House – temperate
Perth

BUILDING TYPE: New home, double brick cavity construction	
CLIMATE: Temperate - Perth suburbs Western Australia	
Topics Covered	Success Level
Reduce energy use	Excellent
Passive design	Excellent
Indoor air quality	Good
Waste Minimisation and Recycling	Very Good
Water use / treatment	Very Good
Reducing transport impacts	Good
Greenhouse gas reduction	Very Good
Reducing embodied energy	Good
Sustainable materials used	Good
NatHERS rating	★★★★★
FirstRate rating - 4.67 stars	★★★★½

This two-storey house is located in a redeveloping western suburb of Perth, Western Australia. It was instigated and developed by the local city council as a collaborative project to demonstrate an energy efficient, passive solar home design.

The Subiaco Sustainable Demonstration House was built to educate people and is open for public inspection until 2006 after which it will be sold. It represents a unique collaboration of the wider community with local government departments, universities and businesses sponsoring the project.

Issues addressed through the design and construction process included cost efficiency, passive solar principles, energy efficiency, low allergenic design, water efficiency, and daptability for universal access. In responding to these requirements, various products and techniques have been used to demonstrate alternative solutions to traditional approaches.

The house is designed to suit diverse occupants and lifestyles. The bedrooms are of a similar size to that of a master room, allowing the possibility of two couples living in the house, each with their own bathroom. Living areas are located for solar access while bedrooms face south. The kitchen, laundry and bathrooms are located in one area of the house to minimise plumbing for cost efficiency, and there is little wastage of space.

Wall construction is a combination of double brick cavity and reverse brick veneer on concrete slabs. The suspended slab for the upper floor was built using a process called 'quickfloor',

GROUND FLOOR PLAN

giving an 80-90mm concrete slab on a permanent steel frame. Harditex cladding is used to the exterior of the reverse brick veneer on a timber frame, and the roof is Colorbond metal on a timber frame.

The timber frame provides less opportunity for heat transfer and condensation compared to a metal frame. The timber is plantation pine, a renewable resource. It is untreated in the roof. [See: Construction Systems – Timber]

The site

The site is a corner suburban lot with the southern and western boundaries facing onto the main streets, with a side street to the northern boundary. The long axis of the site is north-south which is not ideal for a passive solar design. A requirement by the local redevelopment authority was that access to the carport had to be from the northern side street, reducing the potential for northern exposure to the house. [See: Choosing a Site, Orientation]

The neighbouring block to the north was undeveloped at the design stage of this house, and design guidelines had originally stipulated that there could only be a two-storey building on that lot to protect solar access. There is now a three-storey building under construction there that may impact on desirable solar exposure.

A brick and tile factory existed on the block originally. Its material has been recycled and reused in this house as 'rammed rubble'. The crushing process occurred off site, because environmental considerations such as the impact of noise to neighbouring properties prohibited it from taking place close to site. Although not a viable solution for this project due to its small scale, it demonstrates an option that, on larger projects, may be environmentally and financially viable. [See: Waste Minimisation]

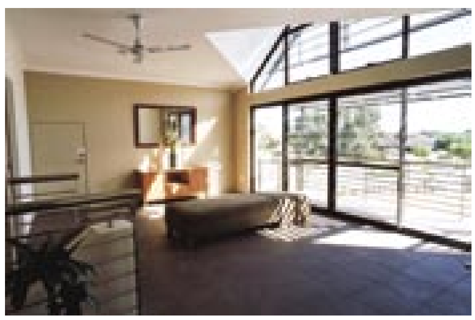
The climate

The climate in Perth is temperate. Winter mean temperatures range from a minimum of 8.6°C to a maximum of 17.9°C. Summer mean temperatures range from 18.6°C to 33.2°C. There is a cool afternoon south-westerly breeze and a cooling easterly breeze from across the land that occurs late evening/early morning; both are common. [See: Design for Climate]

Heating

Horizontal and vertical mass has been utilised for heat absorption, with consideration to location, volume and thickness. Solar access is primarily to the upper floor in winter. The reduced suspended slab thickness heats up and transfers heat through conduction to its surroundings quickly. More heat is stored in this area by a central core of thermal mass surrounding the stairwell. The mass absorbs heat in winter and then transfers it back into the room as the air cools.

