This case study shows how a well planned renovation has improved year round thermal comfort, reduced energy and resource consumption and lowered waste production within a tight budget. The case study showcases the principle of 'reverse brick veneer', one of the most effective construction techniques available.

Building Type:	Addition / renovation to existing weatherboard cottage.
Climate:	Warm temperate Sydney Northern Beaches
Topics Covered	Success Level
Passive design	Good
Lifestyle modification	Very Good
Rainwater harvesting	Excellent
Waste reduction	Good
Greenhouse gas reductions	Excellent
Renewable Energy Generation	Excellent
NatHERS rating – 4 star	★★★★

In this renovation, the lounge room was relocated to the north and redesigned to take advantage of the site and climate. A new home office was located on the first floor away from the noise and fun of family life. As it would be occupied all day most days, it also had to be north-facing.

The remainder of the house remained untouched as it had been previously optimised.

The project aim was to improve year round thermal comfort of the house, reduce its energy and resource consumption and waste production. This is commonly referred to as creating a "sustainable house", although this term should be used with care as it is rarely literally true.

The major constraint was budget: maximum benefit for minimum expenditure. Much use was made of found or secondhand materials and the entire project cost around $95,000.

THE ORIGINAL HOUSE

Since its purchase in 1981, the house has been a testing ground for ideas and the subject of several on-going projects. Its rather rambling layout comprises four bedrooms, two living areas, a games room for the children and an office for the owner, who works from home.

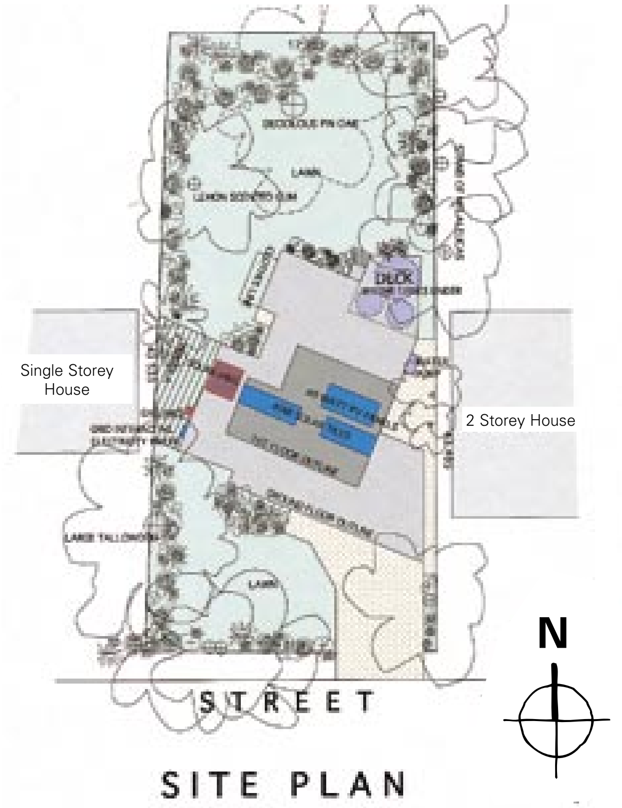
'Design for climate' was not considered by the original spec. house builder when the house was built in 1962. [See: Design for Climate]

The original lounge room was located on the south side of the house, facing the street.

The floor plan was a simple rectangle with a brick perimeter dwarf wall and footings. The timber framed structure with raised timber floor and concrete tiled roof was completely uninsulated.

SITE AND CLIMATE

The site is located on a gently rising escarpment above the northern beaches of Sydney. It slopes gently to the north east, with a stand of mature melaleucas along the eastern boundary. A large deciduous tree is immediately to the north of the house, and several medium to large eucalypts are to the west and south west. To the north east there are some ocean views.



Surrounding houses are single and two storey detached bungalows, dating from 1960 onwards. To the north is a two storey terrace and to the south a large volume single storey house with a garden studio at the rear.

The climate is mild to warm temperate. Because the site is on the north side of a spur and within 2km of the ocean, the micro-climate is milder than the Sydney average. It is well protected from cold southerly winds, suffers no frosts and receives cooling summer sea breezes.

