house – cool temperate

Bairnsdale

This case study is an example of an autonomous house that generates its own electricity and hot water, collects and uses its own water, and recycles waste water onto the vegetable garden and orchard. Due to the highly effective building fabric, it provides a comfortable and attractive internal environment with the temperature fluctuating between 17°C and 26°C.

Building type	New home, Country site, Only service electricity, Heavyweight
Climate	Temperate south-eastern Victoria
Topics covered	Success Level
Orientation	Excellent
Design for climate	Excellent
Passive heating	Excellent
Passive cooling	Excellent
Insulation	Excellent
Thermal mass	Excellent
Glazing	Excellent
Shading	Excellent
Reduced water demand	Good
Water harvesting	Excellent
Water re-use	Excellent
Material selection	Good
Energy use – PV	Excellent
Solar hot water	Excellent
Electric lighting	Good
NatHERS Rating	★★★★★

The site is 75 acres of farmland outside Bairnsdale. The aim was to rejuvenate the land with new dams and a tree planting program. The house site is on a northern slope of the land with mid range views to neighbouring towns and distant views to mountain ranges. There is no overlooking from neighbours and no obstruction of solar access.

The climate is a temperate one in the south-east of Victoria.

The brief from the client team of a husband and wife for this project was for a beautiful low maintenance house that they could use as a base for their trips into the Australian bush. The house had to be light and airy, have wall space for paintings, and have a view from each room. It should be naturally warm and well ventilated when necessary, single level, and be a "shelter".

The owners planned to spend most of their time outside. The emphasis was that the home be "a house in the environment" with an attached carport for the storage of kayaks, camping gear and a 4WD vehicle. Two associated sheds were also to be provided that would form part of the overall design, with one being a woodwork area and the other one an artist's studio. The clients were well informed and very supportive of the environmental approach taken in the design.

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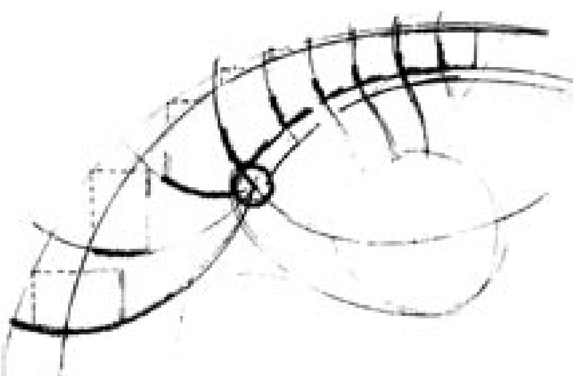
DESIGN RESPONSE

SHAPE AND ORIENTATION

The design was begun by establishing the axis mundi, the vertical axis for the building that secured it to the site. This axis was determined by walking over the site many times until it became clear where the heart of the building should be. **[See: Insulation Overview]**

This axis point was used as the starting point for the design, and later on, as the starting point for the layout and dimensioning. Around this vertical axis, a tower was developed that would form the basis for a stack ventilation effect. It would also function as a welcoming top-lit point of arrival in the entrance space.

From the tower a gently curving spine, oriented east/west, leads off which formes the basis for a corridor connecting all the rooms. The corridor also containes a library. North/south ribs run off from this spine, defining the spaces on either side. This initial concept, seen in plan view in Figure 1 below, made it possible to achieve excellent passive solar design.



Underlying structural concept for house

ZONING OF SPACES

The client requested a house that could be zoned off for various patterns of use. The three core spaces were the main, sitting and dining areas. These three spaces lie side by side on the north side of the building, and can be sealed off from each other and the remainder of the house. Sliding doors separate the zones. The remainder of the spaces required were designed around these main spaces. Figure 2 below shows this arrangement.

BUILDING FABRIC

The building fabric was designed to be high in thermal mass (internal) and wrapped with high levels of insulation.

