The case studies illustrate a range of real solutions to specific challenges faced by people wanting to design, build or buy a more sustainable home. It is important to note that none of them "get everything right".

There are few major challenges that humans are unable to overcome but building a totally sustainable home is one important goal that still eludes us.

The people whose homes are featured have designed, built and renovated in a way that reduces the impact of their home in one or more ways.

Each home has adopted an individual approach that is appropriate to the owner's chosen lifestyle, the climate and their financial position. Each has taken a step towards a sustainable future.

Each Case Study provides an insight into an application of sustainable design features. They illustrate what is possible and highlight areas of potential improvement. The Case Studies are:

TITLE	PROJECT	COST
Modifying a Project Home	New home	Low
Alteration – Wheeler	Renovation	High
Alteration – Clarke	Renovation	Low
Alteration – Melbourne	Renovation	Medium
Alteration – Sydney city	Renovation	High
Medium density – Christie Walk	Medium density	Medium
House – hot humid – Remote	New home	High
House – hot humid – Prosser	New home	Medium
House – temperate – Parker	New home	High
House – temperate – Yarra Junction	New home	Medium
House – temperate – Sydney coast	New home	High
House – temperate – Newcastle	New home	Medium
House – temperate – Southern NSW	New home	High
House – temperate – Perth hills	New home	Medium
House – cool temperate – Clematis	New home	High
House – cool temperate – Kawanda Muna	New home	Medium
House – cool temperate – ACT	New home	High
House – cool temperate – Bairnsdale	New home	High
House – cool temperate – Launceston	New home	High
Eco home – Newcastle	Renovation	Low
Hockerton Housing Project	Medium density	Medium

The Case Studies range from a low cost approach to the comprehensive integration of sustainability in design and technology.

Examine a Case Study that reflects your needs and lifestyle. Be inspired by the journey others have taken.

MODIFYING A PROJECT HOME

The Project Home Case Study shows what can be achieved by slightly modifying a stock, standard Australian project home. It is a low cost, high return example that achieves greatly increased levels of comfort, sustainability and satisfaction in exchange for some simple changes.

The home is in a cool to cold temperate climate in the NSW Southern Tablelands. The energy efficiency of the home was raised from 1 star to four stars in a NatHERS assessment. This significant improvement was achieved by re-orienting the house to north, mirror reversing the plan and relocating the garage underneath to expose more north facing glass to winter sun.

Wall insulation was added, ceiling insulation level was increased, AAA rated showerheads were fitted, a rain water tank was installed and native vegetation retained in a mulched, low water garden. Significant cut and fill on the steep slope was also avoided through the use of a suspended floor.

The owners are delighted with their new home. The small fairly inexpensive changes have created a house that is relatively cool in summer and easily heated in winter. The changes in the building's orientation and design have yielded views, breezes and the benefits of warming winter sun.

The cost of the sustainable features was $7,000 but the additional mortgage repayments are more than offset by savings in water and energy bills. The house has been valued at $25,000 more than it cost to build.

The building envelope energy performance of this home has been modelled in various configurations using the NatHERS software. The results give a clear insight into important issues affecting energy performance of the envelope. The home was also modelled in several cities in different climate zones to illustrate how performance is related to climate.

ALTERATION – WHEELER

This renovation of an old four-room worker's cottage in Sydney achieved passive solar heating and passive cooling through additions to the rear of the house.

The house has an adjustable envelope that allows the occupants to take maximum advantage of the climate and to interact with the weather.

The addition is an F plan that creates useful courtyards and maximises the length of the east-west axis increasing the north facing glass area in single depth rooms. This allows winter sun penetration and optimum summer cross ventilation.

Pre-formed metal louvres over the door systems that are set to an angle that allows deep winter sun penetration but excludes the sun totally in summer.

Rainwater from the house is collected from the rear gutters for storage in a tank for drinking and garden water only. The courtyards are finished in paving and permeable gravel. The house is conventionally powered but was fitted with 5 star rated appliances where possible.

The result is a comfortable house that interacts well with its environment.

ALTERATION – CLARKE

Dick Clark needed extra space for an office. The case study focuses on the office addition but the Clark family will continue improving their house as their budget permits. This incremental approach to making a sustainable house illustrates what can be achieved over time with a restricted budget.

The aims of the project were to:

Reduce traffic congestion and greenhouse emissions, by providing an office at home to cease commuting.

Lower energy consumption by minimising demand and producing as much or more power than is used on site.

Discontinue use of town water by collecting all water needed on site and increasing the efficiency of water use within the building.

Use the freely available heat from the sun to generate as much of the home's hot water as possible.

Treat all waste water on site and release no wastes beyond the property other than some household garbage.

Improve the year round thermal comfort of the house, reduce its energy and resource consumption and waste production.

The extension uses sustainably sourced materials, has improved the insulation levels throughout the house, reduced east and west facing glass areas and improved shading. Cross ventilation was provided on all levels and to all rooms.

Energy efficient fittings such as lights, solar hot water system and a wood heater were added.

Grid interactive solar power provides over half the family's requirements.

Rainwater is collected off the whole roof and stored in tanks.