THE AIMS OF THE RENOVATION

The main aims of the renovation were:

Transport: To provide a design office at home so the owner could cease commuting, thus reducing traffic congestion and greenhouse emissions.

Energy: To reduce energy consumption by reducing demand and producing as much or more electricity than used on site.

Water: To discontinue use of town water by collecting all water needed on site and increasing the efficiency of water use within the building.

Hot water: To use the freely available heat from the sun to generate as much of the home's hot water as possible.

Waste: To minimise construction waste from the renovation, treat all wastewater on site and release no wastes beyond the property other than a minimum amount of household garbage.

PLANNING CONTROLS

The local council has a strictly interpreted Development Control Plan, which limits building height and set-backs to appease neighbours but takes little account of solar access or sustainability. All the aims except solar hot water were subject to development consent.

GENERAL DESIGN PRINCIPLES

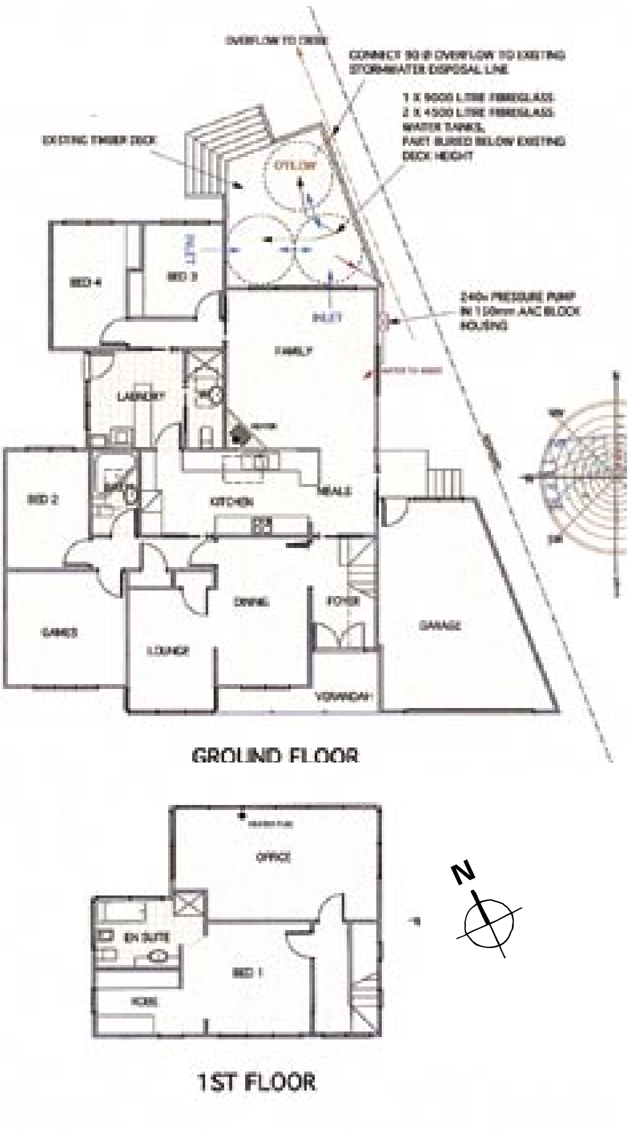
Interaction with the landscape was a critical part of the design response. An intimate relationship between external and internal spaces is encouraged by the relatively natural surroundings. This connection encourages the occupants to appreciate daily and seasonal weather changes.

Natural shading and wind protection is provided by the landscape. [See: Sustainable Landscape]

ORIENTATION

Siting the main living areas on the north side means winter sun is the primary source of heating, with summer cooling provided free of charge by the sea breeze from the north east.

Windows and doors are placed to favour this winter sun/summer breeze orientation. The building envelope achieved a 4 star NatHERS rating. [See: Orientation]



STRUCTURE AND ENVELOPE

The original house had a hardwood frame with cypress pine weatherboards and plaster linings. All subsequent extensions have repeated this but with sustainable plantation timbers used in the frame.

