Tanja NSW

NEW HOME
ZONE 6: Mild temperate

Topics covered
Passive design
Passive cooling
Greenhouse gas reductions
Reducing embodied energy
Waste minimisation/ recycling
Sustainable materials use
Indoor air quality
Solar water heating
Renewable energy production
Reducing water use
Rainwater harvesting
Wastewater treatment
Food production

AccuRate (thermal comfort)	3.3 (regulatory)

This fully autonomous home generates its own power, provides for its own heating and cooling, harvests rainwater and recycles wastewater. The use of low embodied energy materials and modular, prefabricated construction reduces the demand for material resources.

DESIGN BRIEF

The owner, a renowned artist and academic, required a house for himself and his extended family and friends, and a studio for his artwork. As he has frequent visits from family and friends, a separate wing was needed to allow them comfort and privacy.

Contact with the natural surroundings was important to the owner. He had lived for many years in a remote rural location and desired a house that would support his simple lifestyle but with a greater degree of comfort than the barn that he had been using for the last 12 years.

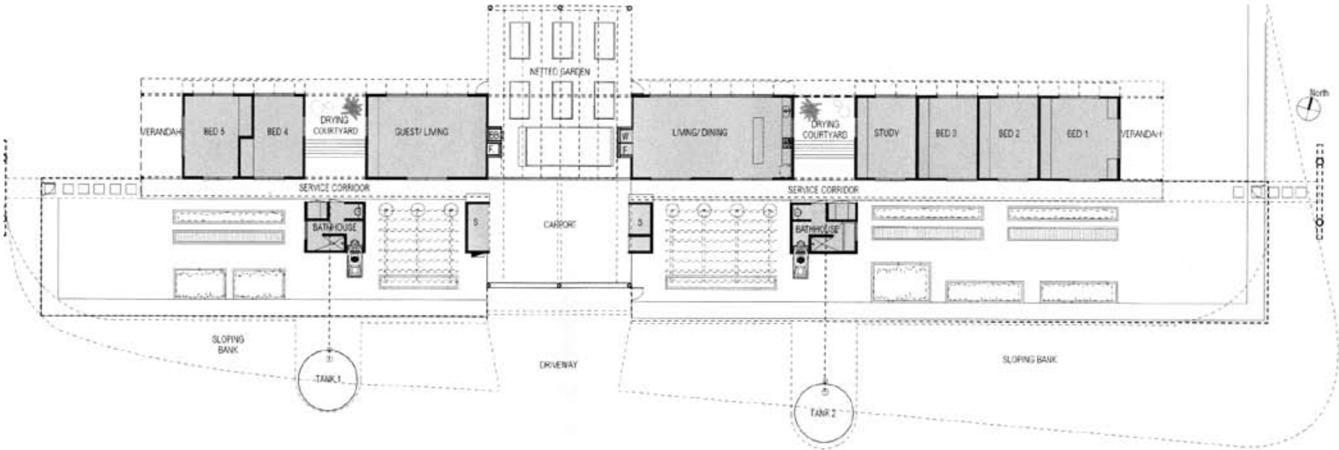
The house was to be fully autonomous, given the remote location – generating its own power, providing its own water and treating its own wastewater. The owner had grown most of his food in the past and wished to continue to do so in an area with abundant wildlife. As he travels extensively the house also had to be secure during his absences.

Innovative use of materials and construction techniques was a long standing interest of the owner's. He was keen to use the house as a 'test case' for prefabricated materials, to minimise on site waste and to explore creative passive solar design responses using low cost construction. The owners interest, as a sculptor, in the 'honesty' of materials and construction is reflected in the 'raw' nature of this construction.

LOCATION AND CLIMATE

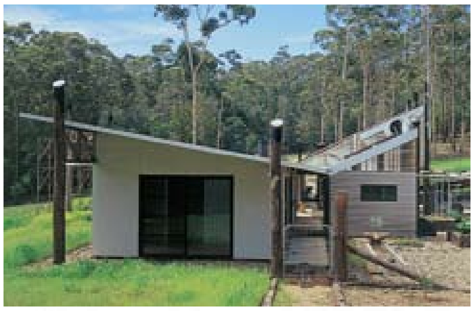
The house is located in Tanja, NSW, on a bush block adjacent to a National Park. The owner selected a suitable site for the house in a secluded valley and then donated the remaining land back to the National Park, so the house is almost entirely surrounded by National Park. The house site itself is a gentle north-facing slope with a dam created at the bottom and the tree line retained on the crest.

