3 Batts	+0.8 stars	+1.2 stars	-128%	3.08
450mm Strawbale (Infill) / Clay Render	+1.0 stars	+1.7 stars	-159%	4.54
175mm SIPs Panels / 50mm Battens (+ERV)	+0.9 stars	+1.5 stars	-105%	4.49
Timber Frame + Reverse Veneer (Mud Brick)	+1.4 stars	+1.8 stars	-178%	3.17
Timber Frame + Reverse Veneer (brick)	+1.4 stars	+1.8 stars	-141%	Not assessed

6.4 Foundations

Objective

To provide building foundations that play a useful role in the heating and cooling strategy of the home.

Guidance

- "Slab on ground" is the most common approach to housing foundations in a cool climate. This is a cost-effective way to achieve thermal mass inside a building and can even serve as the internal floor surface (with appropriate treatment). Production of concrete is responsible for significant greenhouse gas emissions, so it is important to minimise your building footprint as much as you can by eliminating wasted spaces.
- The WEV LCA Report recommended the inclusion of local supplementary cementitious materials in the slab foundations (e.g., Boral fly ash) to reduce the GWP of the slab. This is available locally and is no more expensive than normal cement mixes. It has slightly different qualities to conventional cement (e.g., slower curing time) but has many overall benefits. Recommend incorporation of up to 30-40% fly ash into concrete mix if covering building slab with additional floor cover such as timber. Not recommended for concrete floor slabs that will be cut and polished.
- Other "green cement" products will be considered and approved as alternative materials become available in WA.
- Rammed earth flooring is also an option for home builders and provides a small saving in greenhouse warming potential (GWP) but does require additional concrete wall footings.
- Most Ecovillage lots will provide a level building site, however, on sloping sites, building 'on stilts' with columns and footings is an approach that allows the building to float above the ground. This is not recommended without the provision of either:
  - a suspended slab; or
  - timber floor with the addition of underfloor insulation (e.g., R-2.0 underfloor batts) to prevent heat loss; and
  - either appropriately located thermal mass internal walls, or new generation "phase change materials" to buffer temperature changes.
- For more information on phase change materials, see https://renew.org.au/sanctuary-magazine/building-materials/changing-phase-are-pcms-living-up-to-their-promise/.
- Insulation is required below a suspended slab with no habitable rooms below (e.g., above a garage), however, slab edges on ground do not require insulation. See Section 6.7, Insulation.

Required

- House designs without a concrete slab must demonstrate equivalent thermal performance outcomes through the incorporation of thermal mass materials.

Table 5. WEV Life Cycle Analysis - Foundations

Foundations (All assuming 6 kW PV panels and base case house design)	Heating / cooling load (MJ/m2/y) (lower is better)	GWP % saving of CO2 e compared to standard concrete (lower is better)
Eco (extended) concrete	3.4 / 94.4 = Total 97.8	-3%
Standard concrete	3.4 / 94.4 = Total 97.8	0
Insulated slab edge	4.7 / 94.2 = Total 98.9	+3%
Rammed earth floor	not assessed	-5%

6.5 Spanning Elements

Objective

To select spanning elements which are structurally appropriate and environmentally responsible.

Guidance

- The two most common spanning materials in a house are steel and timber. Concrete is occasionally used (e.g., suspended slabs) but these are always reinforced with steel to handle the tension load.
- Structural steel beams allow for long single spans and portal frames. However, steel is a high embodied energy material and expensive. Cold formed steel is often used in construction for smaller structural members, but it is difficult to recycle. As such, timber should be substituted wherever possible (timber laminated beams or trusses should be able to achieve the required spans in most cases).
- To minimise structural costs, consider the maximum spans of standard timber beams and design accordingly.
- Suspended slab for second storey is permitted if thermal mass and noise attenuation qualities are required. Alternative load bearing cementitious flooring systems will also be considered.

Required

- Timber is to be used as the primary spanning material unless it cannot reasonably be used to meet the structural needs of the design.

6.6 Roofing Materials

Objective

To ensure that roofing within the Ecovillage reflects excess summer heat from the building and provides a consistent aesthetic.

Guidance

- Light coloured and reflective roofing materials such as zincalume or steel sheeting reduce heat gain in summer. Dark coloured steel sheeting or tiles (concrete, slate, or clay) absorb heat and increase heat gain in summer.
- Zincalume steel provides up to four times the serviceable lifespan of galvanised steel sheeting.
- Roofing materials that incorporate solar electricity generation can be approved as a variation if they provide an environmental advantage over standard roofing material and PVs see (Section 9.3, WEV Design Review Process).
- 'Green' roofs planted out with vegetation or grasses are allowed, provided there is still sufficient impermeable roof space for rainwater requirements (see Section 8.2, Water). Green roof proposals must include a management plan and safe access considerations and be *National Construction Code, Vol. 2* compliant.

Required

- Roofing material must be zincalume sheeting (not galvanised or Colorbond).
- Allowable metal profiles are corrugated or standing seam. Other profiles can be considered with approval from the WEV Design Team.

6.7 Insulation

All Australian homes need to be well insulated to ensure comfortable internal temperatures all year round. Materials that are poor conductors of heat and that trap air tend to have high insulation values (see section 6.3, Walls). Some wall construction materials will require no additional insulation (e.g., straw bale with render); others will require additional insulation (e.g., timber framed weatherboard with plasterboard). For more information, see *YourHome*, "Insulation," p. 160-177.

To calculate the overall R value of the wall / ceiling, combine the individual R values of all elements and cavity spaces. Use an online R-value calculator or consult your builder/designer.

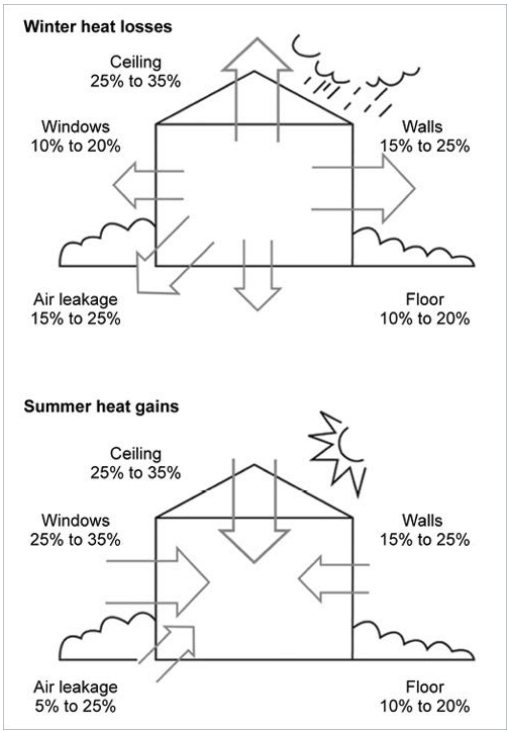


Figure 24. Typical heat losses and gains without insulation in a temperate climate (YourHome).

Objective

To optimise the amount of insulation within the building envelope to minimise the requirement for heating and cooling.

Guidance

- Choose add-on insulation products which are non-toxic, durable, and resistant to fire, water, and vermin. The Witchcliffe Ecovillage Life Cycle Assessment compared the carbon footprint of a variety of locally available add-on insulation materials, see Table 6, WEV Life Cycle Analysis - Insulation.
- Reflective foil barriers combined with a layer of air provide directional resistance to thermal flows in walls and ceilings, ensure it is installed correctly to achieve desired effect and avoid condensation issues.
- Ensure that wall wraps for timber framed weatherboard walls are vapour permeable to prevent condensation / air quality issues.
- Vapour permeable sarking (rather than reflective foil) is recommended for use in roofs with higher levels of ceiling insulation in our cold winter, warm summer climate zone.
- Avoid cellulose blow-in insulation (e.g., recycled newspaper) as this may be flammable and can promote pests and mould.
- Avoid wool insulation as it has a high carbon footprint and may be flammable.
- Ensure that corners of walls, ceilings and floors are properly insulated as this is where most thermal gaps occur.
- The WEV LCA indicated that slab edge insulation is not required in our climate (see Section 6.4). In addition, it does not facilitate visual inspection for termites.

Table 6. WEV Life Cycle Analysis – Insulation

Insulation type (assumed equivalent R-6 ceiling application in base case house design)	GWP % saving of CO2 e compared to rockwool (lower is better)
Hemp Batts (EU)	-4%
Recycled cotton (denim, US)	-4%
Rockwool	+0%
275mm Fibreglass batts	+0%
Polyester batts (virgin)	+1%
Rigid polystyrene	+8%
Wool	+97%

Required

- All house roofs, walls and non-slab floors (open to the exterior) must achieve minimum R-Values as specified in Table 7, Witchcliffe Ecovillage Minimum R-Values.
- Add-on insulation materials must be installed correctly and inspected during construction, with attention to detail to ensure even distribution and no gaps.
- Any thermal mass material forming part of the external walls must be paired with an additional component that provides a layer of insulation sufficient that entire wall assembly complies with minimum R value, see Table 7, Witchcliffe Ecovillage Minimum R-value Standards.

Table 7. Witchcliffe Ecovillage Minimum R-Value Standards

Construction elements plus insulation	Min. R Value	NCC min. R Value (for comparison)
Roof / ceiling	5.0	4.6
Walls	2.8	2.8
Non-slab floor / suspended floor with exterior exposure	2.7	1.0

6.8 Window Frames and Glazing

Inefficient glazing in your home can lead to a loss of up to 40% of a house's heating energy in winter, and a gain of up to 87% of summer heat (*YourHome*). Thermally efficient glazing can add additional cost to a building project, however, in our cool climate it can be an important investment to help you achieve a warm and comfortable home. It is also important to choose window framing materials which minimise the carbon footprint of your home and avoid toxic finishes.

The Witchcliffe Ecovillage Life Cycle Assessment compared the carbon emission potential and thermal performance of four standard window frames and three glazing options in the base case house design (see Table 8, WEV Life Cycle Analysis - Window Glazing and Frame Comparison). This table refers specifically to the WEV LCA of the base case house model, but give a reasonable indication of the relative thermal and GWP performance of the glazing and frame options in a Witchcliffe context. Note that this comparison assumed the use of the same type of window and frame combination throughout the assessed house design; in reality, **the best thermal performance would be achieved with a mix of window frame and glazing types appropriately chosen for each part of the house**.

For more information, see also the WERS rating scheme website http://www.wers.net/werscontent.how-to-select-windows, the Efficient Glazing Calculator on the Australian Window Association website http://www.efficientglazing.net/, and ReNew's "Window and Film Buyers Guide" http://www.renew.org.au/pdf/Windows_guide_table_2018.pdf.

Table 8. WEV Life Cycle Analysis - Window Glazing and Frame Comparison

Glazing and Frames (*relative to assessment in WEV base case house design with 6 kW PV)	NatHERS Star Rating Impact* (higher is better)	Global Warming Potential* (lower is better)
Aluminium frame / single glazed	(Base Case)	(Base Case)
Aluminium frame / 6mm single glazed / low-E	+0.2 stars	-8%
Aluminium frame / double glazed	+0.4 stars	-15%
Aluminium frame / double glazed / thermal break	+0.3 stars	-14%
Timber frame / single glazed	No difference	-6%
Timber frame / 6mm single glazed / low-E	No difference	No difference
Timber frame / double glazed	+0.5 stars	-33%
uPVC frame / single glazed	No difference	-6%
uPVC frame / 6mm single glazed / low-E	No difference	No difference
uPVC frame / double glazed	+0.5 stars	-33%

Objective

To design and locate efficient windows that maximise winter solar gain, natural light, and cross-ventilation, while minimising conductive heat transfer through the building envelope.

