Solar energy, windpower, and careful design

Michael & Judy have power to spare

In a quiet, picturesque Victorian country setting, Michael and Judy Bos have built what is probably the first totally energy-independent house in Australia. Included under one roof (and on top of it!) is the broadest range of solar energy and energy conservation technology available. For the Bos family, there are no more power bills.

Judy Bos sat back, smiling, in the kitchen of her new home at Pearcedale, Victoria. "I'll have to turn a few extra lights on soon," she confided. "We're storing a bit too much electricity today – it's been so sunny lately, you see."

It was ironic that Judy should be working out how to use more electricity while Victoria was in the throes of a recent power strike.

As far as they know, the house that Michael and Judy Bos have built is the first totally energy independent modern home in Australia.

It operates without outside electricity, gas, water and sewerage services. Solar energy provides their electricity for lighting and all appliances, central heating, cooling and hot water. Their coke-fired kitchen stove, which soon will be converted to methane gas produced at home, assists in water heating during winter. Water for the Bos' home is collected from the aluminium clad roof. The only concession they have made to the outside world is an underground telephone line.

Eight solar cell arrays each provide 2.5A at 14.5V, with a total capacity of 20A.

An industrial chemist, Michael Bos has been experimenting with solar technology for more than 20 years. He has an Australian patent pending on a solar panel for heating swimming pools and has established his own small company to manufacture the panels.

Like most home owners, Bos was becoming concerned about rising energy costs. His previous architect-designed home in Mount Eliza was an awful waste of energy, he says. "The south facing glass windows were like having a hole in the wall, in terms of energy efficiency." Despite scepticism from solar energy experts – mainly relating to cost – Bos set about designing his energy independent home in 1977 with Melbourne architects Cocks and Carmichael.

The radical feature of the final design was not that it contained new solar technology – in fact much of the technology has been around for years – but that Bos had included the broadest possible range of existing knowledge into one complete unit, with a few improvements of his own along the way.

"We went back to first principles to design the house," he says. "First, the house was oriented on an east-west axis with the front facing the northern sun. The ratio of length to width was set at 1.5:1 in order to maximise energy gain and to minimise loss. The thermal mass of the house can therefore be used at top efficiency in heat control. Keeping these basic principles in mind it is possible to construct an energy independent house almost any way you like."

The design of the house has received world wide attention. In fact the Bos family now keeps a visitors' book that resembles a who's who of people in the solar energy field.

Locally, the design won a $500 award from the 1978 Victorian Gas and Fuel Corporation's low energy competition. Bos has received $5000 from the National Energy Research, Development and Demonstration Council and $2500 from the Victorian Solar Energy Committee. The Committee's grant will be used

The house is oriented east-west with the front facing the northern sun to maximise energy gain and minimise heat losses.

to monitor each system in the house over a two-year period to accurately determine energy output and use.

It was essential to Bos that the new house should have all of the conveniences of modern living. The electrical system is perhaps the most interesting and innovative of the many energy saving concepts in the design.

Eight photovoltaic cell arrays each supply 2.5A at 14.5V with a combined rated capacity of 20A. Interestingly the combined output can increase to as much as 30A on clear winter days. According to Bos, this occurs due to the lower angle of the winter sun and reflections from the aluminium roof. "The choice of aluminium roofing was important due to its strength (the Bos family has many visitors to its roof), lightness and its reflective capacity."

Electricity is stored in 18 lead-acid batteries. Bos plans soon to double the number which will then provide a storage capacity of 1300 amp hours, or roughly a full month's supply. The batteries are unobtrusively located behind a wall panel on the first floor.

Most appliances in the house can be run from the 12V system. Lighting is provided by 80 eight-watt fluorescent lights

Rainwater is collected from the roof for domestic use and heated by conventional flat plate solar collectors. Hot water is stored in a roof-mounted 730 litre tank.

of the type used in caravans. Bos has built a 12V refrigerator similar to a box-type freezer in appearance but with 7.5cm of insulation all around. The counter-top refrigerator uses about one-tenth the electricity of a conventional unit, he claims.

After extensive research, he is confident he has now even found a way to convert the automatic washing machine to the 12V system. Again, in answer to the sceptics, he has tracked down a 12V Japanese motor capable of carrying the high start-up load of the machine. A 240V converter will be used to provide power for the automatic controls of the washer. He is confident the machine will work – and surprise the manufacturers.