The climate is mild temperate (New South Wales far south coast) with mild summers and cool to cold winters with relatively high rainfall. The concerns of the local Council about the planning of the house were limited, as it cannot be seen from any public area of the park or local roads. [See: 4.2 Design for Climate; 2.2 Choosing a Site]



DESIGN RESPONSE

The design concept for the house is a long, thin string of indoor and outdoor rooms. The kitchen/living/dining area and bedrooms are grouped into separate mini houses with a courtyard between each.



Modular components were used in the design, fabricated offsite to minimise waste and to allow simple, speedy erection of the house. A 1200mm modular grid is used throughout to standardise material sizes based on commonly available sheet materials and windows and doors. Sculptures at either end of the long walkway emphasise this east-west axis whilst internal covered courtyards provide visual axes in the north-south direction opposite the bathrooms. [See: 5.3 Waste Minimisation; 5.5 Construction Systems]

All these rooms face north for maximum passive solar gain. Behind these, on the south side, are three pods containing two bathrooms and a carport storage area. [See: 4.3 Orientation; 4.5 Passive Solar Heating]

The roof of the north-facing string of rooms is tilted to allow maximum sun penetration into the rooms and onto the concrete slab. The roof form of the southern pods is the reverse, with a steeply sloping roof angled to the north providing a base for the solar water heating and PV panels.

The courtyards provide both service facilities (drying area, garbage store, wood store etc.) and also provide external living areas for relaxation and enjoyment. The courtyard opposite the carport store takes the form of a large vegetable garden, netted to protect the produce from wild animals.

A covered veranda space links the long string of rooms and the pods. This recalls the use of verandas for circulation in the early homesteads of Australia, particularly in the Riverina and Southern districts of New South Wales. This was a conscious design choice by the owner who wished to maintain his contact with the daily and hourly weather patterns by continually interacting with the outside, whilst still being protected from winter wind and rain and the harsh summer sun.

The outdoor area to the north of the house is maintained as a gently sloping grass area that allows for maximum solar access and provides bushfire protection. To the south, the house has been dug slightly into the hill providing protected courtyards that received winter sun but are protected by the embankments and planting to the south.

Orientation and glazing

The house is oriented just west of north, aligning with the contours of the land to minimise excavation and maximise solar access in winter. This provides views from every room over the grassed paddock to the dam.

Standard single glazed aluminium-framed sliding doors are used throughout the house. Aluminium was chosen for its durability. Whilst high in embodied energy, aluminium is a low maintenance finish and can be fully recycled at the end of its useful life span. The area's relatively mild winters limit the amount of heat loss via conduction or cold bridging through the aluminium that may be experienced in more extreme climates. It is acknowledged that double glazing with insulating frames would significantly improve the thermal performance of the house, but this was decided against due to the additional initial cost and ongoing maintenance requirement. [See: 4.3 Orientation; 4.10 Glazing]

Structure and envelope materials

The floor throughout the house is a concrete slab.

The walls and roof of the 'string' of north facing living areas are made from prefabricated panel systems.

The wall panels consist of two sheets of fibrous cement bonded to an expanded polystyrene (EPS) foam core. These panels are joined with steel studs that connect a steel bottom plate to a steel top plate, providing rigidity and the strength to hold down the roof. Over the top of these panels is a beam on the south side, and a one metre tall truss on the north side, to support the roofing panels.

The roof panels are made from 'Ritek', a sandwich panel of two corrugated zinc alum steel sheets bonded either side of a 100mm thick sheet of EPS foam. The truss to the north side is clad on both sides with clear polycarbonate sheet, allowing the structure to be seen from inside and outside but providing passive solar gain through a virtual double glazed panel.

The polycarbonate sheet cladding on each side of the truss is a sensible low cost approach to improving thermal performance. The polycarbonate is passively shaded to prevent summer heat gain and performs well in winter. Replacing glass with polycarbonate marginally reduces winter heat gain (by around 3 per cent). However, although the air gap between the polycarbonate sheets allows some convective heat loss to occur, the insulation provided by the trapped air allows the system to perform considerably better than single glazing in reducing conducted heat loss.