Guidance

- Invest in high quality window and glazed door units wherever possible, and be guided by any recommendations arising from life cycle and thermal assessments. The design, quality, and thermal efficiency of your glazing can have a significant impact on the thermal performance and visual presentation of your home.

GLAZING

- Given the cool climate in Witchcliffe (see Section 2.2 Climate), winter heating is the priority. As such, the design requirement for windows is low thermal transmittance (U-values) for all windows and high solar penetration (SHGC) for windows facing north (see Table 8, Indicative Window Thermal Performance).
- The SHGC difference between awning and fixed frame windows (see Table 9, Indicative Window Thermal Performance) is caused by the relatively larger frame to glass ratio in an awning window; therefore awning windows to north should be slightly larger than fixed/sliding windows to achieve an equivalent SHGC.

Table 9. Indicative Window Thermal Performance

Glazing (based on equivalent sized windows in WEV LCA base case house design)	Window type	U-Value (heat conductivity) (lower is better for insulation)	Solar Heat Gain Coefficient (SHGC) (higher is better for winter solar ingress on north facing elevation)
6mm Single glazing	Awning	5.4	0.56
	Fixed / sliding	5.4	0.63
6mm Single glazing Low-E	Awning	4.3	0.42
	Fixed / sliding	4.3	0.50
Double glazing	Awning	3.0	0.48
	Fixed / sliding	3.0	0.56

FRAMES

- Conventional steel and aluminium frames are generally considered to be thermally inefficient and require expensive "thermal breaks" to avoid compromising your home's thermal performance. However, the WEV LCA Report found no benefit from thermally broken frames in our mild temperate climate (see Table 8. WEV Life Cycle Analysis - Window Glazing and Frame Comparison).
- Aluminium window frames were assessed by the WEV LCA to have a higher GWP than plantation timber or lead free UPVC frames, but they have been included as an option to provide a wider design choice.
- Choose operable window types (casement, sliding, etc.) that provide adequate cross flow ventilation while also sealing effectively to avoid heat loss in winter.
- Lead free uPVC frames provide a lower cost and maintenance free alternative to timber frames and are available as efficiently sealed double and triple glazed units, however uPVC frames may have a shorter life span than timber or aluminium.
- Louvre type windows are not recommended unless they are thermally efficient, tight sealing units.
- A high Solar Heat Gain Coefficient (above 0.45) is recommended on north-facing windows for passive heating.

Required

- House design plans must specify window frames / glazing type and must meet the following requirements:
    - U-value (max) of 3.4 for all windows (combined frame and glass) with the following exception: single glazing allowed (min SHGC of 0.45) on north side of homes with sufficient thermal mass, including reverse brick veneer, hempcrete and straw bale homes. This exception only applies to timber frame homes that include significant internal walls made of thermally absorbent material (brick, rammed earth) in north facing rooms.
    - Window frames are made from sustainably sourced timber, lead-free uPVC or aluminium.





6.9 Sealing and Ventilation

Objective

To avoid creating air gaps in the building envelope that can transfer heat / coolness in or out of a building, and to avoid creating air quality issues through lack of ventilation.

Guidance

SEALING

- Minimise the number of penetrations in the insulation layer of the building (e.g., select light fixtures that do not project into the roof space). Where it cannot be avoided, ensure an air seal around the penetration, and where possible add insulation to compensate.
- Pay attention to common leakage points (see Figure 25 below). Consider draught proofing.
- Design airlocks at frequently used external door openings.
- Choose external doors and windows with airtight seals and ensure gaps between window frames, door frames, skirting boards and walls are effectively sealed.

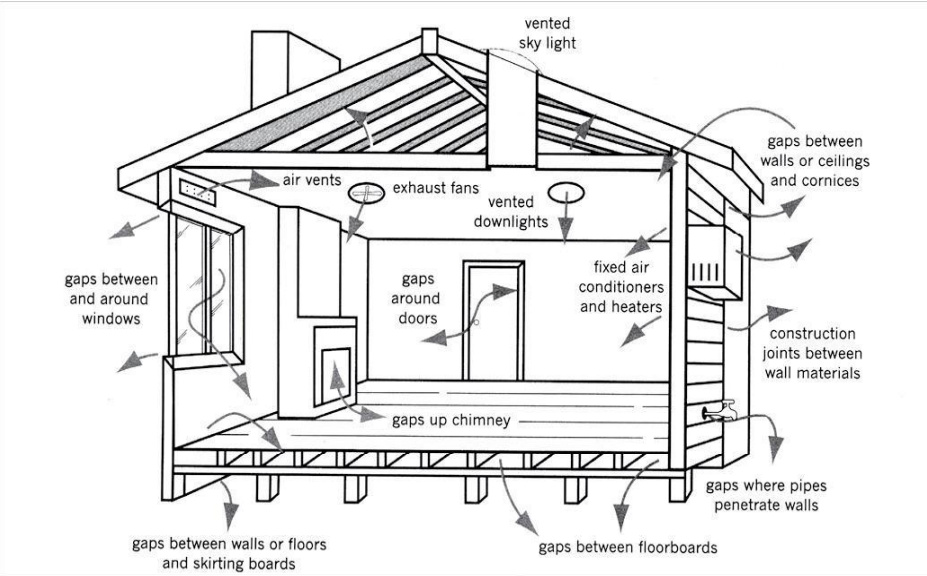


Figure 25. Common Leakage Points (*YourHome*).

VENTILATION:

- Blower-door testing measures the air tightness of a building in "air changes per hour at 50 pascals" or ACH@50Pa. The average Australian home gets an airtightness score of a breezy 15 ACH@50Pa and is generally draughty and expensive to heat and cool. Your house designer / builder can advise you of the expected airtightness score of your new home.
- A sustainable home built with attention to detail to sealing common gaps and penetrations should score between 3 and 7, and will maintain excellent air quality as long as there are operable windows, exhaust fans and no indoor pollutants in winter time when windows are closed for long periods (e.g., gas cookers, wood fires).
- A very airtight home, with a score of 1-3 may require a small mechanical ventilation with heat recovery (MVHR) unit to avoid condensation and air quality issues in winter.
- An extremely well-sealed house, e.g., to Passivhaus standards with a score less than 1, will require a centralised MVHR system.
- Choose external doors and windows with airtight seals and ensure gaps between window frames, door frames, skirting boards and walls are effectively sealed.
- Roof spaces should be provided with adjustable ventilation to vent summer heat and avoid winter heat loss.

Required

- Avoid unsealed recessed down lighting.

- If using ventilated skylights, refrigerator floor vents, wall vents etc., ensure that they can be made airtight in winter.
- Ensure exhaust fans are ducted and have non-return bales.
- Houses built to Passivhaus or similarly airtight standards (>1 ACH@50Pa) will require a MVHR system.

6.10 Termite, Vermin and Wildlife proofing

Feral rodents, as well as native possums, phascogales and lizards, like to live inside roof and wall cavity spaces, and can squeeze through any space which can accommodate their head. For mice and lizards, this can be gaps as small as 1-2cm in width. It is illegal to trap and relocate wildlife off your property and baiting for vermin can lead to secondary poisoning of owls and other native predators. It makes sense to ensure that your roof space and wall cavities are properly sealed to exclude all unwanted visitors and to build physical vermin and termite proofing into the design and construction of the house.

Objective

Design new buildings to exclude termites, wildlife and vermin.

Required

- All houses must be constructed with roof spaces and wall cavities sealed to exclude animals.
- Sub-soil chemical termite treatment is not permitted, including subsoil reticulated systems. Provide physical termite barriers placed under slab, on base plate and/or around slab penetrations in accordance with AS3660.1 1-2000. Other options include low-risk chemical barriers applied to or incorporated into the building slab or base plate as required by the building construction method.
- Houses using straw bale construction or panels must use wire or fibreglass exclusion mesh between straw and render, or other method of vermin proofing.

7. Finishes and Details

7.1 Exterior Wall Finish

Objective

To ensure that the exterior wall finish is compatible with the intended architectural character and sustainability objectives.

Guidance

- The Witchcliffe Ecovillage will achieve a cohesive architectural sense of place through the use of an external palette of natural building materials and finishes, prioritising local, renewable, durable and low-embodied energy materials, (e.g., timber weatherboards, hemp render, lime and clay / earth renders, recycled or mud brick).
- Artificial and composite cladding products are not encouraged, unless they are products that can demonstrate a sustainability / embodied energy advantage and still adhere to the aesthetics of the materials palette.
- A homeowner wishing to use an alternative cladding or render finish must submit a detailed case to the WEV Design Team including the product source, specifications and life cycle assessment information.

Required

- All external building finishes to be in accordance with Ecovillage aesthetic principles and materials palette above.
- Stonework must be a minimum of 100mm thick (no stone veneers).
- Metal sheeting for cladding is only permitted on sheds / outbuildings (not Ancillary Dwelling) and if selected must be Zinclalume.
- Any external brick walls must use recycled or mud brick.
- The following cladding materials are permitted:

Timber Cladding
Any solid timber cladding is allowed that can be verified as one of the following:

- FSC Certified (Forest Stewardship Council)
- Plantation Timber (with a chain of custody document or Statutory Declaration)
- Recycled Timber
- Locally milled timber sourced from fallen paddock / verge trees (a Statutory Declaration required from miller)

Modified / Manufactured Wood Cladding
The following modified wood cladding is approved for use:

- Shadowclad external plywood panels by Carter Holt Harvey
- Vulcan thermally modified timber cladding by Austim
- Accoya chemically-modified (vinegar) timber cladding
- Vacoa thermally modified timber cladding by Mortlock Timbers
- NewTechWood composite timber cladding (recycled plastic / wood fibre)

Fibre Cement Cladding
The following fibre cement cladding options are approved:

- Linea Weatherboard Smooth 150 or 180 horizontal cladding, Axon 133 Smooth or Oblique 200 vertical cladding by James Hardie (product is supported by a detailed EPD that demonstrates the life-cycle / sustainability of the product and manufacturing process). Simulated or faux wood grain profiles are not permitted.

7.2 External Material Transition

Objective

To ensure that material transitions occur in locations that maintain the integrity of the design and the cladding material.

Guidance

- External elevations should generally be made up of no more than two primary cladding or visible materials (e.g. timber weatherboards and rendered straw bale / hemp.)
- Ensure that attention to material choice and details are applied to the whole house, not just the façade.
- Lighter-appearing materials should generally be located above heavier-appearing materials on the building facade.

Required

- Joints between cladding materials in the same plane must be formed using a transition element such as a 'negative detail' (notch) or overlapping trim.
- No exterior material changes on an outside corner (inside corner only).

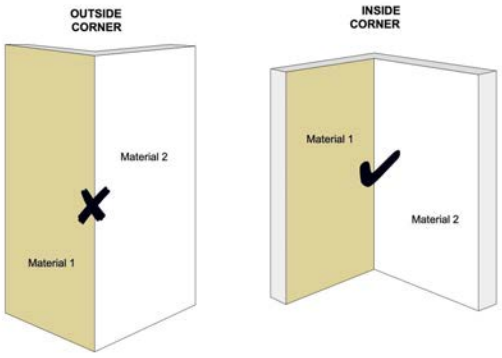


Figure 26. Vertical colour / materials changes

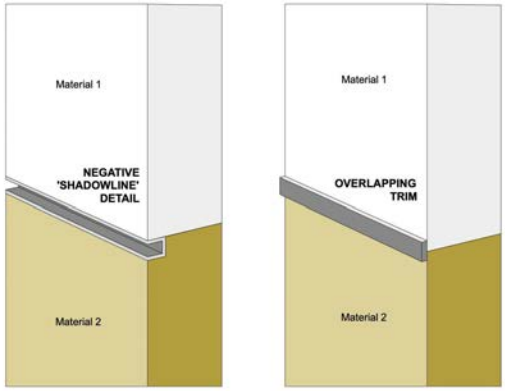


Figure 27. Horizontal colour / materials changes

7.3 Application of Colour

The existing Witchcliffe village centre has a distinctive character largely based on simple historic buildings, natural finishes and utilitarian agricultural sheds. The main street's businesses tend towards an upcycled, quirky look, with light-hearted application of colour and recycled materials. The town's original group settlement houses expressed a simple aesthetic of dark Jarrah weatherboards with lighter trim on windows and doors.