The floor is a concrete slab, and the termite treatment was as minimal in environmental impact as possible for the project. **[See: Thermal Mass]**

The walls are two leaves of rendered concrete masonry brick, with a roofing blanket consisting of 75mm of fibreglass insulation bonded to Sisalation™ that faces the outside masonry leaf. The gap between the insulation and the masonry leaf is maintained by spacers. The overall insulation value of this system is R 2.6. **[See: Insulation Overview; Thermal Mass]**

The windows were made locally in Bairnsdale. Stained local hardwood timber was used in the frames and sashes. Windows were double glazed with both inner faces low E coated. **[See: Glazing – Temperate]**

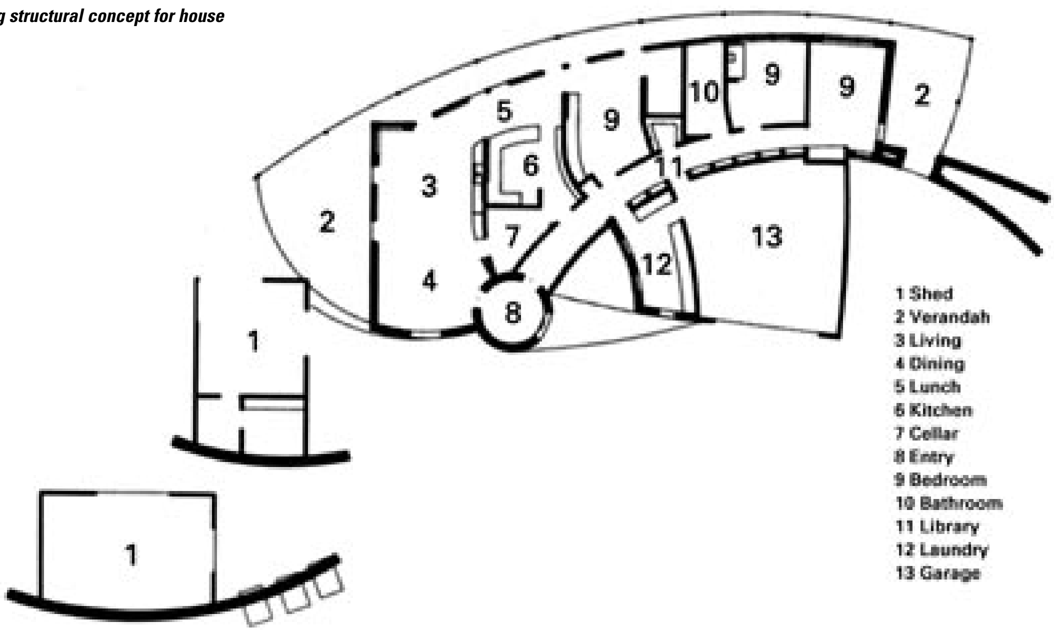


Figure 2 Plan of house

The roof/ceiling was constructed using corrugated steel roofing, a roofing blanket consisting of 25mm fibreglass and Sisalation™, a 30mm air gap, two layers of R2.5 polyester batts (made from recycled polyester bottle fibre) and lined internally with 10mm plasterboard. The overall insulation value of this was estimated at R6.5. [See: Insulation Overview]

All internal walls were bagged masonry concrete bricks, except where service pipes were required between the ensuite and bathroom. Where required, electrical conduits were run through bricks with hollow cores. Elsewhere, solid blocks were used.

PHOTOVOLTAIC (PV) SYSTEM

In keeping with the client's wish to be as environmentally friendly as possible, a grid interactive PV power system was designed. The architect worked with two tenderers, and the Sustainable Energy Authority of Victoria to develop a performance specification that was used as the basis for the tender.

Tender documents incorporated this performance specification (that called for a 1.28 kW peak output system with a grid interactive inverter), a somewhat redundant load analysis table that showed the intended use by the client, and architectural drawings.

The winning tender was for $11.70 per peak watt and both tenders were within 1% of each other. The price included supply, installation, commissioning, six month warranty period and any necessary rectification, negotiations with SEAV in order to achieve a successful outcome with the Australian Greenhouse Photovoltaic Rebate Program (PVRP), and successful negotiations with the supply authority Eastern Energy in order to gain net energy trading.

The system size was later upgraded to include an air displacement water pumping system and the final system was 1.92 kW peak, consisting of two 12 x 80 W peak solar arrays (mounted on low profile zincalum frames) that feed two separate inverters. This twin system was an elegant solution to the two phase power supply to the farm. The final cost, after deducting the PVRP rebate, was $7.70 per peak watt.