New cladding is cypress pine from NSW and Qld plantations. Plasterboard linings have been used in most rooms but a few also have cypress panelling.

THERMAL MASS AND INSULATION

The house is of low mass construction, which is acceptable in its climatic situation where winters are relatively mild.

The lowest night temperature is around 6°C and the lowest day temperature rarely less than 12°C and usually 16-20°C.

However, occasional summer days when there is no sea breeze show how quickly a low mass house is overcome by high temperatures.

Summers are benign, usually upper 20s with a high summer temperature of 42° on rare occasions.

These conditions make it easier for older timber buildings to achieve a satisfactory degree of thermal performance by renovation rather than demolition. [See: Thermal Mass]

Insulation has been gradually added to old walls and all new walls have had 2 layers of reflective insulation and/or bulk insulation added. The average wall insulation value is R1.5.

Ceilings have a minimum of R2.5 in the form of reflective insulation, bulk fibreglass (installed in the past) and more recently installed bulk wool. Some old sections of roofing did not have sarking fitted so additional reflective insulation has been provided.

Floors are enclosed by perimeter brick foundation walls, thus providing some control of air flow to the sub-floor. [See: Insulation Overview]

SHADING

The surrounding trees are used to advantage. There is a deciduous tree immediately to the north and to the east and west native trees such as tallow wood and melaleucas provide morning and afternoon shade. The melaleucas over the deck create a pleasant natural shade pergola.

East or west facing openings are few. The three west facing windows are partially beyond the shadow of the trees. Rolling canvas awnings have been fitted as far from the glass as possible to reduce re-radiation onto the windows. [See: Shading]

VENTILATION

Sliding doors and windows are fitted to all north facing openings. These can be opened and locked in place to varying degrees. All windows and doors have draught seals.

Cross ventilation is provided on all levels and to all rooms. The house can be left unattended in a "breathing" condition without fear of rain entering. Protection from rain is provided by awnings over openings to the east, west and south and appropriately designed eave overhangs to the north. [See: Passive Cooling]

LANDSCAPE

Permeable surfaces have been maximised to prevent stormwater runoff. The double driveway, made to satisfy council's off street parking requirements, is the only large area of paving. Other areas have pebbles with stepping slabs of timber. [See: Stormwater]

Lawn has been limited to about 60 percent of the garden area that is required for children's games. The remainder is planted predominantly with native shrubs and trees.

The garden is encouraged to hug the house for the visual and psychological benefit that this provides. Termite inspection access has been maintained and no soil is allowed within 100mm of the lowest weatherboard.

THE LOUNGE ROOM RENOVATION

The Lounge Room renovation involved several inextricably connected changes:

> Re-orienting the living areas to the north side of the house;

> Increasing the thermal mass in that living area;

> Allowing winter sun in while excluding summer heat; and

> Improving insulation to keep the thermal mass temperature-regulated.

Reverse Brick Veneer was the wall construction technique used for the renovation of the lounge room. Although its use in retro-fits is still almost unheard of, used correctly it allows buildings that would otherwise be demolished to be retained, renovated and significantly improved.

WHY REVERSE BRICK VENEER?

Reverse Brick Veneer (RBV), as the name suggests, is brick veneer turned 'inside out' with the bricks on the inside of the house. It is one of the most effective and powerful construction techniques available to us, yet it has been quite rare until recently.

The principle of Reverse Brick Veneer can be applied to almost any renovation. It provides the home-owner with a radical improvement in comfort for a modest outlay.

Thermal mass is provided by the inside brick skin. For the thermal mass to work well, RBV must be used in conjunction with good passive design principles. [See: Thermal Mass, Passive Solar Heating, Passive Cooling]

Commonly used Brick Veneer is one the supposedly great inventions of the Australian building industry. It provides some important perceived and real benefits:

✓ Low cost for a supposedly brick building

✓ Low maintenance in the long term

✓ Speed of achieving lock-up during construction

✓ Perceived solidity – "it's a brick home".