Objective

To encourage an overall approach to colours within the Ecovillage that is consistent with the intended rural village aesthetic.

Guidance

- If painted, external walls should be predominately light or mid-tone with some allowance for feature elements of brighter colour or darker tone.
- Contrasting colours are allowed on trim and elements such as fascia boards, downpipes, window frames, architraves, balustrades, etc.
- Dark timber finishes are permitted, as are untreated hardwood weatherboards.

Required

- Painted exterior walls should be predominantly light or mid-tone with some allowance for feature elements of brighter colour or darker tone. These contrasting colours are best applied to trim and other elements such as fascia boards, window frames, architraves and balustrades. Dark timber finishes are allowed (e.g. Shou Sugi Ban) as well as untreated hardwood weatherboards. The below chart (Figure 28) shows a standard array of colour tone from the graphics industry. We have set the darkest acceptable exterior paint tone at #4 (assuming it isn't timber cladding). Anything #3 or darker may be acceptable for trim or feature elements but not as a predominant colour for the house. This example is greyscale but the theory can be applied across other colour tones.

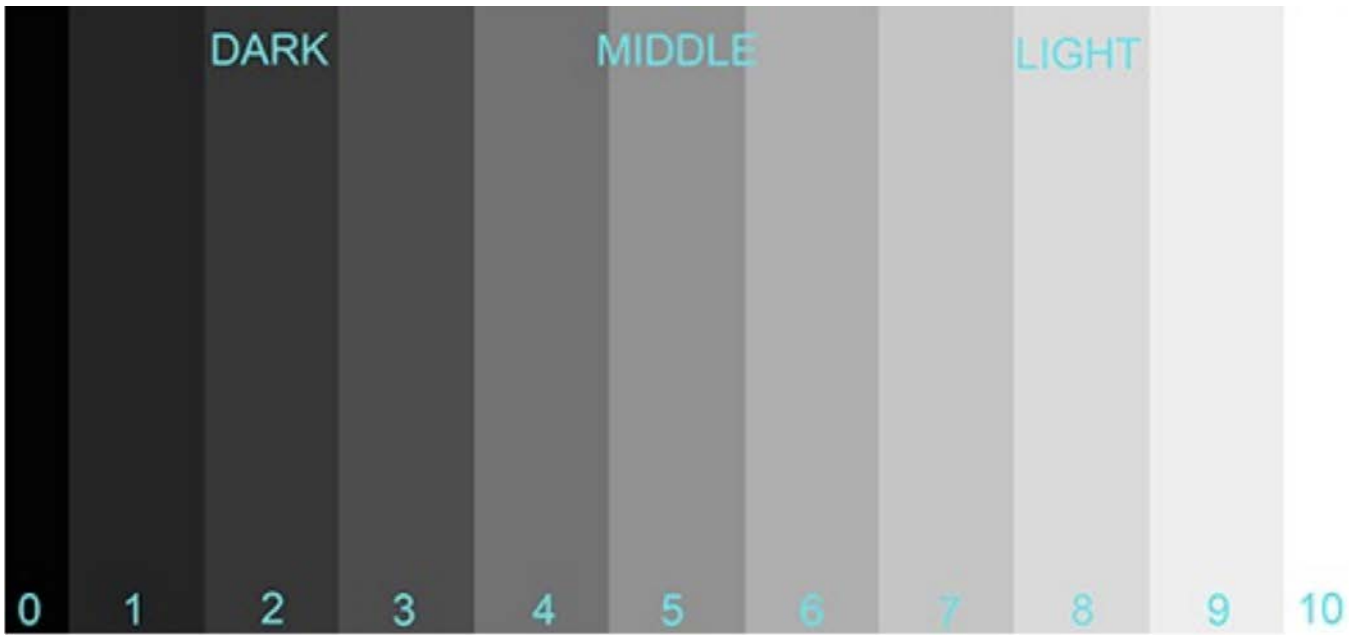


Figure 28. Colour Tone Chart for Exterior Selection

7.4 Gable Ends and Eaves

Objective

To ensure that gable ends and eaves are well-detailed, transitioning between materials at the appropriate locations.

Guidance

- Pay attention to the finish of all roof eaves as this seemingly minor detail will have a substantial impact on the visual presentation of your house.
- Raked eaves may be left open with rafters/trusses exposed as long as the attic space is sealed, as per Figure 9, Margaret River Strawbale Home.
- Raked eaves closed with an angled soffit are consistent with the Ecovillage architectural aesthetic, as per Figure 29, Indicative Gable Eave Detail.
- "Boxed" eaves should be avoided, or closed with a flat soffit with raised heel, as per Figure 29, Indicative Gable Eave Detail.

Figure 29. Indicative Gable Eave Detail (Fine Home Building, https://www.finehomebuilding.com/2019/01/10/design-build-gable-end-eave-design)

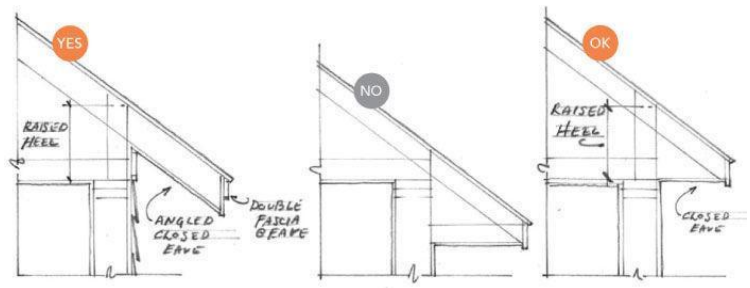


Figure 30. Gable End + Horizontal Eave Transition

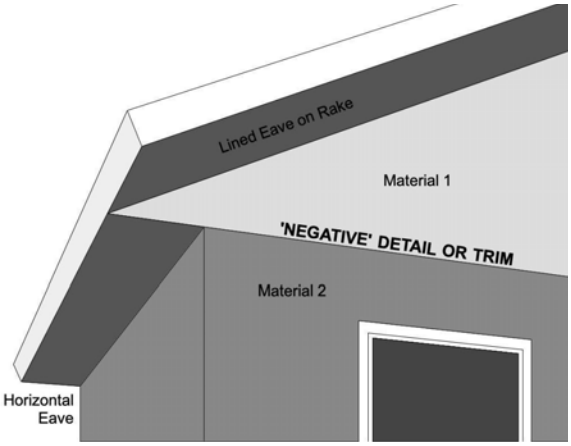
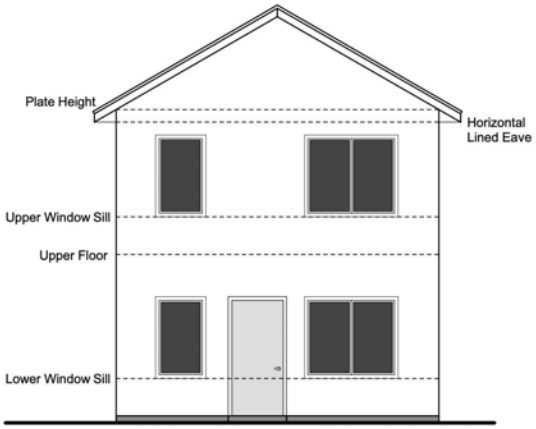


Figure 31. Location for Materials Changes on Gable Ends



Required

- Gable ends should be of a consistent exterior material, or if a material change occurs horizontally it should be at plate height; in line with the horizontal eaves; at upper floor height; or at the bottom of primary windows (Figure 31).
- Transitions between gable ends and hip roofs need to be carefully detailed using one of two approaches:
    - Line entire eave on the rake, and lining follows rafter angle around the corner on the hip roof.
    - If horizontal eave lining is desired for hip roof, gable end must feature material change / moulding at the lower edge of the lined eave to create a regular triangle of one consistent material at the top of the gable end (Figure 30)

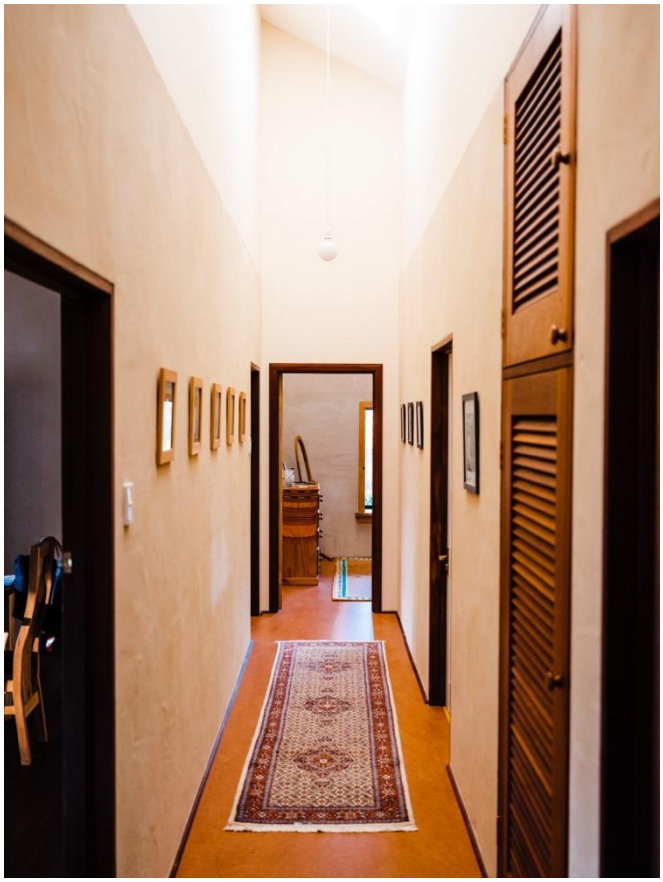


Figure 32. Lino Floor, Straw Bale home, Margaret River

7.5 Flooring

The type of flooring you use in your home makes very little difference to its thermal performance, as long as you have a concrete slab providing thermal mass. However, there is significant variation between the global warming potential (GWP) of some commonly used flooring materials. The WEV Life Cycle Analysis included a comparison of flooring materials in the base case design (Table 10, WEV Life Cycle Analysis - Flooring).

Wool carpet, in particular, was assessed as having a high carbon footprint, while sustainably harvested timber and linoleum were the materials with the lowest footprints. For people who are sensitive to dust mites and allergens, suggest avoiding carpet altogether, and if it is chosen, please choose carpet that is free from PFAS and PVC. Whatever flooring materials you choose, make sure that all glues, sealants, backings, underlays, etc., used to install them have little or no VOC (see Section 7.6, Internal Air Quality).

Table 10. WEV Life Cycle Analysis – Flooring

Floor Types	GWP % saving of CO2 e compared to base case (lower is better)
Living Room Area	
Tiles (base case)	+0
Linoleum	-7%
Polished concrete	-2%
Cork	+2%
Rammed earth	-5%
Timber	-7%
Bedroom Area	
Nylon carpet (base case)	+0
Wool carpet	+52%
Timber	-14%

7.6 Non-Toxic Materials and Finishes

Healthy homes enhance liveability, embrace good design and lifestyle principles, foster environmentally responsible choices and promote quality of life outcomes… [a] healthy home is the missing ingredient to improved family health and positive environmental outcomes.

