house – temperate

Home

Design for lifestyle & the future

Perth Hills

This is a simple and inexpensive home which uses passive solar design techniques, and is situated in bushland near Perth, Western Australia. The design aims for the house were to minimise electricity use, and harness solar and wind energy to regulate the internal climate while staying within a strict budget.

Building Type:	New home, reverse brick veneer construction
Climate:	Temperate: Perth hills, WA
Topics	**Covered Success Level**
Reduce energy use	Excellent
Passive design	Excellent
Indoor air quality	Good
Waste minimization and recycling	Good
Water use / treatment	Good
Reducing transport impacts	Fair
Greenhouse gas reduction	Excellent
Reducing embodied energy	Fair
Sustainable materials use	Very Good
NatHERS rating – 5 star	★★★★★

INTRODUCTION

This energy efficient home is located in a secluded bush setting north-east of Perth, Western Australia, in the hills above the Swan Valley.

The owners commissioned the house for use as a retirement retreat, and it has now been occupied for 2 years. Having a keen environmental awareness and genuine intention to live an environmentally low impact lifestyle, the owners opted for a simple, contemporary concept which maximises passive solar advantages throughout the year. The house is run using very little energy. The two occupants have installed efficient lighting and appliances, and spend a lot of time outdoors, even during winter. The booster switch for the solar hot water heater is easily accessible (in the kitchen), allowing precise control over the power used. Because the house has only two adult occupants, expensive technologies like solar power and gas boosted hot water were considered unnecessary, and would have resulted in a very small reduction in greenhouse gas emissions.

The house is divided into a living section and a sleeping section, arranged in a 'Z' shape oriented north-south (see plan view). This configuration allows for the creation of a 'breeze trap' at the southwest of the house to catch cool afternoon ocean breezes, and a sheltered solar deck at the northwest which catches the morning sun in winter.

Construction is a combination of reverse brick veneer and double brick on a concrete slab. Colourbond steel is used to clad the exterior of the reverse brick veneer section, and for the roof.

THE SITE

The site is steeply sloped, due to its location on the side of an escarpment. It has westerly views across the coastal plains north of Perth, as well as bushland views to the north and northeast.

During preparation of the site, priority was placed on ensuring the absolute minimum of land was cleared. The owner and the architect stood alongside the bulldozer and directed the driver down to the centimetre. The owners wanted to protect as much of the vegetation on the site

as possible, so chose a more expensive partially elevated concrete slab over a full slab on ground to achieve this. This construction also allowed for the house to be on a single level.

At one stage the previous owners of the site had it cleared for farming. Since moving in, the owners have started a program to rehabilitate the bush on the site to its original state.

THE CLIMATE

The climate of Perth is temperate with winter mean max/min temperatures of 17.9ºC and 8.6ºC, and in summer 33.2ºC and 18.6ºC. Solar radiation readings are extreme in summer, similar to those experienced in the Gibson Desert. There is relief from the heat most afternoons courtesy of a cool south westerly breeze. Cooling breezes from the east are common at night between 12.00 a.m. and 6.00 a.m. [See: Design for Climate]

THE 'TECTO' DESIGN METHOD

The 'Tecto' method of low energy design was used to design this house. This method is a step-by-step technique which allows the architect to integrate his or her clients' requirements with rigorous solar passive principles, and does not affect the architects freedom of expression.[i]

The first stage in applying the method is to look at passive considerations. These are:

> ensure solar access for north facing windows;

> face the majority of windows towards the north;

> consider methods of shade control to windows;

> identify compromises to be made in relation to views, light, ventilation, spatial effects and aesthetics;

> decide on the method of construction and insulation strategy;

> integrate thermal mass into the design using the correct volume of masonry and concrete, to store warmth in winter and maintain a cool temperature in summer.

Once these decisions have been made, auxiliary heating and cooling strategies are worked out, and a decision is made about what sort of solar hot water heater to use. Numerical values are determined for glass area on the north, south, east and west walls, total thermal mass in cubic metres, minimum insulation levels in the roof, floor and walls, and the size of the solar hot water system. Finally, a five-stage designers checklist is followed to execute the design.[ii]

HEATING

Auxiliary heating is provided in the house. Gas bayonets have been installed so a portable gas heater can be used when required.