The disadvantages of brick veneer, however, are:

✗ No useful thermal mass (it's all on the outside)

✗ No real brick solidity internally

✗ Difficult to termite-proof when built as slab-on-ground

Placing the bricks on the outside where they are heated by the summer sun and cooled by freezing winter rain and wind, and then attempting to insulate the 10mm of plasterboard that separates the occupant from these extremes is a classic case of "putting the cart before the horse".

Placing the bricks on the inside, where their thermal mass is of most benefit in regulating internal temperatures, is what makes RBV work so well. External walls must be insulated to protect the thermal mass from exterior changes, just like putting a hot or cold drink in a vacuum flask.

The advantages of RBV are:

✓ Thermal mass is protected from external changes

✓ Thermal mass is inside, next to you

✓ Thermal mass regulates indoor temperatures throughout the year

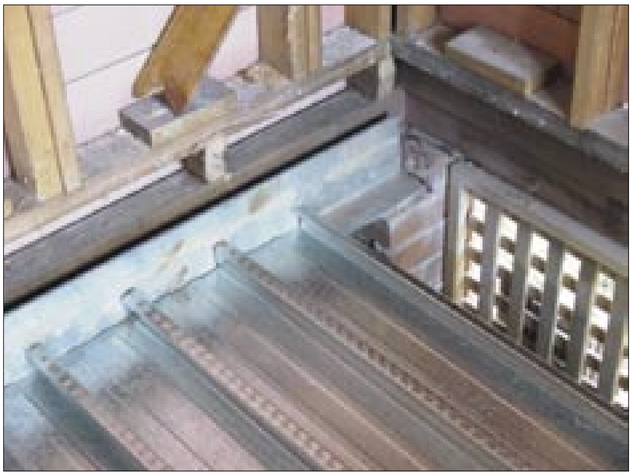
Renovations using RBV as a construction method are particularly cost effective for the following reasons:

The existing building frame can be utilised, eliminating the need for excessive demolition. The RBV can be constructed entirely within the existing building frame, including external claddings.

Existing footings can generally be utilised when using RBV. Footings and support structure will need to be appraised by a structural engineer, but this is standard practice anyway.

NEW CONCRETE FLOOR SLAB

To increase the thermal mass of the lounge room, the original timber floor was removed (and all timber re-used on or off site) and a "Bondeck" suspended slab installed in its place.



This type of slab uses the existing piers and footings, and requires no filling or excavation. The concrete is poured over prefabricated steel decking. The slab was installed lower than the original floor to gain extra ceiling height.

The subfloor was sealed and insulated to limit air movement and heat transfer, thus enabling the slab to make indirect thermal contact with the ground temperatures. If the floor is close to ground, and fill is available, it is thermally advantageous to fill the subfloor and sit the slab directly on the compacted fill. Termite barriers need to be maintained.

The slab surface was burnished (steel trowelled until it shines) and post-stained, avoiding the need for floor tiles or other finishes. Insulative finishes (such as carpet or timber parquetry) should not be used where thermal mass is to be utilised. These materials prevent the thermal mass of the slab from interacting with the room interior.

Winter sun falls directly on the floor, allowing radiant heat to be absorbed by the thermal mass of the concrete. This is then released back to the room later in the day and into the evening, long after the sun has set.

In summer the concrete floor is shaded from direct sun and keeps the occupants cool by absorbing heat. [See: Thermal Mass]

SUB-FLOOR INSULATION

The subfloor walls must be sealed and insulated to some extent when using a suspended floor, depending on the climate. In cold climates all external subfloor walls (or "dwarf walls") should have a layer of impervious insulation installed to the inside face (i.e. not exposed to the outside).

In this case, large lattice-covered openings had woven mesh garden screening applied behind the lattice to keep the external appearance unaltered, and 15mm *Foil-Board* installed inside that. This material has a core of rigid expanded polystyrene (EPS), covered on both sides with reflective foil. Openings to other parts of the subfloor were also sealed with *Foil-Board*.

Other external brick dwarf walls have not been insulated due to the mild micro-climate, but any site 5km further from the coast would demand insulation be fitted. [See: Insulation Overview, Installing Insulation]

NEW INTERNAL BRICK WALLS

Almost any bricks are suitable for RBV construction, but Austral 90mm *SlickBricks* were selected for this project because of their slender width, which consumed less floor space. Second-hand bricks are ideal if available.