An initial study indicates that the minimum internal air temperature achieved is 16°C in winter with summer internal air temperatures generally falling within the comfort range of 18°C – 28°C and a maximum peaking in excess of 32°C.



Cooling

Night ventilation is required to cool the house in summer. The house is designed and oriented to trap and redirect air flow. The southern facade 'steps out' in three locations and channels the afternoon, south-westerly breeze through the house. A vent near the entrance door catches this cool breeze which passes by the thermal mass, absorbing its heat, before exiting via high-light windows on the northern side of the upper floor. Manual opening of windows at night and closing them during the day is essential to achieve the best comfort levels.

Ceiling fans in the bedrooms and living areas contribute to the movement of air over the body and provide a cooling effect to a person in summer.

Cross ventilation has been addressed in the wet areas to reduce the opportunity for mould or mildew and assist in achieving a low allergenic home. Where possible the wet areas have an opening facing north for direct sunlight and assistance in airflow.

No auxiliary heating or cooling has been installed in the house. [See: Passive Cooling]

Shading

There are various methods of shading.

The building form provides shade with the upstairs, northern balcony shading the windows below.

A light-weight horizontal structure of fixed metal louvres protects both the glazing and the mass of the northern balcony to minimise heat build up and transfer into the home. These louvres are angled to Perth's sun to allow maximum sunlight through in winter and to omit it in summer. Vertical solar louvres provide shading to the gable window.

A deciduous tree has been planted in the northern courtyard to provide shade in summer. This is environmentally friendly, low maintenance and more cost efficient than building a permanent structure.

Other methods of providing shade include removable fabric sails and stainless steel cables for creepers to grow along.

Insulation

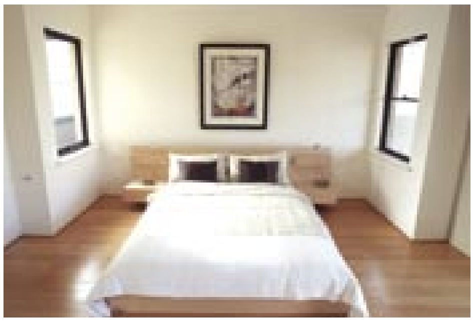
Reverse brick veneer has been used on a portion of the western walls, with R1.5 batts between timber stud frames. 'Aircell' insulation has been fixed to the internal leaf of all western and eastern walls to address the issue of ambient heat build-up, but the northern and southern walls are not insulated although insulation is generally more effective if used in every wall as the 'U' value or conductance of a structural element is the same regardless of orientation.

Blinds or drapes insulate the windows with the gap between drapes and glass maintaining the surface air resistance of still air. Instead of using pelmets, drapes have been located in the recess of the window, to reduce the potential of dust collection for this low allergenic home whilst minimising heat transfer.

The roof is insulated with R2.5 batts at the ceiling level and 'Aircell' insulation is placed between the timber frame and Colorbond metal roof sheeting. To allow for continuous airflow in the ceiling space, a raised central portion supported on punched purlins with fly mesh vents the roof. [See: Insulation Overview]

Solar hot water system

To fit the limited roof surface the solar hot water system has been split into two panels – one to the western side of the roof and the other to the east. Both panels face north with the water storage tank located mid-way in the ceiling space. The roof and ceiling insulation assist the tank in achieving a higher performance by a reduced heat loss. The tank is located over the wet areas to minimise pipe runs. [See: Solar Hot Water]



Windows

Windows have been designed and located to promote cross ventilation. They take advantage of the afternoon south-westerly sea breeze. Airflow obstruction is minimised as the air is channelled through a depth of only two rooms.

