house – cool temperate

Home

Design for lifestyle & the future

Adelaide Hills

This home was designed to operate with no cooling energy and to use auxiliary heating from renewable sources sparingly. It demonstrates unusual passive design techniques. Low embodied energy materials were used throughout and the compact design reduces resources demand. Water supply and waste water treatment are autonomous.

Building Type:	New home, Lightweight construction
Climate:	Cool temperate Adelaide Hills
Topics Covered	**Success Level**
Passive design (See evaluation)	Fair
Rainwater harvesting	Excellent
Wastewater treatment	Excellent
Reducing embodied energy	Excellent
Greenhouse gas reductions	Excellent
Indoor air quality	Excellent
Waste minimisation & recycling	Excellent
Sustainable materials use.	Very Good
Renewable energy production	Excellent
NatHERS rating (See evaluation)	★

Set in the hills above Adelaide, this two-bedroom and study, home for three, has views over the Port River estuary, the Morialta Conservation Park and the CBD.

The aim was to build a 'small is beautiful', ecologically sustainable, family home at a price most people could afford. In the language of the original locals, Kawanda Muna means "North-in-front", which highlights the most important part of the design.

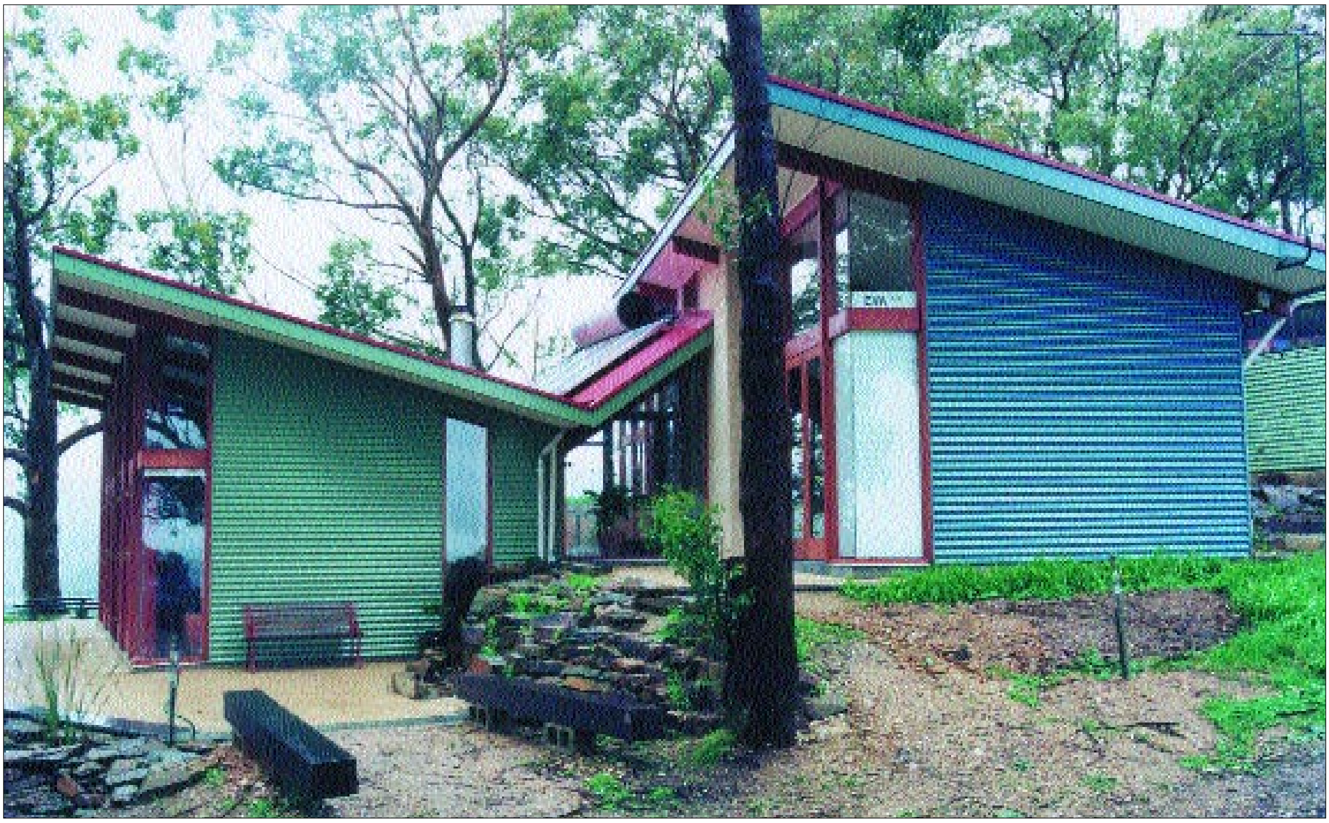
Self sufficiency for water and wastes on a two acre block in an 800mm rainfall zone is relatively simple. The detail required to ensure minimal energy use, especially electricity, without sacrificing a desirable aesthetic required the combined design talents of the architect, the owners and the building team of four. It was a matter of carefully crafting sound ideas, such as minimising embodied energy and using recycled materials, with practical decisions and the willingness to change long held views of what a house ought to look like.