The Smart Living Handbook, 2014.

Indoor air quality is critical for human health and comfort and is largely determined by the materials used in house construction and fit out. It can also be impacted by the everyday use of cleaning chemicals, gas cooktops and fireplaces, as well as the emissions given off by furniture. Construction materials and finishes can also create environmental impacts off site and impact negatively on workers' health. For example, the risk of silicosis to workers in the manufacture and processing of composite stone benchtops. Indoor air quality is additionally important in a solar passive home, where design and construction of the building have paid greater attention to sealing and stopping draughts than a conventional building.

However, toxins within the home are not just inhaled, but can affect human health through ingestion and absorption as well, and this particularly can affect young children who tend to spend more time touching (and tasting!) the internal surfaces of a home. There are 38, 000 chemicals approved for use in Australia, and it is beyond the scope of the Building Design Guidelines to regulate all internal finishes and materials, however, we have set some broad requirements. For more information, we strongly recommend *The Smart Living Handbook* as a very comprehensive guide to building and furnishing a healthy, low toxin home in Australia.

Objective

To ensure excellent indoor air quality in all new homes to promote a healthy environment for residents, and to prevent off site pollution and health impacts caused by the manufacturing of materials and finishes.

Guidance

- When purchasing new furniture, ensure materials and finishes have low toxicity and do not contain PFAS, a potentially toxic fire-retardant chemical.
- Many standard construction materials / finishes (e.g., chipboard / plywood, resin and laminate countertops, vinyl, paint) may contain high Volatile Organic Compounds (VOC) levels and are not permitted, see Table 11, Prohibited VOC & Other Materials).
- Fibre cement board is allowed to be used internally in wet areas and as lining for eaves / outdoor ceilings.
- Use of composite stone benchtops is not permitted in the Ecovillage due to risk to workers of silicosis. See Table 11, prohibited VOC & Other Materials.

Figure 33. Melbourne hempcrete home (image courtesy OzHemp, https://www.ozhemp.com.au/)

Required

- All internal glues, paints and stains must be low-VOC (max 1g/litre).

Table 11. Prohibited VOC & Other Materials

<table>
<tr><th>Category</th><th>Prohibited Item</th><th>Reason</th><th>Suggested Alternative</th></tr>
<tr><td rowspan="2">Treated timber</td><td>New CCA (Copper Chrome Arsenate) treated timber</td><td>Arsenic risk</td><td>Non-arsenic alternatives are commonly available, e.g., LSOP or ‘blue’ pyrethrin based treatment is acceptable. Note: aged CCA timber is acceptable for landscaping use.</td></tr>
<tr><td>Chipboards, MDF, plywood, composite wood products that contain large amounts of formaldehyde resin—used in cabinetry in kitchen, bathrooms, etc.</td><td>Inhalation risk</td><td>Low formaldehyde versions of composite wood products are commonly available.

<table><tr><th>Emission Class</th><th>Formaldehyde Emission Limit (mg/l)</th></tr><tr><td>Super E0</td><td>Less than 0.3</td></tr><tr><td>E0</td><td>Less than 0.5</td></tr><tr><td>E1</td><td>Less than 1.0</td></tr><tr><td>E2</td><td>Less than 2.0</td></tr><tr><td>E3</td><td>Greater than 2.0</td></tr></table>
We suggest E0 as a target, which can be met by all Austral plywood products, for example. Slightly above this target, Ikea cabinetry sits at about 0.6 mg/l.</td></tr>
<tr><td>Paint</td><td>Paints containing VOCs</td><td>Inhalation risk</td><td>Low VOC alternatives are readily available.</td></tr>
<tr><td>Copper</td><td>Copper water pipes</td><td>Copper leaching and toxicity</td><td>HDPE and butelane piping.</td></tr>
<tr><td>Carpets</td><td>Carpets containing PFAS or PVC</td><td>PFAS persists in the environment, linked to cancer and high cholesterol</td><td>Non-PFAS and non-PVC carpets, linoleum, cork, timber</td></tr>
<tr><td rowspan="2">Vinyl</td><td>PVC water piping used inside residences for drinking water</td><td>Ingestion risk</td><td>HDPE and butelane piping.</td></tr>
<tr><td>Vinyl and vinyl-backed floor and wall coverings or other vinyl cladding</td><td>Inhalation risk</td><td>Natural fibre flooring, concrete slab, linoleum, cork, timber.</td></tr>
<tr><td rowspan="2">Glues and coatings</td><td>Toxic adhesives used in quantity, e.g., timber flooring</td><td>Inhalation risk. Adhesives are responsible for much persistent indoor air pollution.</td><td>Water-based alternatives, or screw and joint rather than glue.</td></tr>
<tr><td>Polyurethane finishes for timber, polished concrete, etc.</td><td>Inhalation, absorption risk.</td><td>Water based polyurethane finishes are generally safer than solvent based but check labels for VOC levels. Oils and waxes are a natural alternative.</td></tr>
<tr><td>Composite Stone</td><td>Composite stone benchtops and other items made from the material.</td><td>Silicosis risk</td><td>Example options include timber, natural stone, laminex, stainless steel etc</td></tr>
</table>

8. Services and Appliances

The tragic reality is that very few sustainable systems are designed or applied by those who hold power, and the reason for this is obvious and simple: to let people arrange their own food, energy and shelter is to lose economic and political control over them. We should cease to look to power structures, hierarchical systems, or governments to help us, and devise ways to help ourselves.

Bill Mollison, co-founder Permaculture

8.1 Energy

Renewable energy generated by PVs is by far the most sustainable source of energy for all appliances within your Ecovillage home. The infrastructure required for a village scale wind power, geothermal, biogas or other energy plant is not a viable or practical option in a semi-rural residential area.

While many people will be accustomed to using gas for cooking and heating, it is a fossil fuel and its extraction and consumption contribute to carbon emissions. As the only household gas available in the Margaret River area is bottled LPG, it is also an expensive and inconvenient form of energy for everyday heating and cooking. Likewise, using a wood fuelled heater is a very inefficient way to heat your home or hot water and produces greenhouse gases and particulate pollution (see Section 8.6, Heating and Cooling).

The Ecovillage is therefore designed to be self-sufficient in renewable energy to all households through energy generated during the day by roof top solar PVs on every roof and stored for night-time use in centralised storage battery banks. A Western Power connection is provided to each cluster to enable export of excess renewable power back to the grid and provide continuity of supply. The total renewable energy produced within the Ecovillage over a whole year has been designed (using worst case cloud cover weather data) to be significantly greater than the total energy that residents consume.

Each strata cluster company will maintain a private microgrid and shared battery bank located in strata common property. The microgrid will connect all homes within the strata cluster to each other, to the central battery, and to Western Power, to enable each household to export their excess renewable energy for sale to other households or the Western Power grid. The microgrid network will also include two 3-phase (fast charging) electrical vehicle charging stations in each strata cluster on communal land.

All houses are required to install a minimum 6.0 kW solar photovoltaic panel (PV) array and a maximum 5kW inverter to provide greater than net neutral energy generation. PVs and inverters will be supplied by homeowners, who will be eligible for rebates under the Small-scale Renewable Energy Scheme for up to 6.6 kW of PVs (http://www.cleanenergyregulator.gov.au/RET/About-the-Renewable-Energy-Target/How-the-scheme-works/Small-scale-Renewable-Energy-Scheme). High quality PVs will be made available for residents to purchase at bulk buy discounted prices through the Ecovillage Developer. Every lot will access the shared battery for night-time power, with kW hour allocations as per Appendix D Witchcliffe Ecovillage Residential Energy Supply Handbook.

Table 12. Example Witchcliffe Ecovillage Battery Allocation by Lot Type

Lot type	Cluster 1A	Cluster 1B	Cluster 1C
Groupie	5 kW hours	6 kW hours	6 kW hours
Cottage	9 kW hours	9.5 kW hours	10 kW hours
Family	12 kW hours	13.5 kW hours	15 kW hours

For further details, please see Appendix D Witchcliffe Ecovillage Residential Energy Supply Handbook.

Objective

To ensure a self-sufficient, resilient, renewable electricity power supply to meet the needs of all Ecovillage households.

Guidance

- Solar panels are to be considered as an integrated design element of the building. The permitted roof angles (see Section 5.3, Roof Forms) are designed to allow optimal solar energy production (between 90-100% if facing north) and present an aesthetically pleasing streetscape.

- The minimum PV requirements have been designed to cater for the average Ecovillage household's energy requirements and provide renewable energy self-sufficiency. If your household has higher energy needs (e.g., greater use of appliances, higher than average heating or cooling requirements) or would like to generate additional energy for sale back to the grid, there is no restriction on households installing additional PV's and batteries. However, the PV inverter sizes will be limited as per Appendix D Witchcliffe Ecovillage Residential Energy Supply Handbook.
- At the Initial Briefing (see Section 9.3, WEV Design Review Process) the Design Team will provide assistance with household energy budgeting and infrastructure requirements.
- As electric vehicles grow in popularity and accessibility and reduce in price, it will be important to ensure that all houses in the Ecovillage can provide a convenient outlet for slow charging of electric vehicles in their carports (10Amp is sufficient).
- As of 2019, all solar PV systems, inverters, and storage batteries installed in Australia must comply with the following Australian Standards:

  AS - 477 Grid-connections of energy systems via inverters.
  AS/NZS - 3000 Electrical wiring rules.
  AS - 1768 Lightning protection.
  AS/NZS - 1170.2 Wind loads.
  AS/NZS - 5033 Installation of photovoltaic (PV) arrays.
  AS IEC - 62619:2017 Secondary cells and batteries containing alkaline or other non-acid electrolytes / Safety requirements for secondary lithium cells and batteries, for use in industrial applications.

Required

- Submitted plans must include an Energy Budget and Infrastructure Plan.
- Each lot must meet minimum 6.0 kW PV and comply with all relevant Australian Standards. Allocated maximum inverter size varies by lot type and cluster as per Appendix D Witchcliffe Ecovillage Residential Energy Supply Handbook.
- All lots must supply and maintain a connection to the strata owned microgrid, as per the Witchcliffe Ecovillage Residential Energy Supply Handbook (indicate microgrid connection location on site plan).
- All homes must be fitted with a SATEC NMI meter to enable integration with the strata microgrid.
- The use of bottled gas for heating, water heating and indoor cooking is not permitted.
- At least one parking space per lot must be located within 2m of a standard A/C wall outlet to facilitate slow charging of electric vehicles.

Figure 34. 6.4kW PV array, Cottesloe

8.2 Water

The Ecovillage is completely self-sufficient in water supply, with all water for household use captured and stored in rainwater tanks on each lot, and all water required for community gardens, landscaping and agricultural food production supplied by stormwater captured in the Ecovillage's three sustainable dams.

Objective

To ensure sufficient potable water supply to meet your household's water needs.