Note: A 10 to 15mm air gap between the glass sheets is ideal for double glazing. The trapped air provides insulation and the narrower spacing prevents convection currents from forming to transfer heat between the inner and outer panes. [See: 4.10 Glazing]

On site waste is minimised, possibly even eliminated, by both panel systems. These systems also ensure that an accurate dimension house can be built in a minimum amount of time.

The 'pods' containing the carport/store and bathrooms are built from lightweight stud construction with corrugated sheeting externally and internally, and R1.5 bulk insulation in the walls and roof. The upper areas of the walls are clad with clear polycarbonate sheet to provide maximum daylight whilst allowing privacy within the bathroom areas. This also allows an exposed view of the structure from the inside and outside of those rooms. The ends of the string of rooms and the carport and netted garden are supported on round hardwood logs, cut and milled locally and treated prior to being stood in the ground.

The external surface of the walls to the living areas are left as natural cement sheet with a waterproof coating to emphasise the panel nature of their construction. This also provides excellent weather protection as the fibrous cement sheet is non-porous, unlike brickwork and other masonry products.

The internal surface of the fibrous cement sheet is also left natural in keeping with the owners desire for honest expression of materials. All internal bathroom surfaces are 'mini orb', a sheet steel material that is long lasting, provides excellent waterproofing and replaces the need for the 'wet trades' of plastering, tiling and grouting. The floors are raw concrete sloped to the drains and finished with a waterproof additive and sealant. [See: 5.1 Material Use; 5.3 Waste Minimisation; 6.5 Construction Systems]

Thermal mass and insulation

The thermal mass required for passive design in a mild temperate climate is provided by the concrete slab. The slab has a coloured oxide added to the top surface and is sealed but remains uncovered to utilise the full benefit of the thermal mass. [See: 4.9 Thermal Mass]

Insulation is provided by the layer of 100mm (minimum) thick EPS foam built into the roof and wall panels, which gives an equivalent R-value of R2.0. The carport/store and bathrooms are more conventionally insulated with reflective foil and bulk insulation in the roof and bulk insulation (polyester insulation) in the walls. [See: 4.7 Insulation]

Ventilation

Cross ventilation is achieved by the use of flyscreened doors on both sides of each room. There is no internal corridor, as the veranda acts as circulation space, allowing maximum cross ventilation through each room without compromising privacy to internal spaces.

During summer, night time cooling (radiating heat to the night sky and using the cooler night air to lower the temperature of the concrete slab) ensures that the house remains comfortable. [See: 4.6 Passive Cooling]

Shading

The raked panel roof is extended on the north side to provide shading to the upper level windows and rain and weather protection to the doors.

A series of metal louvres on customised steel brackets have been installed above the doors to control sun penetration. Set at a fixed angle, they allow winter sun penetration deep into the room (as far as the back wall of each room) but shade the glazing and ground in front of the sliding doors in summer. The louvres have been specially designed to act as a self-regulating system- as the sun's angle gets lower in the sky and temperatures drop, more sunlight is allowed into the house. [See: 4.4 Shading]

House energy rating

In a cool temperate climate like this, winter performance of the building envelope is the most critical consideration. High insulation levels, and appropriate type, size and orientation of glazing have a major impact on thermal performance.

Due to the high diurnal (day/ night) temperature range, the high thermal mass solution was ideal. Higher insulation values (around R3.5) for the roof were desirable for this climate but proved too expensive to achieve with the Ritek roofing system. The large areas of glass used to maximise solar gain also allow heat loss at night. Double glazing would significantly reduce this heat loss but was considered too expensive due to the large quantity of glass used. [See: 1.5 Rating Tools]

Furnishings

Every room in the house is fitted with built in furniture, made from Hoop pine plywood (plantation sourced timber) and some recycled timber collected by the owner over a number of years.

SERVICES AND APPLIANCES

Space heating and cooling

Auxiliary heating is provided in winter by the use of an open fireplace located in the two living areas. The 'Jetmaster' system provides radiant heat from the fire together with some convective heat around the fire box.

The owner uses the local timber harvested from fallen logs on the surrounding property.

Cooling is by natural means. There is no artificial cooling system or fans as the shading, cross ventilation and diurnal cooling together provide sufficient comfort during the summer months. [See: 4.6 Passive Cooling; 6.2 Heating and Cooling]

Lighting and daylighting

Daylight levels are high, with every room fitted with sliding glass doors to two sides. This promotes a maximum amount of balanced daylight.