The owners had read widely since embracing the concepts in Brenda and Robert Vale's book 'The Autonomous House' in 1977 but needed an architect to work through and choose between some competing ideas.

The ecological footprint was to be as small as possible and the setting demanded the house have that touch of magic.

CLIMATE

Over the last 150 years designing with the climate has been lacking in South Australian housing and one aim was to demonstrate that it is relatively easy to keep a home cool or warm in this climate.



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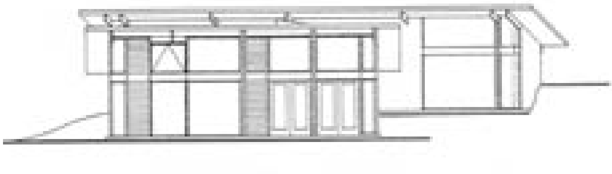
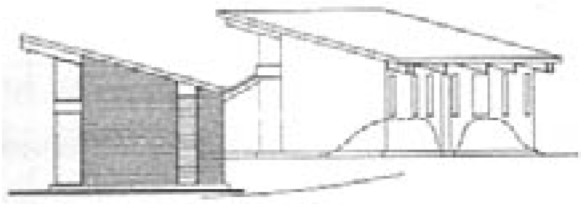
Temperatures range from 11-37°C in summer and 1-18°C in winter. The average rainfall is 28mm in summer, 100mm in winter and the wind speed averages 3m/s in cold south easterly or westerly blasts. Wind is the price paid for the excellent views.

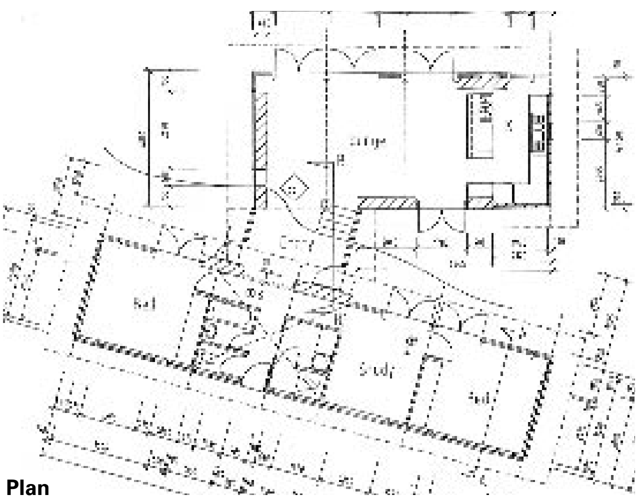
Adelaide residents worry mostly about summer heat and 'cheat' a little in winter by using wood heating to compensate for less efficient use of passive heating. At 360m above the plains there is frequent cloud cover from June to October. The local Stringy Bark overstorey also reduces access to sunlight and dictated that the photovoltaic array on a tracker be positioned 50m to the west of the house.



North Elevation



West Elevation



Plan

DESIGN

The north sloping ridge and a desire to make the best of the views whilst keeping warm, prompted the architect to design a house that hugged the ridge. The upper, bedroom/bathroom zone is sited to the south and the open, living zone to the north.

The two concrete slabs are separated by a recycled jarrah floor in the entry with a one metre high cellar, fronted by a bluestone wall (reclaimed from the owner's bulldozed boyhood home). Each is separately glazed.

The southern slab is oriented 15° east of north and is earth bermed to one metre. Recycled polystyrene pieces are placed horizontally 300mm below the soil surface to assist with insulation on the cooler southern side. The living area faces true north.

SHADING

Extensive north glazing is passively shading by carefully calculated fixed width eaves allowing sunlight to heat the dark coloured concrete floors. The sun reaches half way up the inside rear walls in mid winter.

