House – cool temperate
Dandenong ranges

This family home was designed to the highest energy efficiency standards to minimise auxiliary heating requirements. Low embodied energy materials were used at every opportunity. Water supply and waste water treatment are autonomous.

BUILDING TYPE: New home, composite construction	
CLIMATE: Cool temperate - Melbourne outskirts Victoria	
Topics Covered	Success Level
Rainwater harvesting	Excellent
Waste water treatment	Excellent
Reducing Embodied Energy	Excellent
Greenhouse gas reductions	Very good
Sustainable materials use	Very good
First Rate score – 5 star +	★★★★★

The project is a four-bedroom family home on a gentle sloping site in the Dandenong Ranges on the outskirts of Melbourne.

The site has spectacular views over the Clematis valley to the north and this was of prime significance in the design and siting of the house.

The building was to be designed to the highest energy efficiency standards to minimise auxiliary heating requirements in a climate where temperatures as low as minus 5oC are experienced.

The dwelling achieved an impressive 5 star plus on the First Rate software. (It uses less than half the energy of a 5 star rated house). The design created a highly-insulated building envelope that steps along the contours of the north sloping site protected by an earth bermed wall to the south and opening to large areas of glazing to the north.

LOCATION AND CLIMATE

The site covers approximately 4 hectares on a gentle ten-degree slope to the north-west. It was originally a tree plantation with 0.4 hectare cleared to form the house site. The remaining area was retained for commercial tree plantation.

An access road is situated to the north-east of the site where water, electrical and gas services are available.

No sewerage service was available.

The elevation above sea level means that site temperatures are several degrees cooler than that in Melbourne, ranging from minus 5ºC in winter to the high 30s in summer.

Prevailing winds are from the south-west in winter and the north-west in summer. The internal temperatures are designed to fall between 18 and 25ºC.

DESIGN RESPONSE

The building is situated on the highest point of the property to take advantage of the spectacular northerly views and to facilitate vehicular and services access from the existing road.

The designers chose to orient the building approximately 15º west of north to follow the line of the contours and to avoid overshadowing by the large adjacent trees to the north-east.

The two storey building form is set into a bermed wall on the south and opens out with large areas of glazing to the north.

All main living areas are located on the north of the home for optimum solar access. The ground floor steps up the contours of the slope from the west to the east with a floor level difference of 0.75m.

Living areas are located on the ground floor with bedrooms on the upper floor set back from the line of the ground floor to form a north facing deck.

Service areas and carport are located on the south side and the entrance is on the sheltered east side. Existing trees were retained to the south and west to provide a windbreak. [See: Passive design]

DESIGN SOLUTIONS

Day-lighting and sun control

Natural daylight is maximised in the building. Main living areas are orientated north. Adjustable shading devices are used on ground floor rooms to allow flexible control of solar access in an unpredictable climate.