No cavity is required for RBV. The brick skin is laid tight to the wall frame without a cavity, as the external cladding provides the primary moisture barrier.

Wall ties must be provided to meet the requirements of the local council and the Building Code of Australia, as in any other brick construction.

In this case, ties were limited to the top course of two of the straight walls, due to the *SlickBrick's* inherent rigidity and acceptable slenderness ratio. Other shorter and cross-connected internal walls can stand without tying to the structure.

A cement render finish with a white set plaster top-coat was used on the inside walls. As for floors, it is important to maximise the interaction of the thermal mass with the room interior, so insulative wall finishes should not be used.

The set plaster top-coat looks exactly like the existing plasterboard linings when painted, ensuring that the renovation is not out of character with the original.

The owner considers the Reverse Brick Veneer a 'winter heat investment'

When winter sun enters the room, some is reflected off the concrete floor and absorbed by the brick walls. This stored heat is re-radiated into the room later when needed, like a "warmth bank". The insulation on the outside prevents heat from escaping (unlike RBV's poor cousin, brick veneer). [See: Passive Solar Heating]

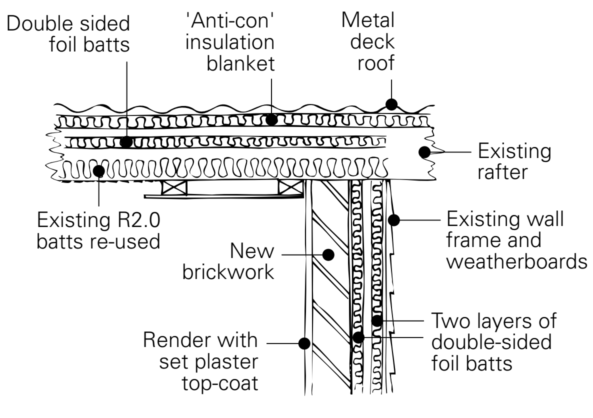
Summer heat is kept outside the building envelope, and provided that doors and windows are kept closed during periods of extreme heat, the thermal mass of the walls will act like a "cool-bank", absorbing heat and keeping the occupants cool. Stored heat dissipates in the evening, when the building is thrown open to a cool southerly breeze. [See: Thermal Mass, Passive Cooling]

WALL INSULATION

Insulation is a critical step in the process, as it protects the internal thermal mass from temperature changes outside. If there is adequate insulation already in the walls, internal wall linings do not need to be removed. In this case, no insulation had ever been fitted, so all linings were removed and insulation added throughout.

Reflective foil insulation was used, as it is well suited to a coastal climate with no winter frosts and hot summer afternoons. In cooler climates, a combination of reflective and bulk insulation would be used. [See: Insulation Overview]

Reflective insulation resists radiant heat better than bulk insulation, whereas bulk insulation is better at resisting convected and conducted heat and protecting against cold-induced condensation.



Two layers of *Foil Batts* with air gaps between each layer were installed. If the building had sarking (reflective foil laminate) in its original construction, one layer of *Foil Batts* would have been sufficient.

ROOF AND CEILING INSULATION

The roof and ceiling has R3.5 insulation installed in the form of a combination of an anti-condensation blanket under the metal roofing, double sided foil with air spaces both sides, and bulk fibreglass (re-installed from existing ceiling). It is important to get the insulation correct in roofs and ceilings, as most heat is gained and lost there. [See: Insulation Overview]

GLAZING

North-facing glass has been maximised. About 60 per cent of the north-facing wall area is glass (75 per cent including the window frame) to allow winter solar gain.

The one south-facing window is a tall narrow slot, just 400mm wide. This shape minimises the amount of glass at the top of the room (closest to the ceiling), where the warm air rises and collects. There are no west or east facing windows.

Existing north-facing windows were removed and larger openings provided. Constraints of existing ceiling heights and window head heights meant that there was as little as 200mm for a new lintel, which had to span over 3m.