To take advantage of a magnificent view over hills and orchards, the one easterly window over the kitchen sink is larger than recommended. This has necessitated an awning to shade early morning summer sun. A sail has also been added to the outdoor BBQ area for summer shade.

PASSIVE HEATING

Fourteen external doors, two casement windows and a phase-change Trombe wall store heat in winter and allow night time cooling in summer. External spaces are also used to assist heating and cooling. A garage joined to the house by a covered breezeway funnels cooling breezes and provides a buffer against cold winds.

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The “Trombe” wall relies on thermal mass (a rammed earth wall) placed behind passive shaded north facing glass areas. The “phase change” technology is experimental and exploits the properties of Calcium Chloride (CaCl) which changes phase (from solid to liquid) at 28°C taking up large amounts of “latent heat” in the process. The heat is re-released as the CaCl cools. Small ”cupcake” shaped black containers of CaCl are attached to a rammed earth wall (see above).

SUPPLEMENTARY HEATING

Wood grows and dies naturally on the property and is a renewable energy source. Greenhouse gas emissions from burning wood are equivalent to those released as it rots. Wood is carefully harvested by the owners taking care to avoid destruction of hollow trees and other habitat features important for maintaining biodiversity.

Supplementary heating via a 71 percent efficient, 9.1kW, Eureka slow combustion stove was an obvious choice. This has a water jacket around the flue to supplement the solar water heater in winter. [See: Heating and Cooling]

The stove heats the whole house but a sliding door across the passage to the bathroom has been added to divert warm air towards the study and the bedrooms.

A bluestone wall with a small gravel heat bank next to the stove supplements the thermal mass of the surrounding 400mm thick, stabilised rammed-earth walls and the dark, low maintenance, concrete floors. The upper level slab is black terrazzo.

The stove is positioned centrally and the nearby colourbond steel clad, west-facing, walls are well insulated. This cladding has been used extensively on walls and roof because of its durability, cost and functionality.

COOLING

Ceiling fans create air movement to enhance evaporative cooling in the low humidity climate. Double doors in the front and a single door in the rear of each room allow cross ventilation.

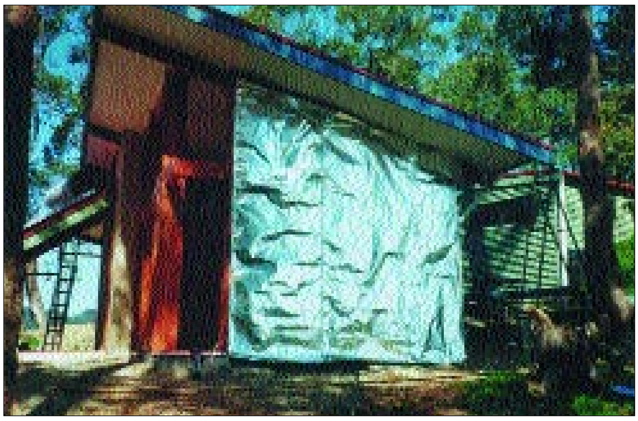
Stack ventilation also exhausts hot air as it rises and escapes through large opening windows at ceiling level.

Ponds in the path of ventilating breezes create additional evaporative cooling.

The house uses no mechanical cooling and usually remains within thermal comfort levels. Internal temperatures did reach a maximum of 33°C after a prolonged heat wave when night time temperatures remained high.

INSULATION

Walls and roofs are insulated with R2.5 and R3.5 fibreglass batts respectively. Reflective foil insulation is placed under the colourbond as a moisture and bushfire barrier with an air gap under the downward facing reflective surface.



White Luxaflex Duette blinds (R 0.3) reflect summer heat when needed from January to April. In combination with pelmets over the doors they also trap still air between glass and blind providing insulation to retain winter warmth. This allows more flexible individual room temperature control.

Danpalon, multi-celled, translucent polycarbonate sheets are placed on the inside of bedroom windows as additional insulation when external temperatures drop below 10°C.

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WINDOWS

Western Red Cedar is used to frame all doors and windows to avoid heat losses that would occur through aluminium frames. All are draught proofed.

Double glazing has been achieved cheaply using easily applied, shrink-wrap plastic which emulates double glazing. Some problems with durability have been experienced with the film.

South windows provide true colour task lighting that is ideal for reading, sewing, etc. As they allow heat loss to cold winds with no compensating solar gains they have been kept to a minimum.