During winter, passive solar heating keeps the house to a minimum temperature of 18ºC.

COOLING

There are three means of non-mechanical cooling incorporated into the design of the house:

proper orientation of the building helps form a breeze trap to the south-west (see plan view). A bank of louvre windows picks up the sea breeze to channel it into the house;

> a breeze trap on the north-east funnels cool easterly winds overnight;

> the two breeze traps function together to help suck air through the house. See description below.

The house is designed to ensure that cooling breezes move through the house on even the stillest of hot summer days. On the windward side (the southwest) the windows are small, which creates an area of increased pressure. After the pressure has built up a bit, the wind spills over the top and around the sides of the house and creates an area of decreased pressure on the side of the house away from the wind. This low pressure zone helps to suck the air through the house, increasing the wind speed and improving the cooling effect. This design results in increased air speed inside the house. If the wind speed outside the house is 5 metres per second, then the wind speed inside the house can be up to 10 metres per second.

Ventilation is achieved with ceiling fans in the living area and bedrooms. In a larger, less efficient house, the design would have included an exhaust fan mounted in the ceiling in the centre of the house to draw fresh air through the habitable areas. This is a very efficient way to cool a house which doesn't have sufficient natural airflow, as the fan need only be rated to 200 watts if well designed. However, in this fairly small house, the ceiling fans were all that were needed.

The house naturally achieves 5 air changes per hour (5 ACH) during the night. Because the house does not absorb much heat, this is more than enough to ensure that the occupants remain comfortable even when it is very warm. An average, non-solar passive house requires about 30 ACH to keep cool.

The efficiency of the system is demonstrated by the temperature in the home, which does not exceed 28 ºC. [See: Heating and Cooling]

SHADING

Approximately 50% of the northern facade is glazed. Based upon experience, the architect has found that this ratio is the optimal balance for maintaining a pleasant internal temperature throughout the year.

There is a solar verandah to the north-east which collects the winter morning sun. Timber blades set at a fixed angle shelter the verandah. They provide 100% shade during summer and 80% sunlight during winter.

A large north overhang at a 65º cut–off angle provides solid shade to living area windows. The cut-off angle is the angle between a line drawn from the bottom of the walls to the outer edge of the overhang and the ground (see diagram).This allows full exposure in winter and gives 100% shade in summer.

INSULATION

The roof is insulated with 50mm R2 fibreglass batts at ceiling level, a 50mm air gap and a 'roof blanket' made of Sisalation™ (reflective aluminium foil) glued to a 50 mm thick fibreglass batt. The roof blanket is installed, contrary to manufacturers instructions, with the Sisalation™ facing down. This means that dust does not accumulate on the foil, which renders it useless, and the foil can reflect back heat from the inside of the house. Because the Sisalation™ is reflective on both sides, it can still reflect radiation from the roof back out. This roof has an overall rating of R3.

In the reverse brick veneer walls, R 1.5 polyester batts are placed in between the timber studs. Sisalation™ covers the framing, and then colourbond steel is attached over the top. This insulation isolates the thermal mass on the inside of the house, allowing it to regulate the internal temperature more effectively.

In the double brick walls, insulation is a 35 mm expanded polystyrene sheet plus a 15 mm air gap. [See: Insulation Overview]

SOLAR HOT WATER SYSTEM

An electric boosted solar hot water system was chosen as the occupants were only catering for 2 people most of the time. This system has a low initial cost compared to a gas boosted system and manageable electricity costs. The extra cost of the gas system was not justified for the small amount of energy that would be required to supplement solar heating for only two people. The booster switch was mounted in the kitchen to enable the booster to be turned on and off easily and help minimise operating costs.

WINDOWS

The windows are placed to take advantage of the sea breeze from the south-west. The house can be divided into 'breeze ways' to channel air through whatever part of the house most needs cooling, including to the north the living wing, to the east into the sleeping wing, and straight through onto the solar deck at the northeast of the house.