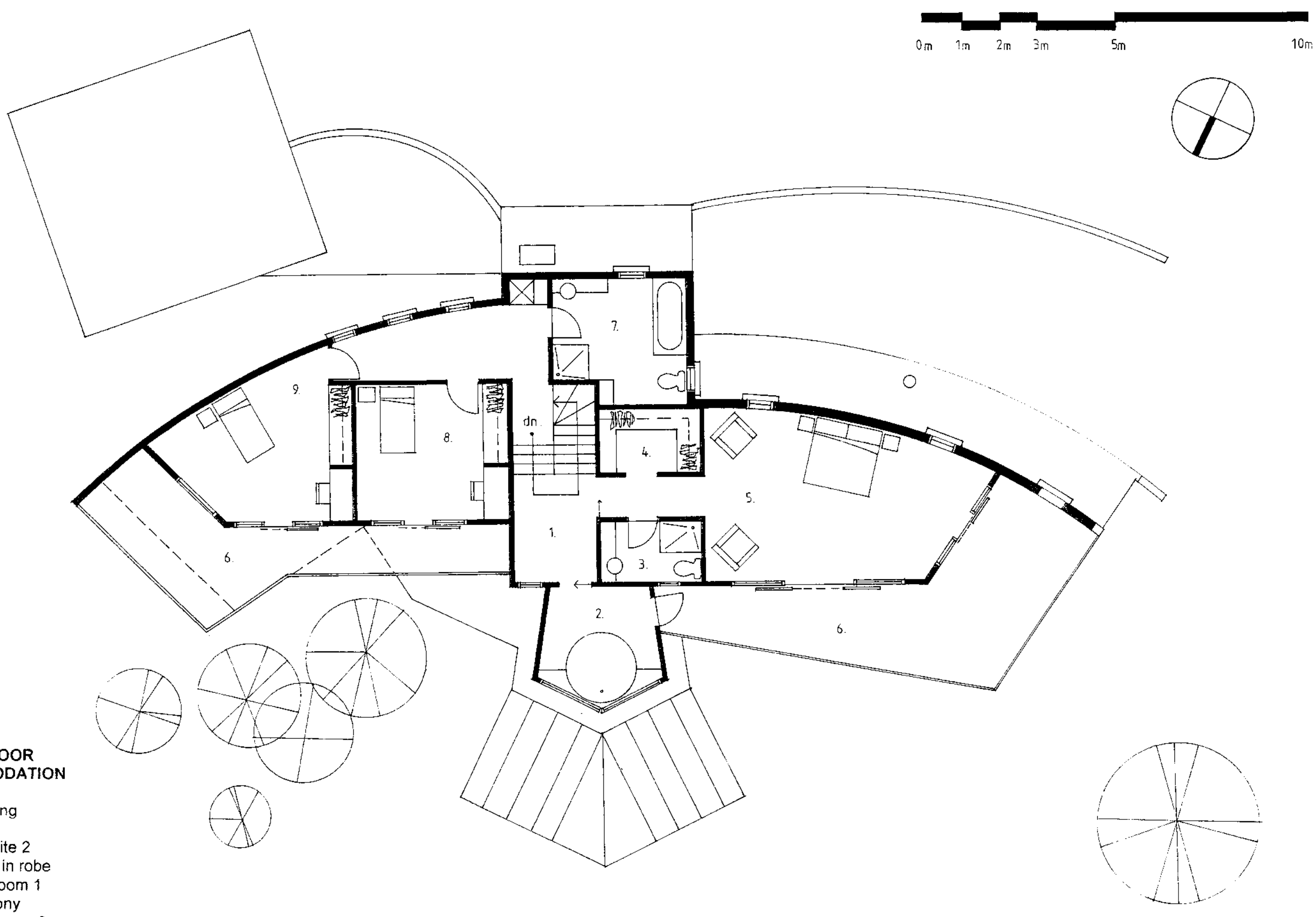
The dining area is shaded by a pergola with adjustable shade sails. Other north and west facing windows are shaded by parallel arm awnings. First floor windows are shaded by fixed eaves, sized to admit winter sun and exclude summer sun.

In addition to the fixed eaves, the spa area is also fitted with Azurlite, a heat restricting glass with a shading co-efficient of 0.66 and visible light transmittance of 77percent. While this is insufficient to prevent some unwanted heat gain in summer, the spa can be closed off from the rest of the house and vented through the door and the north-east windows. [See: Shading]

Passive heating and cooling

The main energy efficiency strategies for the cool-temperate climate were to provide a well insulated envelope with internal thermal mass and maximum solar gain in winter.

Large areas of north glazing admit winter sun, which is stored in the thermal mass of the ground floor slab and earth bermed wall to the south of the dwelling.



UPPER FLOOR ACCOMMODATION

1. landing
2. spa
3. ensuite 2
4. walk in robe
5. bedroom 1
6. balcony
7. bathroom 2
8. bedroom 2
9. bedroom 3