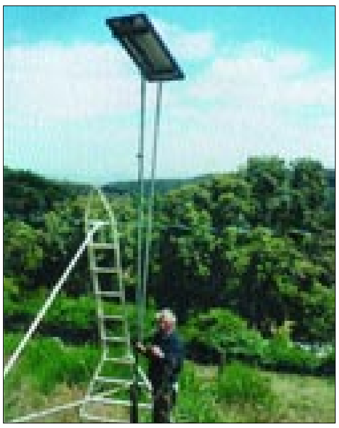
LANDSCAPE

The property is being revegetated with indigenous plants in an attempt to encourage wildlife to use it as a corridor between nearby national parks.

WATER AND WASTE WATER TREATMENT

RAINWATER HARVESTING

Rainwater is collected in two 22,700L polytanks and pumped 12m up to a 1000L polytank on a 6m galvanized tank-stand at the rear of the garage. A 45W Solarex panel powers the pump. The house runs comfortably on collected rainwater, with sufficient surplus for spa baths.



For bushfire purposes there is a connection to a neighbour's storage tank of dam water. An interconnected petrol pump and sprinklers are installed on the north and west sides of the house, some 3-5m away.

GREY AND BLACKWATER TREATMENT

Septic tanks are a problem in the Adelaide Hills, especially in the watershed. Newer designs often require regular chlorination and electricity to operate effectively so a Dowmus wet composting system with a Biolytic Filter is used.

The system uses earthworms to process wastes, including kitchen scraps, cardboard, etc. but has a normal flushing arrangement. An auger allows the composted material to be removed every 5-8 years, but at present the level remains fairly constant.

A well designed 37m effluent trench carries nutrient rich seepage across the block. If not for the plan to revegetate with indigenous plants, fruit trees would be planted below the trench to make good use of the nutrients and water.

A reed bed filtration system was considered but rejected because health regulations assume massive water consumption, thereby increasing excavations and costs. So far there have been no problems with the disposal.

RENEWABLE ELECTRICITY GENERATION

The grid-interactive PV array of 12@86W BP Saturn modules feed into a Sunny Boy 1200W inverter set under the meter box for normal 240v AC supply. The meter reverses when excess electricity is generated and this excess is sold back to the supplier. The Davy tracker for the PVs follows the sun, resets automatically each night and can be adjusted manually for different seasons. Data is transmitted from the inverter to a computer, thereby allowing the effectiveness of the $10,000 (after rebate) investment to be monitored. It is critical to the goal of self sufficiency to know when the system is 'down'.

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APPLIANCES

Hot water is provided by a 3@1m² panel, 300L Beasley, close-coupled system, installed in conjunction with the water jacket on the stove that can be open vented. Its effectiveness is optimised by the 35° pitch of the north facing roof. The vent pipe runs through the house and garage and up the header tank, giving both hot and cold runs the same pressure.

An instantaneous Rinnai 18 gas booster can be adjusted to heat water up to 55°C. Bathing and showering only require water at about 42°C and a temperature gauge allows one to check before showering. If neither the sun nor the wood provide enough hot water, an electric booster is manually operated for about 30 minutes. Occupant behaviour is the key to making most use of the sun, eg. showering at night after the sun has had all day to heat water.

The washing machine is run using cold water and an Asko dishwasher is run from the hot water. Both machines are low energy and AAA water rated.

KITCHEN

After much debate, LPG was chosen for cooking. All appliances were selected with the help of Choice magazines. A Fisher and Paykel refrigerator is placed near a ground level register for ventilation. Hot air rises through vented cupboards above. The dishwasher conserves both water and time.

LIGHTING

Compact fluorescents have been used as downlights throughout with normal fluorescents used for pelmet lighting. Light shines down the blinds and translucent polycarbonate in the upper part of the pelmets allows light to shine up to the ceilings. Natural daylight is the most significant form of lighting. Only the laundry needs artificial light if there is insufficient task lighting from a small skylight.

WASTES

Recyclable materials are collected weekly and soiled wastes collected monthly by the council.

MATERIALS USE

Materials were carefully selected on an "environmentally preferred" basis including consideration of embodied energy content, durability and low maintenance. Recycled materials were used wherever possible.

This lifecycle thinking approach has reduced:

> embodied energy content
> lifecycle maintenance costs
> lifespan of the house
> biodiversity impacts [See: Materials Use Introduction]

Rammed earth is an excellent source of thermal mass with low embodied energy. It was well insulated externally to reduce heat loss that would otherwise occur in this climate. [See: Thermal Mass; Embodied Energy]

THE FOUR Rs

Refusing to waste resources.

Reusing others' caste offs.

Recycling as much as possible.