Guidance

- To calculate roof area and water storage requirements, please see Table 13, Tank Sizing Table, Table 14, Tank Sizing Chart, and read the Witchcliffe Ecovillage Water Handbook (Appendix E).
- Recommended minimum sizes / person are 50m2 of roof and 18,750L of tank storage.
- Seek expert advice from a licensed plumber to ensure an appropriately sized pump is fitted to the rainwater tank.
- It is recommended that houses are fitted with integrated "smart" water monitoring systems.
- Additional information is available regarding the management and use of rainwater tanks in the Australian Dept of Health's "Guidance on Use of Rainwater Tanks," (https://www1.health.gov.au/internet/main/publishing.nsf/Content/0D71DB86E9DA7CF1CA257BF0001CBF2F/$File/enhealth-raintank.pdf).
- Ensure efficient use of water within the home by installing high efficiency WELS rated fixtures (see Table 15) and appliances (see Section 8.8, Freestanding Appliances.)
- Overland flow paths for stormwater runoff and rainwater tank overflow from private lots through community gardens to the stormwater system located within their community garden must be maintained.
- Pre-tank filtration can provide a very high standard of water quality, depending on filtration system.
- UV treatment systems may be installed post-tank but do add an energy consumption factor to household energy budget. UV treatment systems are covered by Australian standards, see https://ww2.health.wa.gov.au/Articles/U_Z/Ultraviolet-disinfection-of-drinking-water.

Required

- Submitted plans must include a Water Budget (as per Appendix L - Household Water Budget Template) and Infrastructure Plan, demonstrating that 100% of water requirements can be met by onsite water collection and storage.
- Tanks to be fitted with an external tank level gauge and/or integrated flow monitoring device to assist in monitoring usage and detecting water leaks.
- Rainwater filtration systems (pre- and / or post- tank) must be installed to guarantee water quality and safety and reduce tank maintenance.
- Any roof discharge points not connected to rainwater tanks and rainwater tank overflows must be managed by connection to a rain barrel or rain garden and directed to vegetated areas that will spread and slow down water flows.
- Install fixtures (e.g., toilets, showers, taps) as per Table 15, Minimum WELS Fixture Ratings.

ROOF AREA PER PERSON	WATER DEMAND PER PERSON		
	100L/PP/D	122L/PP/D	150L/PP/D
50m2	18,500	-	-
60m2	17,500	29,000	-
70m2	17,000	23,000	-
80m2	17,000	21,500	30,000
90m2	16,500	20,250	25,500
100m2	16,500	20,100	25,000
110m2	16,250	20,100	24,800
120m2	16,000	20,000	24,600
130m2	16,000	20,000	24,400
140m2	15,750	19,900	24,200
150m2	15,750	19,900	24,000
	MINIMUM TANK SIZE PER PERSON		

Table 13. Rainwater Tank / Roof Sizing Table

Table 14. Rainwater Tank / Roof Sizing Chart

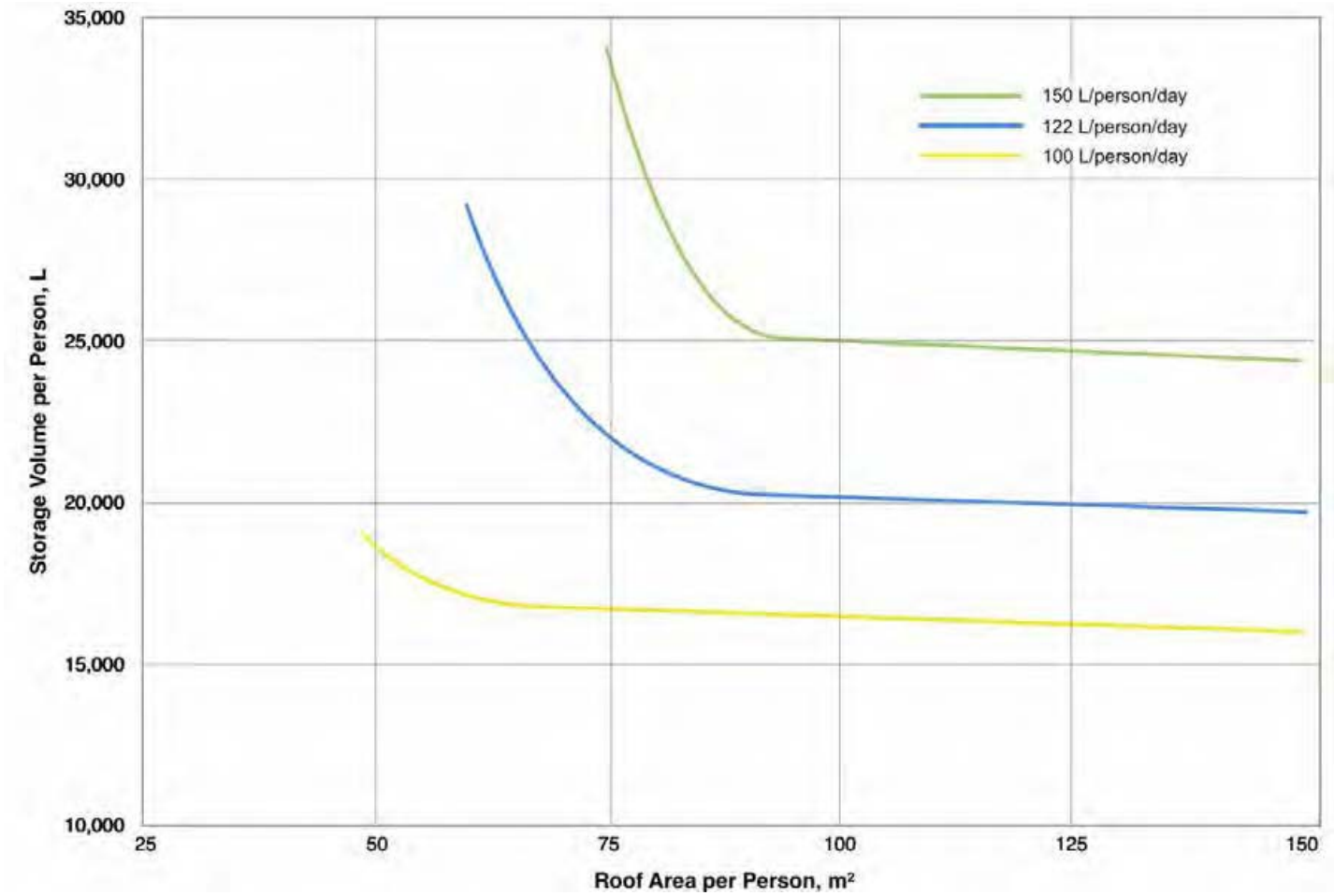


Table 15. Witchcliffe Ecovillage Minimum WELS Ratings

Fixture	National Construction Code minimum	Witchcliffe Ecovillage minimum / recommended	Comment
Taps	4 stars: 6-7.5L/minute	5 stars: 4.5-6L/minute	
Showerheads	3 stars: 7.5-9L/minute	4 stars: 6-7.5L/minute 5 stars: 4.9L/minute	Choice will depend on budget and level of water efficiency aimed for.
Toilets	4 stars: 4.5-3L/flush	4 stars: 4.5-3L/flush 5 stars: 4.5-3L/ flush with integrated hand basin 6 stars: 3-1.8L/flush (e.g., vacuum flush macerator technology that reuses water)	Choice will depend on budget and level of water efficiency aimed for.

8.3 Wastewater

The Witchcliffe Ecovillage Wastewater Treatment Plant is a private wastewater facility located on Davis Rd at the southern end of the development, powered by renewable energy. It is operated by TMC Witchcliffe, a wastewater service provider licenced by the WA Economic Regulatory Authority. Ecovillage residents will be charged an annual connection fee and rates for the treatment of their wastewater, similar to a conventional Water Corp sewerage service. Wastewater treated to A1 agricultural standard will be discharged onto Ecovillage Common Company agricultural land to grow tree crops.

For more information, see https://www.ecovillage.net.au/sustainability/water/.

Objective

To provide sustainable wastewater treatment that retains and reuses grey and black wastewater on site.

Guidance

- Installation of a household greywater system is recommended to supply additional water for gardens.
- Composting toilets are not allowed by WA Health Department regulations on any residential lot that has a sewer connection, therefore composting toilets are not permitted in the Ecovillage.
- A 'Builder's Kit' to facilitate future installation of greywater systems is recommended but no longer required.

Required

- All houses must be connected to the Witchcliffe Ecovillage wastewater treatment system.
- All houses on Cottage or Family Lots must install dual plumbing to allow for greywater separation for water recycling. Connections are required only from the bathroom(s). Connections to the laundry are optional and need to be carefully considered as water can become quite alkaline, which is inappropriate for some landscaping. All grey water systems need to be able to be diverted to the WEV sewer. This is necessary for winter months, to avoid overwatering gardens, to enable flushing of the sewer during the wet months, and should it be required from time to time during summer months.
- All greywater recycling must be via WA Health Dept. approved systems.

8.4 Internet

Objective

To provide high-speed fibre internet connections to every dwelling and commercial building.

The provision of the best available fibre-to-the-home NBN connection is a key feature of the Ecovillage, and was included at significant cost to the project to provide Ecovillagers with every opportunity to work from home, transfer their city jobs to country life, run home businesses, study online, etc. In addition to this, the NBN connection provides the connectivity and speeds required for the metering and monitoring of our private microgrids, which will allow peer to peer energy trading, equitable sharing of the battery, sale of energy to EV's, etc.

The trenching of the conduit from the roadside NBN pit to houses should be covered in house building contracts. As part of the NBN's "New Connection Charge" (approx.. $300) an NBN contractor will pull through the NBN fibre and set up the home with NBN. Households will then be able to either transfer their current service or choose from a range of providers to provide internet service and the connectivity needed for microgrid control and metering.

Guidance

- The Witchcliffe Ecovillage will provide National Broadband Network (NBN) fibre to the premises (FTTP) connections via the common service trench to all lots to facilitate telephone and high-speed data services for every building in the development.
- FTTP is the highest level of NBN service provision available and will ensure households and home businesses will enjoy a higher level of NBN service and capacity than is available with the fibre to the node connections or satellite services generally provided in rural areas.

Required

- NBN, or similar microgrid compliant internet connection*, is required to every home to enable microgrid control, energy monitoring and metering networks.

*Stage 1-3 minimum connection requirement is 4G wireless modem (not dongle) with data plan and 2 free ethernet ports, but may be subject to change in stage 4 and 5.

8.5 Hot Water Systems

21% of energy used in the average Australian home heats water (*YourHome*), so it makes sense to ensure that you choose a hot water system that minimises your energy consumption. Unlike homes in a conventional subdivision, Witchcliffe Ecovillage homes are powered by renewable energy, so electric hot water systems are far more environmentally sustainable and affordable to run than gas systems.

Objective

To ensure that hot water systems are well-insulated and high-efficiency to minimise energy use.

Guidance

- Hot water systems should be chosen to fit within the overall electricity budget of the house and sized to suit the living requirements of the household.
- Heat pump hot water systems are highly efficient (up to 80% energy savings) and are more efficient in our colder climate than solar hot water systems, but can be variable in quality and carbon emission performance. Preferred heat pump hot water systems use low greenhouse warming potential (GWP) refrigerant gas (e.g., CO2 or R32) and must be higher quality, leak free units. We are able to offer excellent discounts on Reclaim, which are high quality units that meet these standards.
- Solar thermal panels for solar hot water systems only have one function – to produce hot water. Once the tank is hot, the panels are idle. In contrast, solar PV panels can produce hot water via a heat pump, as well as run other appliances inside the house, charge the batteries, or an electric car, etc., so it is more effective to use the space on your roof for PVs rather than a solar hot water system.
- For more information, see the extensive analysis of electric-based systems in this review: https://renew.org.au/renew-magazine/buyers-guides/hot-water-buyers-guide/.

Required

- All hot water systems must be electrically powered or boosted, no LPG gas.
- Heat pump systems must demonstrate that refrigerant used has low greenhouse warming potential. Systems that use R32 refrigerant are the lowest acceptable standard (R134A or lower units are not acceptable).
- Include nominated system in Household Energy Disclosure Template (Appendix M) and Infrastructure Plan.