Standard, single glazed, aluminium framed windows are used to maintain cost efficiency. Glazing to the north is maximised (50-60%) to allow sun penetration to the thermal mass of the house.

The west facade was required to have a window by the local redevelopment authority as it addressed a main street. It is the only window facing west and the only window to be double glazed. A frame of vertical solar louvres has been fixed to the outside of the wall to assist in shading the glass. The performance is not optimal, which reinforces the need for appropriate window design for western facades. [See: Glazing - Overview]

Colours and textures

Colour is important in realising the full potential of a passive solar design. Light, smooth finishes will reflect some of the sun's radiation, while dark, rough surfaces will mostly absorb it. Light colours such as cream-beige face brick, off-white render, and grey steel roof sheeting have been used externally, while dark, rough floor tiles have been laid in the northern living spaces to absorb winter sun.

Energy use and efficiency

The passive solar design reduces the need for auxiliary heating and cooling.

Photovoltaic cells (1.5kW) are grid-connected to allow import (purchase) and export (sale) of electricity.

Lighting is energy efficient with the use of compact florescent and 12V pan lights. There are low energy ceiling fans and a conduction cook-top.

Water use and recycling

The house is connected to the main city water supply. It recycles grey water from the bathrooms and laundry through an underground 'Galvan' system for pumped distribution to the gardens. Because grey water from the kitchen contains a high percentage of organic waste it is not recycled. All black water is directly plumbed to the main sewer. [See: Wastewater Re-use]

Low flow plumbing fixtures have been installed to reduce water use.

A compact 4000 litre rainwater tank collects water off the roof but is not plumbed into the house. A carbon filter makes the water drinkable but the water is primarily used on the gardens. The tank shows rainwater can be captured without detracting from the home's aesthetics. [See: Rainwater]

Low allergen and universal access

Special consideration was given to the kitchen design. It is structured on a 'flow system' with the fridge and pantry being at the threshold of the kitchen to be most accessible. The sink and preparation area follow so that the 'danger' zone of the stove top and oven is only occupied by those using them.

Cabinetry is of standard materials for cost efficiency. Cut ends and penetrations have been sealed to try and prevent any leakage of toxins from the MDF board.

Design features for universal access include door clearances of 850mm, light switches at 1000mm and power points at 600mm above the floor level, lever style door handles and a straight staircase to allow for a future stair lift if necessary. [See: The Adaptable House]

Materials used

Costs were kept down and construction was builder-friendly. Standard building materials and construction methods were predominately used to make the process accessible to the mainstream market. These included concrete for the slabs, bricks for the walls, Colorbond metal sheeting for the roof and plantation pine for the framing. Predominantly, double brick construction is used, with a portion of reverse brick veneer on the western walls. [See: Material Use Introduction]

Landscaping

The vegetation and planting is water-wise and low allergen. There is a raised garden bed that is wheelchair accessible.

Leaves from the deciduous tree are used for mulch on the garden beds. There is a compost bin and worm farm in the courtyard.

Potential improvements

The design might have benefited from greater northern exposure at the lower level by creating a solar access court or by redesigning the carport as a solar-type verandah. The upper floor may be over glazed on the north adding to the upper level heat loads. Until the house has been occupied its in-use performance cannot be evaluated but computer models indicate that overall a very good performance can be expected.

PROJECT DETAILS

Designer: Mr Griff Morris, Solar Dwellings. www.solardwellings.com.au

ADDITIONAL KEY REFERENCES

Baverstock, G.F. and Paolino, S. 1986. *Low Energy Buildings in Australia: a design manual for architects and builders.* Volume 1 – Residential Buildings. Graphic Systems.

Sustainable Energy Development Office website for Western Australia: www.sedo.energy.wa.gov.au

House website: www.subiacosustainable.com.au

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