Engineered timber allows these longer spans to be handled with minimal member depth. A laminated 200 x 45 mm timber beam called a *Hyne Edgebeam LGL* was used in this instance.

Double glazing has been used on all major external glass. The north-facing windows and door have double glazing with a "low e" coating to the inner glazed face of the inside sheet (facing into the air space of the double glazing).

Low e (low-emittance) coatings prevent heat from being radiated or "emitted" from one side of a pane of glass to the other. Thus, they can limit the heat entering or leaving a building. For this reason they must be used appropriately, or they may actually work against you.

In winter, the double glazing allows sun to enter deep into the room and prevents the welcome heat from escaping again. The air gap in double glazing does little to inhibit the sun's radiant heat from passing through, but provides a barrier to conducted heat losses from inside to outside. The low e coating prevents that captive heat from re-radiating out on winter nights. [See: Glazing Overview, Glazing- Temperate]

In summer, the glazing is shaded from direct sun. During long hours of intense heat, all windows and doors are kept closed and the thermal mass of the walls and floor works like a 'coolness battery' to keep the occupants comfortable. Heat dissipates from the room by opening the windows in the evening. [See: Passive Cooling]

SHADING

In this case, the seasonal shading angles provided by the existing roof overhang to the north were already near perfect, admitting winter sun to the north facing windows and excluding summer sun.

There are no east or west-facing openings in the lounge room, so the existing roof overhang on those walls has remained untouched, reducing costs.

Additional shading, if required, need not mean a new roof. Separate shading devices such as louvres or pergolas are an easy and lifestyle-enhancing alternative.

Active (moveable) shading devices enable the occupant to select how much heat is admitted on a daily basis: a cold snap in November can be treated like winter (sun admitted) and a heat wave in August can be treated like summer (sun excluded).

The shade of the surrounding trees is used to advantage. There is a deciduous tree immediately to the north, which provides copious summer shade, yet lets winter sun directly in to the lounge room. The owner opposes the planting of exotic trees, but where established and useful they are tolerated.

Native trees to the east and west such as tallow wood and melaleucas provide morning and afternoon shade. [See: Shading]

VENTILATION

The north facing windows are casements, which are side-hinged like a door. They open towards the nor'east sea breeze, effectively scooping it into the room. The windows are timber framed and all windows and doors have draught seals.

Criteria for window selection included the need for good sealing when closed, permanent flyscreening and partial opening in a locked position so the house could be left unattended but "breathing". *Stegbar AT2000* series were selected.

Cross-ventilation in the lounge room is maximised by the use of a south-facing floor-to-ceiling louvre window. Louvres allow 100 percent of the window area to be opened and have the added benefit of allowing ventilation to occur during rain.

Louvres with good seals must be used in southern climates. *Breezway Altair* louvres, which have a better seal than any other type to date, were selected. [See: Passive Cooling; Glazing Overview]

APPLIANCES AND SERVICES

HEATING AND COOLING

A high efficiency wood burning heater fitted in a brick hearth is installed in the centre of the house. This burns only waste timber, typically old hardwood fences supplied by a local fencing contractor. This ensures "greenhouse neutrality". [See: Heating & Cooling]

A hybrid solar thermal collection and storage system is planned for the near future. This will collect heat from the back of the solar panels to be stored in a heat bank for use in the evenings.

There is no artificial cooling system in the house, which has been designed to optimise natural ventilation

LIGHTING AND DAYLIGHTING

All lighting commonly used for more than five minutes at a time is either tubular fluorescent or compact fluorescent. Some fittings have been specially coloured to make the light value warmer.

Vented downlights have been replaced with non-vented fittings that accept the longer enclosed, compact fluorescents. These provide a suitably warm light, are much more efficient than low voltage halogen downlights and have a less uncomfortable effect on peripheral vision.

It should be noted that low voltage is not the same as low current – in fact 12 volt halogen lights are generally inefficient.

The wall lights in the lounge room use compact fluorescent bulbs with a "warm white" colour (2700k light temperature) and translucent glass covers. These covers allow a softer diffusion of light to the whole room.