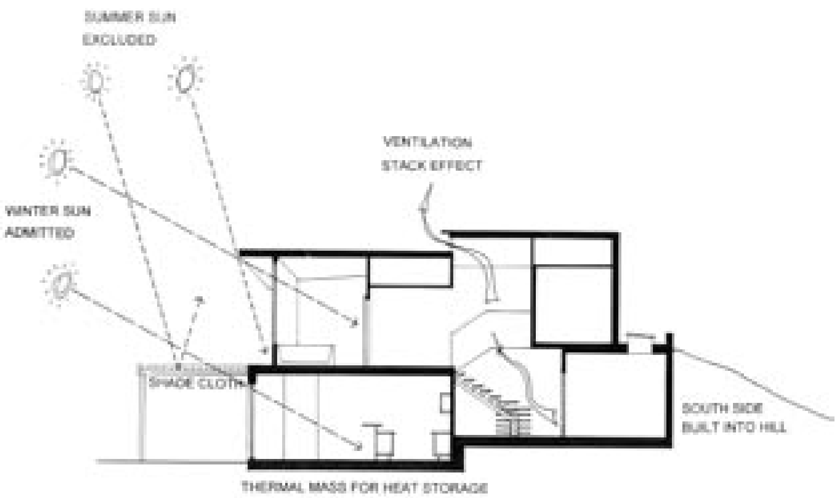
UPPER FLOOR PLAN

Thermal mass also moderates the internal temperature in summer by acting as a heat sink.

A wine cellar is located in the south bermed wall section so that fairly even cool temperatures are maintained throughout the year. Night-time cooling of the thermal mass is achieved by admitting cool summer-night breezes from the south. [See: Insulation Overview; Thermal Mass]

Ventilation

Cool summer breezes from the south-west are funnelled by the western, south bermed wall and admitted through small casement windows in the south wall that open to admit the breezes.



Passive solar design - Cross section

Insulation and draught proofing

The entire building envelope is well insulated.

Walls: Some R1.5 AAC blockwork is used in service areas. R2.0 wool/polyester bats are used in timber framed walls (majority of walls).

Roof: R3.0 wool/polyester bulk insulation and R1.0 polyester blanket with down facing reflective surface and 25mm air gap. Total composite R4.5

Slab edge insulation of R1.0 is fitted to prevent heat loss from the slab to cold outside air.

All windows and doors have draught proofing.

Windows are double-glazed, with all large areas of glass on the ground floor fitted with low-E glass to give performance equivalent to triple glazing.

Window frames are timber to minimise heat transfer losses through the frame.

Cool air passes through the living area and out through the glazed doors to the north of the living and dining area. The eastern side of the home is also ventilated through southern casement windows, but due to the smaller areas of glazing does not require the same level of ventilation. Stack effect ventilation is also encouraged in summer through openable roof level windows above the staircase. The upper floor is ventilated in a similar manner with the addition of roof ventilators to supplement the ventilation rate.

Appliances and equipment

Auxiliary heating is provided by a Rinnai 4.5 star rated gas wall heater and an open fireplace in the living room.

Auxiliary heating is located at the lower level of the ground floor to allow heat from this area to rise to the mezzanine level and then up the staircase to heat the upper floor.

Additional off-peak electric floor coils were provided in the slab of the meals, kitchen and rumpus area. These were intended only to take the chill off the slab on cold winter nights after several sunless days. During the first year of operation they were used by the owners as the main source of space heating. The resulting high energy bills soon changed this practice and now gas heating is used almost exclusively.

No auxiliary heating is required on the upper floor.

No auxiliary cooling is employed throughout the entire residence.

The hot water system is an Aquamax 200 gas 5 star storage unit. It was thought that a solar hot water unit with electric backup would be too expensive to run due to the amount used in the spa. The owners now regret this decision because the spa is rarely used.

The designers specified low-energy appliances and a high proportion of efficient compact fluorescent light globes. [See: Hot Water Service; Lighting]

Embodied energy

Building materials with low embodied energy and highly durable finish were chosen. Most walls are constructed in aerated concrete block, a material that has approximately half the embodied energy of standard brickwork.

Wall finishes are a highly durable exterior coating that has a guaranteed service life of more than 20 years. Other materials used in the construction, such as pine framing, recycled timber and cement sheet cladding were also chosen for their low embodied energy.

ENVIRONMENTAL CONSIDERATIONS

Water and waste management

All roof water is collected and fed into two large water tanks, sized to provide all the water requirements for the property.

Grey and black water is recycled in a Biocycle integrated waste management system and then re-used on the garden.