8.6 Heating and Cooling

Space heating and cooling accounts for 40% of the average Australian house energy use (*YourHome*) and was responsible for 25% of the total carbon emissions (embodied and operational) of the base case house assessed in the WEV Life Cycle Assessment. A well-designed solar passive home in the Ecovillage will remain thermally comfortable for most of the year, greatly reducing that energy requirement. However, during extended periods of overcast weather in winter and spikes in summer heat, some supplementary heating and cooling may be required. It is important to choose an energy efficient, easy to use, and environmentally friendly heating or cooling system.

Objective

To ensure energy efficient heating and cooling of homes and avoid local air pollution.

Guidance

- Ceiling fans provide a very efficient and low energy approach to summer cooling and are recommended in all living spaces. Locate fans above main occupation areas (dining tables, lounge suites, beds, etc.). While fans do not actually cool the air in rooms, the air movement they create cools people very effectively.
- Choose a fan which has reverse or "winter" mode, to assist circulation of warm air around living spaces in cold weather, particularly in living areas with raked ceilings.
- Reverse cycle air conditioning units powered by renewable energy are a relatively efficient, convenient and inexpensive way to provide occasional heating / cooling capacity. Make sure you choose a system which:
    - has the most energy rating stars for COLD climate zone you can afford (aim for ≥ 3.5 star cooling and ≥ 4 star heating);
    - is suitably sized for your living space's area/insulation/glazing/shading (use an online calculator);
    - has an "eco" mode and an automated timer; and
    - provides air filtration.
- The new Zoned Energy Rating Label for air conditioners is explained here: http://energyrating.gov.au/sites/new.energyrating/files/documents/Factsheet_How_To_Read_The_ZERL_For_Air_Conditioners.pdfhttp://energyrating.gov.au/sites/new.energyrating/files/documents/Factsheet How To Read The ZERL For Air Conditioners.pdf.
- The smaller the area you are heating or cooling, the more efficient the air-conditioning system, so try to design spaces which can be shut off with doors to create zones, so you are not heating or cooling unused space.
- Another heating system to consider is hydronic heating (radiator or in-slab) powered by heat pump hot water systems, but be aware of the variable quality and Greenhouse Warming Potential (GWP) of different heat pump models (see Section 8.5, Water Heating).
- Underfloor hydronic systems may also assist in cooling the house in summer.
- Gas space heating contributes to carbon emissions, gives off fumes inside your home, and is only available in expensive and inconvenient LPG bottles in the Margaret River area.
- Wood burning stoves and heaters are not recommended for everyday use in built up areas as they are inefficient converters of fuel to heat, contribute to carbon emissions, cause local air pollution to neighbours and residents with breathing difficulties, and are generally fuelled by unsustainably harvested forest hardwoods. They are not recommended in well-sealed houses, as they burn oxygen inside the home and require ventilation. In poorly sealed homes, they pull in cold air from outside. Outdoor fire pits are allowed.
- We recommend pellet heaters over solid fuel combustion heaters due to their efficiency and low particulate emissions (dependant on make and model), use of plantation softwoods, convenience, and ability to regulate temperature via thermostat control and timers.

- For more information see https://www.energy.gov.au/households/heating-and-cooling, and the *YourHome* and *Renew* websites.

Required

- Space heating and cooling provision and specifications (including Zoned Energy Rating Certificate) are to be included in Infrastructure Plan and Household Energy Disclosure Template (Appendix M).
- Air conditioner energy rating certificate must demonstrate the appliance suitability for area to be heated/cooled, and demonstrate a minimum 3.5 star (cooling) and 4 star (heating) rating for COLD climate zone.
- Wood burning stoves are no longer supported in the Ecovillage and are prohibited in Stages 3, 4 & 5 of the development. Please consider alternatives such as pellet heaters or reverse cycle air conditioning for space heating/cooling, if required.
- Any selected pellet stove must not exceed 0.8g/kg particulate emissions (Australian Certified). See list of units on the Australian Home Heating Association website (https://www.homeheat.com.au/wood-heaters/certified-wood-heaters/)
- Gas or wood fired space heating is not permitted.
- Underfloor hydronic system must specify low GWP heat pump system (R32 or better).

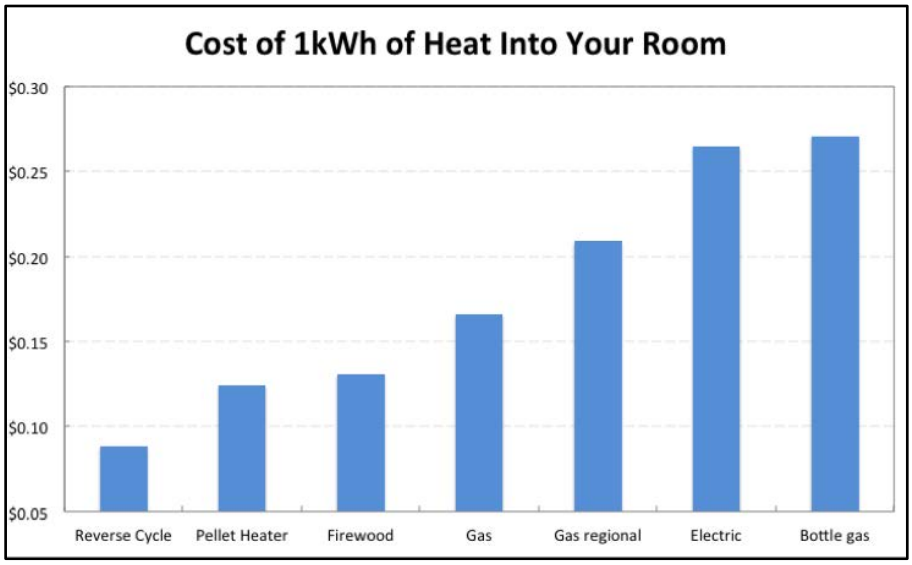


Figure 35. Comparison of Heating Costs (Enviroheat Australia, http://enviroheat.net.au/home-heating-2/running-costs-of-pellet-heaters-versus-alternatives/.)

Figure 36. Pellet Heater (Innovations Enviro Heating http://www.enviroheating.com.au/heaters/nike-pellet-heater)

8.7 Lighting

Lighting contributes about 6% of your home's energy consumption (*YourHome*), and the interior spaces of many houses are over lit. Thoughtful lighting design can reduce day to day energy use and provide appropriately lit living environments.

Objective

To ensure that lighting design is fit-for-purpose and energy efficient.

Guidance

- Avoid applying a generic "lights per m2" lighting approach, and instead design a specific lighting plan for each room. Focus direct lighting (downlights) over task areas such as benchtops and work areas and use indirect light (uplights, wall brackets) for general ambient lighting. Use lamps to provide additional locational lighting related to furniture configurations.
- Create lighting zones on separate switches, rather than one large bank of lights controlled by one switch.
- Consider the colour temperature that is appropriate for each room and use. Colour temperature in lighting ranges from warm white (2700-3500K) to natural white (3500-4500K) to daylight white (5000-6000K). Higher colour temperatures become more blue and less yellow, are less cosy and are better for detailed tasks. Choose warm spectrum lights for bedrooms and night-time living spaces, as blue spectrum light disrupts melatonin production and can impact on sleep cycles if used at night.
- We recommend LED lighting for efficiency and to avoid any lighting higher than 4500K.
- Keep external lighting to a minimum and face away from neighbours to avoid light pollution.
- Use low bollard-type or at-ground lighting outside rather than taller pole lights.

Required

- Submit a lighting plan with house plans.
- All lighting for dwellings (interior and external) must be high-efficiency.
- All external lighting must be directed away from neighbours and community garden areas.

8.8 Free Standing Appliances

As your Ecovillage home is completely self-sufficient in renewable energy and water, it is important to include the expected energy and water consumption of freestanding appliances in your energy and water budget calculations. Household appliances account for approximately one third of household energy use, and laundry appliances account for over 20% of household water consumption. Choosing household appliances carefully can have a significant impact on reducing your energy and water consumption, directly reducing your operational carbon emissions, and freeing up more renewable energy that you can sell back to the Western Power grid.

The importance of household appliance choice was confirmed by the WEV Life Cycle Analysis Report, which found that if our base model house used **average** energy efficient (1-2 star) appliances instead of **high efficiency** appliances (4-7 stars), the global warming potential would increase by 154% and would create 26 t CO2 e over the 80 year life of the building. The results of this scenario highlight the importance of the use of high-efficiency appliances in the dwelling to ensure a net carbon negative result.

The Smart Living Handbook and the YourHome, WELS and energyrating websites all provide excellent advice on choosing energy and water efficient appliances. If your budget to upgrade appliances is limited, focus attention on appliances which are always on or used frequently (e.g., refrigerators) which can deliver the best investment to energy savings return, and aim to replace all appliances over time to 4-7 stars. **The higher the stars, the greater the efficiency.**

Objective

To assist households in choosing appliances that are energy and water efficient.

Guidance

- Use the highest rated water efficient appliances possible (4-6 WELS star rating).
- Use the highest rated energy efficient appliances possible (4-10 Energy Rating stars).
- Carefully select refrigerators and freezers that suit your family size and requirements, and ensure seals and motors are well maintained.
- To ensure efficient operation of appliances, provide ducting/minimum clearances as per appliance specifications.
- If using a tumble dryer, choose one with a heat pump to increase efficiency.
- Consider appliances that do not require standby power or install smart management devices.

Required

- Include indicative freestanding appliance specifications, including star ratings, in Energy and Water budgets.

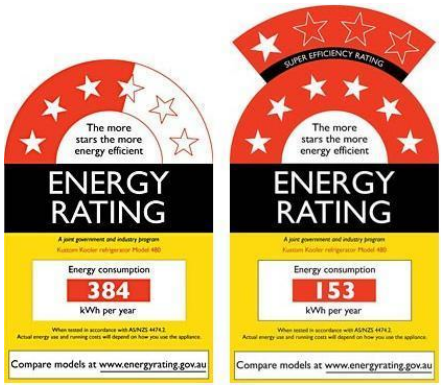


Figure 37. Energy rating labels
(https://www.energy.gov.au/households/energy-rating)

WITCHCLIFFE ECOVILLAGE

C. APPROVALS AND CONSTRUCTION

9. Approvals

9.1 Local Development Plans

A Local Development Plan (LDP) "is a mechanism used to coordinate and assist in achieving better built form outcomes by linking lot design to future development" (*Framework for Local Development Plans*, Department of Planning WA, 2016.)

LDPs can supplement or amend the development requirements within the Residential Design Codes (R-Codes) and are signed off by the Shire (on behalf of the WAPC). If a development proposal is consistent with the LDP standards, a proponent can avoid going through the Development Approval (DA) process and go straight to Building Permit, saving considerable time.

Key requirements that our LDPs cover are:

- boundary setbacks, building height, primary dwelling orientation
- locations for rainwater tanks
- crossover locations
- building materials
- fencing and retaining walls.
- Minimum finished floor levels to avoid 1:100 year flood levels

Please review the LDP for your specific lot (see Appendix A).

Required:

- LDPs must be adhered to and will override all other requirements in this document.