Translucent wall light covers should be used in preference to solid covers. Solid covers only allow light to be reflected off the wall immediately above the fitting, shielding a large proportion of the light produced. [See: Lighting]

Skylights have been provided to internal bathrooms. These have operable venting built in. The dining room on the south side has a *Velux* skylight at its southern end to increase natural lighting.

Two clerestory windows are both double glazed with a 100mm sealed air space between the glass. Because hot air accumulates near the ceiling, creating a large temperature difference across the window, some heat leakage to the outside still occurs through the double glazing.

ELECTRICITY GENERATION

Three grid-interactive photovoltaic arrays provide a total of 1.76kw peak power:

Two building-integrated photovoltaic (BIPV) systems are built into the roof, and oriented with the house to 22° east of north.

A third array mounted in a tilting frame is oriented to true north, allowing for seasonal adjustments. There is provision for an extra tilting array in the future to bring the total peak power capacity up to 2.35kwp.

The photovoltaic arrays produce 110v DC that is changed to 240v AC by an inverter. The inverter, located in the first floor office for easy access, is mounted in a ventilated cupboard to reduce background noise. It has a cooling fan for periods of high load.

The inverter records the instantaneous output in amps and volts, the total productive hours, total produced for the day, running totals and the last 31 days' history. [See: Batteries & Inverters]

Energy Australia has a straightforward buy back arrangement using a "reversing" meter to measure the amounts imported and exported. The meter is electronic and records the amounts separately. The billing is easy to read and has always correlated with the owner's readings.

One common misconception is that solar electricity gives a building a stand-alone ability in case of blackouts. This is not presently the case with grid interactive systems. If the grid goes down, the inverter senses this and shuts down the PV system. This prevents power flowing back out to the grid, electrocuting an unsuspecting linesman.

Future systems will isolate from the grid without shutting down but current safety regulations prevent this.

Production figures	
Total building consumption	4367 kWh
Total production from PVs	1753 kWh
Total export to grid	774 kWh
Total import from grid	3563 kWh
Net import from grid	2789 kWh
Percentage produced on site	40.14%

(from 2000 calendar year records)

Electricity produced is available for consumption on site before any excess is sold back to the grid. The slight limiting factor affecting the production rate is the less than ideal orientation of the BIPV arrays. [See: Photovoltaic Systems]

Despite limited use of high efficiency lighting and energy saving computers, electricity consumption is substantial.

Several factors cause the high electricity consumption rates. The fridge is 30 years old and due for replacement when the kitchen is upgraded and a busy design office is operating 15 hours a day 6 days a week.

WATER

RAINWATER HARVESTING

Rainwater is collected from the roof for use in the house. Leafguards on gutters provide initial filtration and screened diverters are fitted at the inlets to each of three tanks. These trap sediment and debris and are emptied after each rainfall.

First flush devices are common in urban areas where atmospheric contaminants are high. In rural areas they are rarely necessary.

The atmosphere over Elanora is generally the cleanest in the Sydney region, as it receives fresh air from the Tasman Sea in summer and from the Richmond/Colo area northwest of Sydney in winter. For this reason, first flush devices were not used because of the volume of water they waste.

The tanks are located under the timber deck on the north side of the house and are partly buried. They are interconnected by default but can be individually isolated by remote operated valves.

Polyethylene was the material of choice for the tanks, however at the time of building no tanks were produced in the optimal sizes to maximise storage capacity.

The alternative was to compromise the embodied energy and recyclability preference and use fibreglass tanks. There is one 9000 litre tank and two 4500 litre tanks, giving an effective usable total capacity of 16,000 litres.

According to CSIRO figures, 16,000 litres would provide 80 percent certainty of supply. This has proved accurate over an 18 month period. Reserve supply is still from the mains. Future additional capacity of 4000 litres will be via an above ground tank located under the pergola.

The system is pressurised by an electric pump housed in an acoustically dampened box adjacent to the house. The box is constructed from 150mm thick AAC Hebel blocks and has a removable lid made of Ritek panel: a foam sandwich panel with two skins of corrugated colorbond steel.