There have been some problems with the functioning of both inverters but they have now been rectified. Final payment for the completed and commissioned system is not due until the system has been operational for six months, and this includes the errant inverters. This money retention is a sensible course of action for any installed appliance, renewable energy or not. However, it is a delight to visit the site and see the electricity meter going backwards. [See: Photovoltaic Systems]

SOLAR HOT WATER SYSTEM

The solar hot water system was installed with a 400 litre stainless steel tank, using off-peak electricity as the back up since no natural gas is available. The system had some leaks from faulty gaskets, which have been replaced by the manufacturer under warranty. Pipes are insulated with black foam lagging. [See: Solar Hot Water]

WATER SYSTEM

Rain water is collected off the roof and piped to three water tanks positioned to the west of the house. The storage capacity of the tanks is 15,000 litres, and the water is returned to the house under pressure using a pump. The tanks were relocated to a lower position on the site when it was found that discharging rainwater did not have sufficient head pressure to flow into the tanks without overflowing from the gutters. [See: Rainwater]

WASTE WATER TREATMENT SYSTEM

A waste water treatment plant was supplied locally. It cost much the same as a normal septic tank and consists of two chambers. The first chamber is a septic tank that requires cleaning out every five years or so. The second chamber air treats the liquid that is then used as a spray to irrigate the landscape. [See: Wastewater Re-use]

COMPOSTABLE WASTE AND VEGETABLE GARDEN

A composting enclosure is provided on the site as well as a vegetable garden.

CLOTHES DRYING

Clothes drying is done on an external line.

BUILDING COSTS

Excluding the cost of the photovoltaic system, the house and garage cost $1350 per m². The sheds and their associated retaining walls cost $700 per m² .

EVALUATION

ENERGY RATING

The house was rated using the FirstRate system from the Sustainable Energy Authority of Victoria and received 57 points out of a potential 67 points. The house is a Five Star house, where Five Stars are awarded to houses scoring 18 points or more. An additional ten points could have been achieved by adding 20m^2 of north facing windows, which would have brought the north window/floor area ratio up from 16% to 27%. It was felt that this would severely compromise summer performance, unless the window had been provided with more shading which in turn would have produced poorer winter performance.

The use of fuels will be monitored over the coming year to determine the actual operating performance.

RULES OF THUMB

The internal floor area is 174m^2 excluding the garage and laundry, with the library corridor making up 20m^2 of this. The north facing windows have a surface area of 28m^2 measured to the outside of the frames. The surface area of the internal masonry walls is 144m^2 , with the surface area of the internal faces of the external walls being 149m^2. This accords with the general rule of thumb that the area of the floor, the area of the internal walls, and the area of the internal faces of the external walls of a house should all be roughly the same value.

A rule of thumb established by the author for this climate indicates that the north window area should be 15% - 20% of the floor area, with a tendency to be on the small side to compensate for the very hot summers that can be experienced in this climate. This house has a north window/floor area ratio of 16% - 18% depending on whether the library corridor is included or not.

The surface area of the internal mass should be a minimum of six times the surface area of the north facing glass area, with nine times and above being preferable. This house has a thermal mass surface area/north window area ratio of 16 indicating that there is ample thermal mass.

A rule of thumb for thermal mass developed by Brenda & Robert Vale (Vale, 2000) suggests that 1200 kg of thermal mass per m^2 of floor area will produce a zero heating house in cold European climates, with the Vales' own autonomous house at Southwell, UK having a ratio of 723 kg/m^2. This Bairnsdale house has approximately 101,000 kgs of thermal mass, which is 580 kg/m^2 of floor area. More theoretical work needs to be undertaken for temperate climates to determine the appropriate rule of thumb for this mass/floor area ratio, as experience shows that the level of mass provided at the Bairnsdale house is sufficient.

CONCLUSION

The Bairnsdale house represents a good example of an autonomous house that is grid connected. It is a single storey house with high mass, very good insulation, and correct window sizing. It incorporates a solar hot water system, a 1.9kW peak grid interactive photovoltaic system, an environmentally friendly sewage disposal system, and rain water collection storage and reuse. Details of these are provided. Kitchen waste is composted. Clothes are dried on a clothes line. A vegetable garden and orchard have been established. Whilst these ESD design features are now not unusual, what is different in this house is that they have been incorporated into a finely crafted building that was designed using a philosophical position that encompasses both the physical and metaphysical aspects of design.

PROJECT DETAILS	
Architect	David Oppenheim, Melbourne
Builder	NJ & MN Brooker
ESD design	Sustainable Built Environments, Melbourne
PV system	Allied Solar, Melbourne
Solar hot water	Gippsland Energy Alternative, Bairnsdale