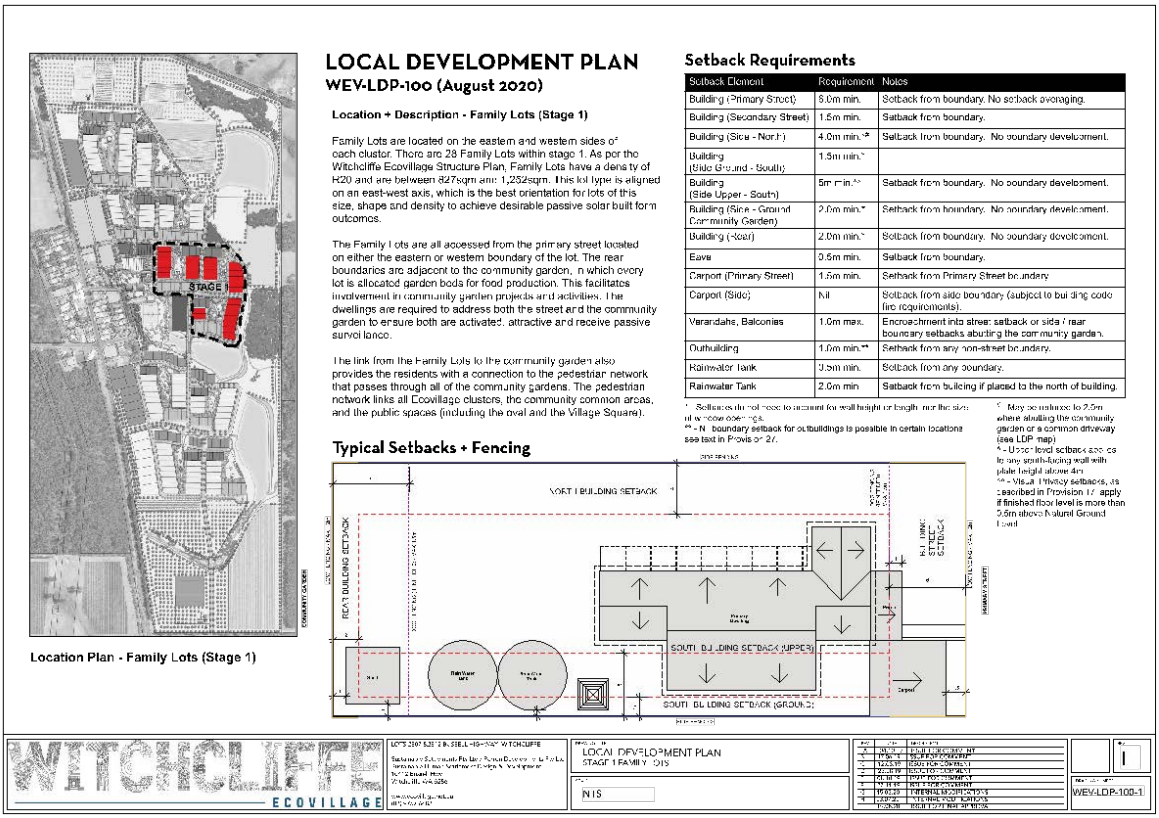


Figure 37. Example Witchcliffe Ecovillage Family Lot LDP

9.2 Thermal Assessment and Life Cycle Assessment

All Ecovillage buildings must meet minimum building permit standards as required in the National Construction Code (NCC) Vol. 2., which includes the requirement to meet the building thermal performance requirement for Class 1 buildings via one of three methods of thermal assessment:

1. Obtaining a Deemed to Satisfy energy rating of at least 6 stars using a software tool accredited under NatHERS;
2. Complying with the relevant Deemed to Satisfy elemental provisions detailed in the NCC (which prescribe specific levels of energy efficiency materials be included in the home, such as insulation and glazing); or
3. Providing a Performance Solution, where it can be demonstrated that the proposed solution meets the Performance Requirement through other means. For example, a Performance Solution could demonstrate that the heating and cooling loads of the proposed building are less than or equal to the heating and cooling loads of a reference building, as prescribed in the NCC (V2.6.2.2).

We anticipate that most Ecovillage houses will easily achieve the energy efficiency requirements of the NCC. Therefore, the Design Guidelines specifies a higher minimum standard, requiring a NatHERS star rating of **7.5 stars** for Stages 3-5 (**7 stars** for earlier stages) in order to achieve our sustainability outcomes. NatHERS only rates thermal performance and not the embodied energy or other environmental impacts of building materials and fixtures. It may be that the embodied energy or cost of the additional materials and products required to achieve a 10 star house (additional insulation, added phase change materials, triple glazing, etc.) outweigh the operational energy gains that would achieved in our climate zone. To account for the operational energy use of the house, a NatHERS assessment of each house will be required (i.e. a star rating out of 10).

Life cycle assessment provides a far more comprehensive tool for analysing the thermal performance and long-term global warming potential and environmental impacts of your building (see Figure 38, Star rating vs Life Cycle Design).

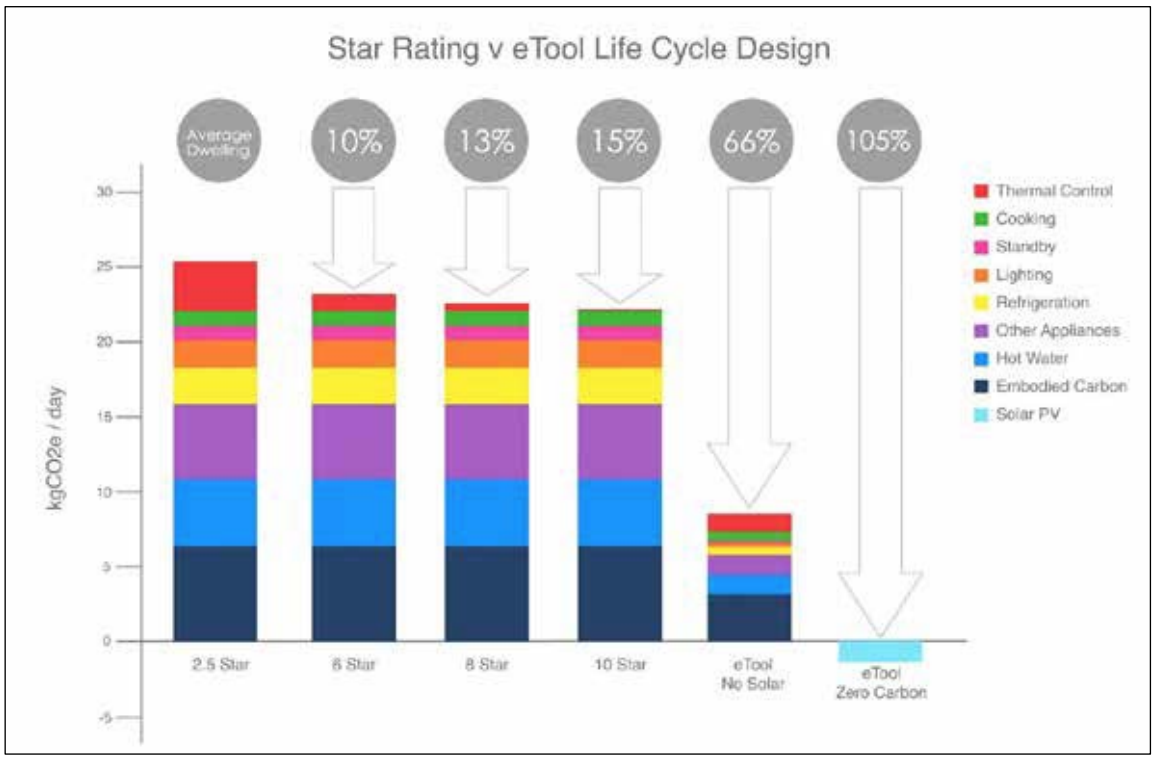


Figure 38. Star Rating vs Life Cycle Design (courtesy eTool https://etoolglobal.com/)

To ensure that all homes are meeting the high Ecovillage sustainability standards, every home will be required to undergo a standardised Life Cycle Assessment and achieve minimum carbon emission outcomes, as per Table 16, WEV LCA Minimum Carbon Emission Outcomes. The Design Team has negotiated a discounted LCA service for Ecovillage homeowners called RapidLCA (https://rapidlca.app), which will be included in the lot price. You should undertake the LCA following the submission of your initial concept plans and specifications and prior to submitting final documents for Formal Assessment (see 9.3 WEV Design Review Process).

The targets we are setting for each lot type will ensure that each house is carbon negative (incl. the solar panels and microgrid).

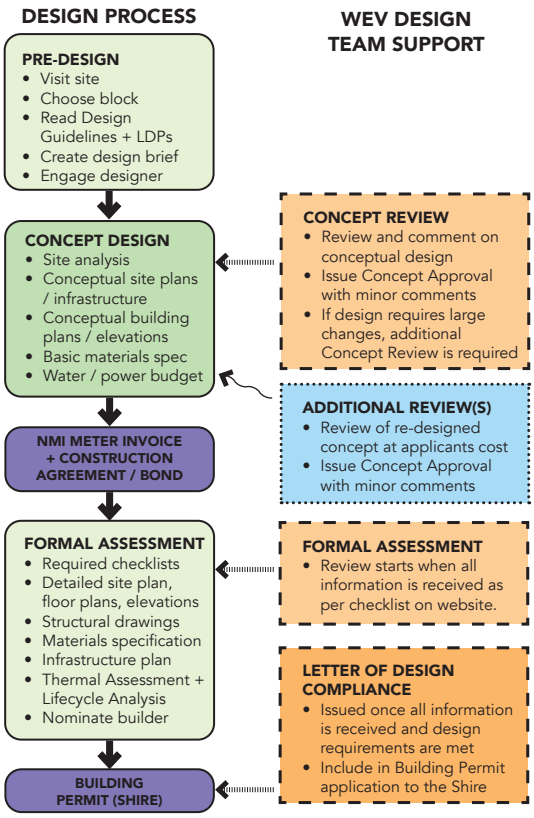
Table 16. WEV LCA Minimum Carbon Emission Outcomes

Lot type	Operational and Embodied Carbon kg CO2 e
Min. Requirement	**-105%** Carbon Emission compared to OECD Average

* Occupancy figure used is not actual household size; rather it is average occupancy (ABS Data) by house size based on number of bedrooms. Negative number means more carbon is taken out of the atmosphere than is emitted as a result of the project.

Access to the assessment software and instructions can be found by clicking on the following link:
https://rapidlca.com

9.3 WEV Design Review Process



To ensure that new homes in the Ecovillage are designed in accordance with our sustainability objectives, you (and/or your designer/builder) must participate in a two-step iterative design review process with the Witchcliffe Ecovillage (WEV) Design Team, comprising Concept Design Review and Formal Assessment. Please ensure that you have thoroughly read these Design Guidelines and LDPs before starting the design process.

Please note that one full design review (concept and formal approvals) is included in the price of your lot for 36 months (3 years) from the date of registration of your relevant strata scheme. This provision is specified in 'Governance Bylaw 16'. WEV can provide design review support beyond this date, however, a charge of $300 per full review is applicable.

If you require an additional design review because you have significantly changed your concept design, this will be separately charged at $300 per review to help cover staff costs. The design will then be reassessed by the WEV Design Team before a further Concept Approval can be issued. No additional fee will apply for formal assessment if the design has not significantly changed from the approved concept.

Further guidance on this process is provided in the Appendix G 'Guidance Document - WEV Design Review Process and Approvals'.

Step 1 - Concept Design Review

This is step-one in the design review process and can be undertaken via email review. This is to establish that the proposed design is generally consistent with the key principles of the Design Guidelines and LDPs prior to you documenting the proposal in detail. Once submitted to the WEV Design Team, if the concept design is significantly non-compliant, we will note the issue briefly and ask that you resubmit with a complying design. If your design is largely compliant with the requirements, we will respond via email providing you with Concept Approval. Along with this approval, we may also respond with a couple of minor changes or suggestions and as that you incorporate them in the drawings submitted at step-two – the Formal Assessment.