Reducing overall size to conserve resources.

"Found" materials, including timber, copper, aluminium, electrical fittings, wire, plumbing, etc. were collected over the years. The challenge was to reuse as much as possible without spoiling the look of the house.

90 percent of the timber used is second hand. Some was sought deliberately from old Adelaide buildings (often, high quality jarrah and oregon). Only the purlins are new SA plantation pine.

Door and window frames are new cedar but its origins are difficult to establish.

All copper piping, except gas lines, was second hand. Some was purchased cheaply at the recyclers, by weight rather than by length. Galvanized piping was similarly sourced.

Second hand items, such as plumbing fittings, are adequate in many places and can remain hidden. Money and resource consumption can be saved but 'time' is the tradeoff as much time can be spent de-nailing timber and searching for and cleaning up reusable resources.

Steel and plastic scrap from the building process were taken to the recyclers and all wooden offcuts were saved for winter heating.

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ENERGY CONSUMPTION

6kWh of electricity was used per day during the first summer of occupation and before the PV system was installed. In winter 16kWh per day was required. When the house is running at maximum efficiency it is predicted that the home will produce more electricity than it consumes in summer and some will be purchased in winter. These requirements should break even over a year. About 45kg of LPG and 1000Kg of local firewood is used each year.

Transport – one car is used to travel 18km to work and another is used for errands, at about 100km per week.

NATHERS RATING

The home scored a disappointing one star when rated on NatHERS. Considering the effort put into the design by the owners and the house's apparent comfort levels and minimal energy requirements, an explanation is required.

The annual heating and cooling energy required to maintain comfort for this climate was 39 giga Joules for heating and 7 gJ for cooling.

The rating clearly identifies that heat loss through the envelope is a potential problem. There are several reasons:

> Parts of the upper glass areas on the north walls are in permanent shade and are therefore a constant source of heat loss with no compensating solar gains.

> The internal temperature graduation is greatest at the highest part of the room. Heat loss through glazing located there is greater than at floor level. The rate of heat transfer is directly proportional to the difference between inside and outside temperatures.

> The assessment was done before the insulating plastic film was applied to some of the glazing and the effect of the insulating blinds was not modelled. These would have improved the rating.

> Significant areas of east and west facing glass are unshaded (in reality, they are shaded by trees). These windows would account for most of the cooling energy predicted demand as well as considerable heat loss.

> In general, there is too much low performance glazing.

NatHERS does not consider energy sources and is not intended to measure greenhouse gas emissions. It models predicted energy use only. As the heating in this home is from a renewable source, the greenhouse gas emissions from envelope inefficiency are minimal. A more efficient envelope would still reduce fire wood consumption and contribute less to diminished air quality.

Adelaide University monitored the house for the first 12 months and found that only 11.5 gJ of heating energy was actually used compared to NatHERS' 39 gJ prediction. No cooling energy is used at all – yet the rating assumes 7gJ.

The manual operation of the house, and an acceptance of a broader comfort range, has proven to compensate for a lower passive performance level.

The assessor also felt that the climate data used in the assessment did not accurately represent the unique micro-climate of the Adelaide Hills site.

Conclusion: HERS ratings are a measure of the performance of the building envelope only. They are based on certain assumptions that are useful for making comparisons about the relative performance of a house.

Ratings do not always accurately predict the actual performance of a given design – particularly in regard to occupation patterns and individual household energy use.

A NatHERS rating, although a good indicator of passive design performance should not be taken as an indication of the overall environmental performance of a house. This is certainly true in the case of Kawanda Muna.

EVALUATION

The three residents, two adults and a teenager, find the house's openness, ease of communication and sense of "outdoors inside" pleasant and relaxing. The house is comfortable and stimulating to live in.

Cantilever windows may be added to each bedroom to dump summer heat. Dust from the driveway will be controlled when vegetation is established on the southern berm and the 'dunes'. Growing herbs in the internal courtyard will improve temperatures there.

The close proximity of trees, sunsets, moonrises and abundant wildlife all remind us pleasantly of our parts in the web of life.

PROJECT DETAILS	
House	Rammed-earth, concrete, glass, steel and timber -area 123m2, garage 49m2
Cost	$173,000 including fittings, appliances, etc.
Occupancy	2 adults, and a 17 year old
Architect	John Maitland, Energy Architecture
Builder	Malcolm Dallwitz Cherryville
Finishing touches	Alf Wood and John Smith

Principal author: John Smith
Contributing authors: Chris Reardon, Steve Shackel