Colour television, a stereo system, and a wide range of electrical appliances are powered through the household system. Where appliances can't be purchased to run from 12V, the 240V converter is used.

All living spaces, including bedrooms, family room and living room, face north to enable maximum exposure to the sun. Eighty-five per cent of the north face ($51.5m^2$) is glass to maximise passive solar energy collection.

The carefully designed house is a demonstration of energy-independent living.

According to Bos, the traditional way of building houses, with brick on the outside and cladding inside, is like building a house "inside out". The thermal mass of a house – walls and concrete slab floor – should be used to collect and contain energy, not repel it.

The floors and walls are insulated with 60mm urea formaldehyde. The roof is clad with aluminium decking and insulated with 100mm urea formaldehyde and double sided sisalation. U valves (the measure of ability to transmit thermal energy) range from 0.54 to 0.62. In comparison, an ordinary brick veneer house can have U valves ranging upwards from a minimum of five. An air lock at the south side entrance prevents excessive heat loss.

An artificial suspended ceiling in the living room can be rolled back to permit greater internal penetration by the winter sun. Adjustable aluminium louvres built on an aluminium tubing frame and positioned outside the windows control heat penetration into the house. The house has no eaves on the north side.

Bos has been selective in the use of carpets. Most rooms have ceramic tiles on the concrete base to permit maximum heat transfer from the slab. Ducts in the concrete slab take cold air from the south side to the warmer north side near the full length windows. By reversing the air flow in the ducting system (and using small 12V fans) a cooling effect can be achieved in summer.

An unusual passive use of solar energy is the "green house" located adjacent to the living room on the north side. It contains a unique solar heated circular "plunge pool" which serves a purpose other than being great fun for the three girls of the Bos family. Its more practical application is to provide a heat sink to augment the concrete slab. Cool air is drawn into the green house from the south side of the home and returned as warm air. On a clear winter day it can contribute over 10% to the heating load.

The indoor green house is ideal for beautiful tropical plants.

The house makes extensive use of active solar energy collection techniques. Hot water is supplied by eight squares of conventional flat plate collector. Storage is in a 730 litre tank which has 15cm of insulation. The Aga coke fired kitchen stove supplements water heating in winter by up to 410 litres per day. It consumes about two tonnes of coke per year.

Methanol gas, however, ultimately will be used to fire the stove, while a methane digester is planned to replace the septic sewer system. Gas production will be boosted with the addition of sugar beet. Bos has already commenced cultivation of a trial plot of sugar beets and plans to use these also to produce ethanol to fuel the family car.

Rainwater from the roof for domestic use is stored in a concrete tank of 46,000 litres capacity. In addition to the aluminium roof, Bos has used aluminium guttering and flashings to ensure water purity.

The house contains heat form fire places in the living room and den. Of special interest, however, is the solar chimney. Designed for winter heating, the chimney is a rectangular duct coated with heat absorbing black paint. The aluminium framed chimney has an area surface of 20 square metres double glazed with polycarbonate sheeting and has 5cm of foil-covered insulation. In slopes from the front of the house to the roof at an inclination of 40 degrees. The sun heats the air inside the duct, causing it to rise. Under ideal conditions the air temperature in solar chimneys of this type can be as much as 150°C.

The rising air is controlled to pass through a heat bank built in the centre of the house. It is insulated with 5cm of urethane. The heat bank consists of 68 round aluminium tubes five metres in length and 100mm in diameter. The sealed tubes contain a total of 1100 litres of water.

The system operates when a cold air duct connecting the bottom of the solar chimney to the heat bank is opened. Small 12V fans enhance natural circulation at night when the stored heat in the aluminium tubes is transferred to the circuating air. With only a 40°C temperature rise in the solar chimney the heat bank can store 232,000 kilojoules (222,000 BTU). The system can be used for cooling in summer by reversing the system – exhausting heat from the house at night and cooling the internal air by day.

At a total cost around $90,000, Bos is using his house to demonstrate that total energy-independent living is indeed a reality. How far the cost can be reduced is now the second step.

Bos is eager to talk with design and construction experts to devise ways of reducing building costs to affordable levels. In the meantime, he is happy to continue with his experiment and new way of life.

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