An 80 micron filter is on the outlet of the pump. Initially there were three additional filters, down to 20 microns but, after much sampling and debate, these were bypassed.

Flow restrictors were fitted to every tap before fitting the rainwater system. They have since been removed due to lower operating pressures compared to mains supply. [See: Rainwater]

WATER HEATING

The hybrid system comprises an un-boosted 300 litre *Edwards* Stainless solar heater and a high efficiency 130 litre *Rheem Stellar* gas storage heater. [See: Hot Water Service]

Earlier experimentation used a Solco low pressure solar heater but it was incompatible with the pressure pump system and had to be abandoned. Others have had mixed success with these units, which are cheap to buy.

The preferred design choice was to use an instantaneous gas heater in line after the solar pre-heater but the manufacturer advised that the lower pump pressures were unsuitable.

A manually operated bypass valve allows the storage heater to be taken out of the system, thus using unboosted solar heating whenever the conditions allow; about 75 percent of the time in summer. The gas heater is left on pilot at these times and its efficiency is such that the pilot maintains a water temperature of over 50^{o}.

GREYWATER SYSTEM

Greywater is used to flush toilets and irrigate the garden. The holding tank allows a small electric pump to fill the cisterns of all three toilets in the house. Overflows run off to a drip system feeding two garden beds.

This system has reduced total household water demand by approximately 16 percent. Wastewater from the shower, handbasin and laundry is treated in this system. Kitchen and toilet wastewater proceeds separately to the local sewage treatment plant.

Treatment is via a three tank gravity-fed reed bed system, which runs into a holding tank. Each treatment tank has the infeed water entering under a galvanised mesh grid, which supports a coarse fabric with a gravel filter bed on top. Selected reeds grow in the moist top layer of this gravel, consisting mainly of Acorus gramineus 'Variegatus'.

The waste water is fed up through this matrix, overflowing at one end into the bottom of the next tank, where the same process is repeated, and again into the third tank.

A small solar powered pump recirculates about 40% of the water stored in the holding tank as a means of preventing putrification.

The system is in its initial testing phase, and if the quality of the treated water exceeds the expected standard for a 12 month period, it will be tested for use in the clothes washing machine. This would reduce demand by a total of 27 percent. [See: Wastewater Reuse]

alteration

Northern Sydney

EVALUATION

The owner/ designer has made the following comments:

Given an unlimited budget, we would do many things differently, but since that was not an option, the outcome is generally very satisfactory. Greater automation of things like the hot water would be nice, but doing it manually keeps you in touch with what the weather has been doing.

The benefits of Reverse Brick Veneer are many, and considering the relative lack of pain and expense in achieving such a startling result for the lounge room, it should become a regular option in renovations.

The walls of the first floor within the lower roof need a higher level of insulation. There is a single layer of foil with R1.5 batts behind. The batts appear useless to stop radiant heat and will have to be replaced with double sided foil, which is far more effective for this purpose.

The acoustic performance of a timber framed, brick veneer house is not as good as a masonry house and with teenagers and their music this is a concern.

PROJECT DETAILS	
Owner/Designer	Dick Clarke, Envirotecture Projects Pty Ltd
Builder	Dick Clarke, Owner/Builder
Windows & Doors	Stegbar AT 2000 Breezway Altair
Suspended slab	Lysaght Bondeck Boral Boralstone concrete
Bricks	Austral Slickbrick
Insulation	Foil Batts and Foil Board supplied & installed by Solartex
Engineered Timber	Hyne Edgebeam LGL
Water tanks	Tankworld, Dubbo NSW
Water pump	Onga JS130 & AquaPack 50 Supplied by WaterWorld, Dural NSW
Toilet flush limiters	BB Water Saver Systems
Water heaters	Edwards Stainless LX305 (pre-heater) Supplied & installed by 4 Seasons Solutions Rheem Stellar 130 litre (part time booster)
Photovoltaics	PV Solar Tiles BP 40 watt (integrated roofing) BP Solar 80 watt panels (tilting array) Supplied by PV Solar Energy, Sydney
Electricity buy-back	Energy Australia
Local Approval Authority	Pittwater Council