The garden has been designed with xeriscape plants, heavy mulch and a drip irrigation system to reduce water requirements. [See: Wastewater Re-use; Sustainable Landscape]

Appliances such as the Dishlex global 400 dishwasher and AAA rated showerheads and taps were also selected for their low water usage. [See: White Goods]

Biodiversity and resources

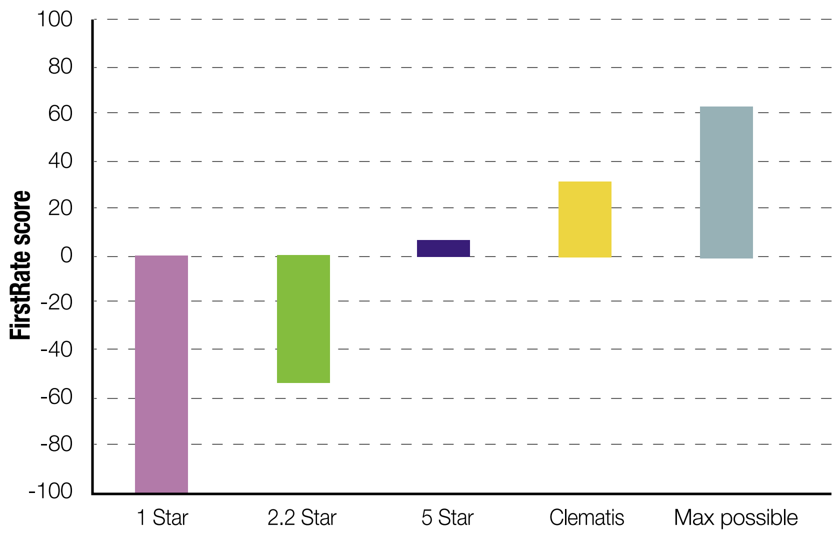
Site excavation was minimised by locating the home close to the road and designing a stepped ground floor slab to follow the contours of the site.

Soil from the excavation was used to form the earth bermed wall to the south of the dwelling. Waste from off-cuts of the AAC and concrete blocks were also used in the bermed wall to provide a degree of drainage.

All timber in the dwelling was selected from sustainable managed sources, including the plantation pine framing, 'Plyfloor' flooring and cedar windows which are harvested from sustainably managed forests in Canada.

EVALUATION

Heating and cooling requirements for the building were first simulated using First Rate software. This was done by the designers during design stages and later verified by Sustainable Energy Authority Victoria (SEAV) prior to construction. The building is significantly better than a 5 star rated home.



Relative performance on FirstRate

The owners have found the house to be extremely comfortable year round. Although shading devices have yet to be installed, the owners did not find the house uncomfortable in summer due to the high ventilation rates.

The house is used as the designers intended in summer with the operation of the south casement windows and the roof windows to create a thermal stack-effect, flow through ventilation.

The single criticism of the performance of the dwelling by the owners was a lack of cross ventilation to one of the upstairs bedrooms. A roof ventilator will be installed to remedy this problem.

The main lessons

Despite high level passive design and use of energy efficient appliances and lighting, the energy used during the first year was more than double that of a standard dwelling.

An audit revealed that this was due to pumping equipment not associated with the house. Planning is now under way to install solar pumps and gravity feed tanks.

The designers intended that the floor coil be used as an occasional source of slab heating only and that the more efficient gas heater should be used as the primary source of heating.

Unfortunately, the floor coil was used as the primary heating source until high energy bills forced a re-think.

This highlights the equal importance of operating patterns on energy consumption. The designer has now explained the impact of different fuel types on greenhouse gas emissions and the consequences of heating choices on energy use to the client.

On completion of a building, this information should be included in a user manual presented to the owners. A more drastic alternative would be to limit user choices by not specifying electric storage heating systems in future projects.

PROJECT DETAILS	
Building area	$320m^2$ + $92m^2$ balcony & carport.
Occupancy	Full-time owner occupied, 2 adults and 2 children.
Building cost/m^2	$1000.00 (approx.)
Designer	Sunpower Design.
Structural Engineer	Andreas Sederof, Sunpower Design.
Builder	Totally Organised.

Adapted from the Roger Fay/Ceredwin Owen Australian Building

Energy Council (ABEC) case study by Steve Shackel and Chris Reardon.