The window sizes are designed to create a pressure differential across the house, with small windows on the windward side, and large windows on the leeward side. See the 'COOLING' section for a description of how this helps to keep the temperature of the house low in summer. Fifty percent of the glass area is on the northern wall, and twenty percent on the eastern wall, with the remainder on the south. Minimal glass is used on the west facing wall.

Single glazed aluminium framed windows were used throughout due to cost constraints. A bank of louvres is located in the southwest corner of the house to allow for ventilation by cooling afternoon breezes during summer.

Sealed highlight windows are installed to allow abundant light to enter and reflect off the ceiling. This results in a soft, even natural light illuminating the interior of the house, which is far less harsh than direct sunlight. The architect always uses fully sealed windows when installing them in inaccessible, high places. Aluminium windows that can be opened leak air at the rate of about 0.5 ACH. If they are installed near the ceiling, in winter they suck out most of the warm air in the house.

COLOUR

Colour can play an important role in passive solar design. Light colours (off white) and steel grey finishes have been used on the roof and wall panels. These reflect a lot of the radiation during hot summers.

LANDSCAPING

The gardens are filled with native plants. The owners have embarked on a rehabilitation program for the site, based on research they did on species endemic to the area. The site was cleared by farmers many years before the current owners purchased it, and there had been a natural regrowth since.

The owners have also established an organic permaculture vegetable garden on the site, which is watered using captured rainwater and fed with compost.

No watering is required for the native garden, and red gums planted on the east and west of the house will provide extra shading when they mature. A hakea hedge has been established on the southwest, which will attract birds with its abundant spring flowers.

ENERGY USE

The architect estimates that, based upon his experience with similar houses he has designed, the house uses about seventy percent less energy than an average house of equivalent size.

Lights used are a combination of low voltage halogens where lights are on for a fair period of time, and incandescent bulbs in cupboards and passageways where lights are on for only a short time. Energy efficient appliances are used, with gas cooking. The owners lifestyle is quite frugal, and they spend a lot of time outdoors throughout the year. The house stays at a comfortable temperature all year round, and to date the owners have not needed to use any means other than the sun and the wind to heat or cool the house

WATER USE

The house and garden is water efficient but not completely self-sustaining. The house is connected to mains water and a rainwater tank of 20,000 L is installed for drinking water.

Because there are no lawns the organic vegetable patch is the main water consumer in the garden. The soil on site has good water retention, which helps keep water use low.

A standard septic tank system is used for wastewater, with a leach drain that allows excess water to be released onto the land. The drain is covered with a minimum of 600 mm of soil which allows air to penetrate. The wastewater is rendered safe by naturally occurring processes beneath the soil. There are no waterways nearby so there is no risk of contamination. [See: Sustainable Landscape]

MATERIALS USE

Conventional and inexpensive materials were used in the construction of the house. These are: plantation pine framing and clay bricks for the walls; concrete for the slab, and colourbond steel to clad the reverse brick veneer walls, and roof. Reverse brick veneer construction over 2/3 of the house provides thermal mass in the interior of the house where it is most useful, while keeping costs low. The remaining 1/3 of the house is double brick. The house is combined construction for aesthetic reasons only.

POTENTIAL IMPROVEMENTS

For the cost of the project, the architect believes that the home is the optimum solution. However, with the addition of insulation beneath the floor of the suspended section of the house, efficiency and comfort would have been improved. In addition, a gas boosted hot water system produces less greenhouse gas emissions than the electric one installed. Both of these options would have increased the cost of the house.

ADDITIONAL KEY REFERENCES

See "Low Energy Buildings in Australia: a design manual for architects and builders. Volume 1 - Residential buildings" by Baverstock, G.F. and Paolino, S. Graphic Systems, 1986

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i The 'Tecto' method was developed by Garry Baverstock between 1978 and 1986. It is based upon research done by Dr P Little, Dr R Laurance and Garry Baverstock.

ii For a complete worked example of the 'Tecto' design method, see 'Low Energy Buildings in Australia', page 21.