It is important to note that Concept Approval only establishes that the design is generally moving towards compliance and consistency with key principles. It is not a full detailed assessment, nor is it a final sign off or pre-approval of all elements of the design. Receipt of Concept Approval is a first mechanism that allows you to proceed to the Formal Assessment stage for more detailed assessment. Whilst the WEV Design team will flag items of major concern or non-compliance that would impede the design proceeding to Formal Assessment it is not in our remit to highlight all design requirements to you. This is why we

encourage you to thoroughly review the Design Guidelines and LDP with your designer/builder at the outset and throughout the design review process.

After Concept Approval is issued, the onus is on the owner/designer/builder to further refine the design against all requirements of the Design Guidelines and LDP prior to submission for Formal Assessment.

This is a checklist assessment process – a completed Concept Design Assessment Checklist (refer to Appendix H) must be submitted along with all required documentation (noted below) for the WEV design Team to commence concept design review.

Concept Design submission requirements include:

- Concept design drawings of dimensioned site plan, floor plan, elevations, 3D massing
- Basic materials specification: cladding, structure, roofing, windows
- Proposed roof area, water tank location and size, PV panels location and size

Step 2 - Formal Assessment

Formal Assessment is step-two in the design review process, proceeding only after you have received WEV Concept Approval. You will refine the design and prepare detailed documentation to submit to the WEV Design Team for review and final approval. This is a checklist assessment process and includes a concise list of the submission requirements and detailed documentation required. The WEV Design Team will not commence assessment until a full package of documents is received including a completed Formal Design Assessment Checklist (refer to Appendix I). The onus is on the designer/builder/owner to provide all details required and demonstrate compliance with the Design Guidelines and LDP.

Submitted documentation must include the following:

- Building Permit drawing documentation.
- Finished Floor Level nominated on Building Permit documentation.
- Detailed specification (prior to Shire or private certification) for materials and finishes (see Appendix N - Specifications Summary Template).
- WEV Building Design Guidelines Checklist which demonstrates your home's compliance with all Building Design Guideline requirements and/or provides rationale for all instances of variation.
- Liveable Housing Design Checklist - all housing in the Ecovillage must meet the 'Silver' standard for accessibility in the Liveable Housing Design Guidelines (see Appendix O – Liveable Housing Design Guidelines Checklist).
- Local Development Plan (LDP) & Residential Design Codes (RCodes) Compliance Checklist.
- Infrastructure Plan showing details of all service infrastructure, including:
    - location of underground infrastructure, including connections to energy microgrid, WEV sewerage service, and NBN (or similar microgrid compliant internet connection);
    - location and sizing of PVs;
    - inverter type and location;
    - rainwater tanks, downpipes, overflow pathway, greywater system & builder's kit;
    - energy and water ratings for all fixtures and appliances; and
    - monitoring devices.
- Fencing concept design for front and rear fences
- Thermal Assessment Report identifying natHERS energy efficiency star rating
- Life Cycle Analysis (Rapid LCA eTool report), including GWP Summary indicating percentage of GWP savings achieved.
- Energy and Water Budget, including energy rating and WELS star rating information for all major appliances, demonstrating that estimated average daily energy and water consumption will be supplied (Energy and Water Budget templates).
- NMI Meter proof of purchase.
- Bushfire certification.
- Construction Agreement and Bond payment (see Section 10.1, Standards During Construction.)
- Construction Waste Management Plan (see Section 10.2, Construction Waste).

All checklists, templates and documentation guidelines can be downloaded from the Witchcliffe Ecovillage website.

https://www.ecovillage.net.au/library/document-library/.

Letter of Design Compliance

Once you have satisfactorily completed the Formal Assessment process, WEV will provide you with a Letter of Design Compliance that you should submit to the Shire alongside your Building Permit documentation. Please note that it the design complies with the Local Development Plan and the Residential Design Codes (RCodes), you can submit to Building Permit approval at the Shire. However, if you are seeking variations to provisions in either of those documents you will first need to go through Shire Planning Approval.

Design Review Timeframes

The WEV Design Team is small and tasked with oversight of a large and complex project to deliver. As such, our ability to respond varies depending on workload and staff availability. In normal circumstances, we estimate a timescale of:

- 2 weeks to complete Concept Review; and
- 2 weeks for Formal Assessment.

These timescales are based on designers/builders/owners having thoroughly reviewed the Design Guidelines and LDP so that when we receive a proposed concept or formal design it is largely compliant with our requirements and allows timely turn-around of the review.

We will not assess incomplete applications, please ensure all information required at each stage is included and you have completed relevant documents/checklists.

The WEV Design Team will do their best to meet these timescales, but at times and for various reasons, some applications take longer.

9.4 Construction Agreement & Bond Payment

A Construction Agreement must be signed and bond paid prior to the owner receiving Formal Approval from us for the house design. The Construction Agreement is co-signed by the Director of Sustainable Settlements, as the representative of the Strata.

This will acknowledge that the purchaser and builder are aware of the requirements for building in the Ecovillage, and that the builder and all trades will comply in an orderly and courteous way. It states that the lot owner will be responsible for any damage to the common property or the adjacent public road verge caused by any contractor engaged by the owner.

Owners of lots must also commit to making every effort to ensure minimum damage to roads, paths, landscaping on verges and in community gardens during construction. Owners will be liable for replacement and repair costs of any damage (enforced via each cluster's strata bylaws).

The owner must pay a $1,000 bond which is kept in escrow in the Strata bank account and held against the lot purchaser (not the builder). Once construction of the home is completed, the owner can request a Bond Inspection and if no damage is identified, the bond is returned. If damage is identified, the cost of rectification is then taken out of the bond and the balance returned to the owner.

To ensure no delays, the WEV Design Team will initiate the Construction Agreement process after Concept Approval. Our Admin Team manages these agreements and will be your main point of contact (admin@ecovillage.et.au). Please note that the invoicing process can take up to 4 weeks.

The WEV Admin Team will contact you to initiate the process. The Construction Agreement can either be emailed to you for hard copy signature or signed electronically via DocuSign.

Proof of completion of the Construction Agreement and Bond payment to your strata bank account should be included in your documentation for Formal Assessment.

9.5 Augusta-Margaret River Shire (AMRS) Building Permit

Building Permits must be obtained prior to the commencement of any building work. To obtain a building permit, an application form (BA01 or BA02, see below) together with one copy of all plans, structural engineering specifications, and our Letter of Design Compliance must be submitted to the Shire Building Services. Submission requirements can be found on the Department of Commerce website and information on the Shire Building Services on their website.

There are two methods you can pursue: pre-certified and uncertified. You engage a Building Surveyor to pre-certify that your plans comply with the National Construction Code (NCC) and then submit to the Shire. Or you can submit all your documentation the Shire directly (un-certified) and they will assess the building compliance of your plans:

- Certified applications – BA01 – approval timeframe 10 business days
- Uncertified applications – BA02 – approval timeframe 25 business days

10. Construction Management

10.1 Standards During Construction

To ensure a quality build, an orderly construction process and to reduce impact on neighbours, the following requirements must be met during construction:

- Construction works must comply with all Shire policies, regulations, and strata bylaws.
- Ensure all trades and contractors are aware of sustainability infrastructure requirements, e.g., correct installation of insulation, correct location of rainwater tank inlet and overflow, correct placement of PV array, etc.
- The site must be kept clean at all times during construction to minimise impact on neighbours. All rubbish must be disposed of off-site and skip bins appropriately covered to ensure contents are adequately secured.
- The lot must be maintained prior and during construction, with grass cut, weeds, rubbish removed and surface drainage maintained.
- Earthworks are to be managed carefully, and dust is to be controlled.
- Storage of all plant and materials to be on the subject lot only (not on adjoining lots, open space or common property even if unoccupied). Locations of site sheds, toilets, skip bins and sea containers must not impede vehicle sight lines or pedestrian pathways.
- Vehicle parking is not permitted on other lots, open space, median strips, footpaths or other landscaped areas. Footpaths are not designed for heavy vehicle access and appropriate protection shall be implemented by trades and contractors to protect existing paths.
- Existing vegetation and installed Street Tree planting shall be protected with tree protection barriers.
- Stormwater is to be appropriately managed (sediment to be controlled and managed so it does not impact downstream swales) and in accordance with the overland
- Swales along road verges must be maintained and not obstructed or filled in, and cross-overs / culverts over swales must not be damaged.
- Ensure all trades and contractors are aware of existing public and private infrastructure locations in both the public and private (community garden) lands. Please conduct a Dial Before You Dig and refer to the relevant 'As Constructed Drawings' (see Appendix F).
- Site topsoil that may be removed for house pad construction is a valuable resource. It should be retained on the private lot for use in gardens and matching house pads into existing ground levels, or appropriate locations within Ecovillage Commons land can be provided by the WEV Office.
- Allowance for supply of construction water for all trades and contractors should be considered. WEV accepts no responsibility for supply of water for construction purposes. The ECL water supplied to community garden and garden plots is not permitted to be used for construction purposes.

10.2 Waste Management

Avoiding and reducing waste directly benefits builders and owners in reducing costs and should be standard practice as part of every building project. At the Formal Assessment stage, the owner and/or builder must submit a Waste Management Plan to the WEV Design Team to demonstrate that sustainable waste management requirements are understood and fulfilled.

At the Ecovillage, best practice construction waste management will be achieved in the following ways:

- With the assistance of your designer and builder, apply the best practice principles of **AVOID, REDUCE, REUSE** and **RECYCLE** to the construction of your home.
- The Ecovillage encourages the reuse of materials in new buildings and supports property owners who wish to utilise recycled/repurposed materials provided they meet building code standards and do not compromise the performance of buildings.
- The Ecovillage will provide a temporary site for storage and recycling of surplus building materials such as off-cuts, over orders, and incorrect materials to increase the reuse of materials on site and to help increase the availability of reusable materials.
- To maximise the recycling of building waste that cannot be reused on site, builders will be required to separate materials into waste streams that can be best handled at the local waste management facility operated by the Shire on Davis Road:
    - Rubble, including broken bricks, concrete waste, broken tiles, small offcuts of plasterboard;
    - Metals; and
    - Timber offcuts and timber waste.

For more information, please see the *Master Builders' Association of WA Smart Waste Guide (2014)*:

https://www.mbawa.com/wp-content/uploads/2014/09/Smart-Waste-Guide-resized.pdf

and the *WA Local Government Associations' Construction Waste Management Plan Guidelines*:

https://www.wastenet.net.au/Profiles/wastenet/Assets/ClientData/Document-Centre/WAL2708_Construction_waste_A4_v2_singles.pdf.

10.3 Post-Construction Inspection

The correct installation of sustainability infrastructure is vital to its functional operation. To ensure the sustainability outcomes of the Ecovillage are being met the WEV Design Team will conduct a post-construction inspection to confirm all sustainability infrastructure is installed correctly and to the specification of the submitted Infrastructure Plan.

Appendices

(All appendices are located in the Witchcliffe Ecovillage Document Library: https://www.ecovillage.net.au/library/document-library/)

Reference Information:

A - Witchcliffe Ecovillage Local Development Plans
B - Rural Hamlet Design Handbook Extract
C - Bushfire Management Plan
D - WEV Residential Energy Supply Handbook
E - WEV Residential Water Handbook
F - As Constructed Drawings

Design Review Guidance Document

G - Guidance Document: WEV Design Review Process & Approvals

Templates and Checklists:

H - Concept Design Assessment Checklist
I - Formal Design Assessment Checklist
J - Building Design Guidelines Checklist
K - Local Development Plan / R- Code Checklists
L - Household Water Budget Template
M - Household Energy Disclosure Template
N - Specifications Summary Template
O - Liveable Housing Design Guidelines Checklist (Silver Standard)