Energy efficient fluorescent light fittings with efficient electronic ballast and starters are used throughout the house. They are located in pelmets that shine light up onto the zinc alum ceiling from where it reflects back into the rooms. The use of reflected light from the ceilings gives a more even lighting to the room without harsh glare. The location of the fittings in pelmets also allows for easy maintenance.

Compact fluorescent fittings in a waterproof case are used externally, and internally in the bathrooms and parts of the carport/ store. The waterproof case also keeps insects away from the light, extending their life and reducing maintenance. [See: 6.3 Lighting]

Water heating

Separate solar hot water systems are located above each of the two bathrooms, thus minimising the runs of piping to all points of use. All shower and tap fittings are WELS 3 Star rated to limit water wastage. [See: ; 7.2 Reducing Water Demand]

Electricity supply

A Remote Area Power System is installed. The system is a commercially available series of panels linked to a series of batteries and an inverter located in the carport / store area. Energy from the PV cells is stored in these batteries and is converted to 240 volt AC by the inverter to supply the house. This allows the use of conventional lights, audio equipment, television, computers etc. The system has been sized to allow the use of a five star rated fridge. [See: 6.4 Appliances; 6.7 Photovoltaic Systems]

Rainwater/ stormwater

Rainwater is harvested from the entire roof area for drinking and use throughout the house. The large area of north-tilted roof over the living areas is fitted with a special gutter system that incorporates dual gutters to allow filtering of the water and removal of all leaf material before the water enters the system. Water is also collected from the bathroom roofs. The water is collected in rain heads/box gutters at each of the bathrooms.

The water is piped through the bathrooms in an exposed galvanised steel pipe and to the rear of the house where it is stored in twin 15,000L concrete tanks. Prior to entering the tanks this water passes through a first flush diverter system that removes the first 40L of water containing dust, dirt and other material from the roof that has not been filtered by the gutter system. The tank water is pumped under pressure to the taps and to the roof mounted solar hot water system for the two bathrooms. [See: 7.3 Rainwater]

A secondary system of water supply is the dam, which supplies water for all the gardens and for the emergency bushfire spray system.

Black / greywater systems

The house is fitted with two composting toilets that have pans located inside the bathrooms and the composting unit below grade on the outside. Fitted with a large diameter tall black exhaust, they provide maximum air flow to dry out the waste and only require emptying between long intervals. The dry residue is used on non-edible parts of the garden. This system has Australia-wide health department approval. [See: 7.7 Low Impact Toilets]

Waterless toilets are probably the most effective way to save water in a household – reducing water demand by around one third and reducing wastewater needing treatment.

Greywater from the basins, showers and sinks is treated in a modified septic system before being fed to a reedbed system for transpiration. The septic tank and transpiration beds are located to the north of the house on a downward slope and are in line with the axis from the bathrooms. This provides a visual connection between the water collection from the roof, through the box gutter to the tanks at the rear, and then back through the bathrooms to the transpiration beds on the north side. Thus the owner and occupants can feel the water system flowing around them as they use the house. [See: 7.4 Wastewater Re-use]

LANDSCAPE

The landscape has been designed to complement the series of outdoor rooms in the house.

Seeded natural local grasses are planted in the area to the north of the house. To the south side, ornamental grapes provide shade to the pergola areas and the embankment is planted with species that are resistant to bird and possum attack and fenced in to prevent attack from wallabies, kangaroos, goannas and rabbits.

Enough vegetables and fruit to supply the household are grown in the netted garden, protected from birds and other animals. [See: 2.4 Sustainable Landscapes]

EVALUATION

This case study is an excellent example of the numerous possibilities that exist for reducing a home's environmental impact.

As a fully autonomous house, all water and energy resources are generated on site. The remote area power system generates electricity from solar energy, rainwater is harvested for domestic use, fallen logs are collected for auxiliary heating, and vegetables and fruit grown on site reduce the need to import food for household consumption.

Prefabricated modular construction has also been used in an innovative way to minimise materials wastage.

The remote location of the home inspired its autonomous nature, however transport to and from the home is by motor vehicle. The dependence of occupants of remote sites on motor vehicles often significantly increases environmental impact. In this case study, the owner lives and works on the site for lengthy periods, reducing travel requirements.

PROJECT DETAILS	
Architect:	Tone Wheeler, Environa Studio
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