MEDIUM DENSITY – CHRISTIE WALK

The Wirranendi Development Cooperative has built 14 dwellings on a T-shaped site the size of two quarter-acre blocks in inner-city Adelaide, South Australia. The Case Study presents elements of a communal lifestyle through expansive shared areas.

The development includes two and three storey detached cottages and three storey linked townhouses. Blocks of three storey apartment buildings are linked to the townhouses, set like bookends on their north and south ends. The appartments have no north-aspect only east-west. Solar access is controlled by shading devices. The other dwellings have ideal solar orientation. Solar access angles dictated building heights and form within the site. Solar access to the neighbouring childcare centre was protected by careful design of roof profiles.

Each purchaser owns their own dwelling but also shares ownership and responsibility for the landscaped community areas. These include a community garden, a community house with a kitchen, a laundry and a small, general-purpose hall for parties that won't fit in small apartments.

The dwellings use passive solar design, cross and stack ventilation and high thermal mass to regulate internal temperatures. Windows are all custom made from recycled timber with aluminium flyscreens. The embodied energy content of these is justified on the basis of long life, low maintenance and recyclable potential. All fixed windows are double-glazed.

Water shed by the roofs, balconies and other impervious surfaces is collected for use on site in two 20,000 litre underground tanks situated beneath the carports. After filtering, the water is used for irrigation and toilet flushing reducing total water importation to the site.

HOUSE – HOT HUMID – REMOTE

A writer required a small house that he could use as a retreat to allow time for thinking and writing. He also required that the house provide maximum comfort. Given its remote location, no services from outside the site were available.

The Case Study examines how the remote location created a need for sustainable, fully autonomous solutions. It is an example of a comprehensive and relatively capital intensive approach that yields a high level of self-sufficiency.

A ventilated roof and large eaves are used for passive cooling. The open plan nature of the house and flexibility allows the living and bedroom areas to be doubled by using the adjacent decks.

The house has sliding shutters that provide protection to a series of flyscreen and glass doors, allowing for maximum manipulation of the external envelope. Outside these is a cyclone proof shutter. The exterior of the building is lined transportable commercial aluminium sandwich panel. The interior is lined with plantation grown, hoop pine plywood.

Rainwater is directed to water tanks underneath the house. Water is sand filtered and all drinking water is reverse osmosis filtered for use in the kitchen sink.

A commercially available remote area power supply provides all the electricity. This uses a solar tracking photovoltaic array to collect electrical energy for storage in a battery bank. The house has low energy light fittings installed. Similar fittings are used inside and out to simplify maintenance.

A single composting toilet (Rotaloo) has two pans arranged back to back in the two bathrooms. Grey water from the basin, shower and sink is treated in a reed bed system before being passed into the soil.

The owner is extremely pleased with the design solutions and said that the house "worked well".

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HOUSE – HOT HUMID – PROSSER

The Prosser family wanted to *"ensure their children's health and planetary inheritance and establish a sustainable development blueprint to show others what can be achieved"*.

The house was designed by an architect and is a best practice example of sustainability in a suburban context.

The home has north orientation and appropriate shading to provide solar access in winter and solar exclusion in summer. Detached utility and storage areas buffer living areas from westerly sun and heat gain.

Breather wall insulation avoids condensation and provides two reflective air spaces for efficient insulation. Adjustable shading was designed to provide maximum available illumination and passive solar control on east and west exposures.

The pre-painted steel roof with clerestory windows is resilient, versatile, light and corrosion resistant. It is 70 percent recycled, has superior strength and collects drinking water quality rainwater. All building materials used have minimal environmental impact, low embodied energy and an excellent lifespan. They have been selected to minimise the harmful health effects of chemical outgassing.

A water flow control system reduces water use by up to 50 percent and controls the amount of hot water used, saving heating energy. The grey water treatment system allows grey water reuse and reduces the load on the council treatment plant.

The Prosser family has built a comfortable and functionally aesthetic house that has low running costs and low environmental impact.

HOUSE – TEMPERATE – PARKER

The owners wanted to create a living demonstration of passive solar design. One owner, Bill Parker, is the editor of the Australian and New Zealand Solar Energy Society's journal, entitled "Solar Progress". The house is an elegant example of energy efficiency achieved through good design.

The living area and the kitchen were faced north in accordance with principles of passive solar design. The kitchen's northerly aspect also meant that cooking odours could be exhausted naturally using the prevalent south-westerly breeze. The slope of about 1.5 metres from south to north has been exploited, allowing further solar gain through windows situated above the lower pavilion.

Electricity is generated by a 1kW array of solar panels. The house is grid connected through an inverter and excess electricity produced during the day is sold to the grid. Electricity is purchased back from the grid when required at night.

There are two major benefits of living in the home. Firstly, the house maintains an even, natural temperature throughout in winter. Secondly, the home does not consume a lot of energy and consequently has comparatively low running costs.

The owners firmly believe that, once designed in, the benefits of winter warmth from the sun can be enjoyed for the life of the house at no cost.

HOUSE – TEMPERATE – YARRA JUNCTION

This Single Storey House was designed to allow maximum winter sun penetration and total exclusion of summer sun. It has no heating or cooling and stays at approximately 17 degrees in winter and 24 degrees in summer.

The home is split into two sections, the main has three bedrooms and a study while the second section is a self-contained unit with a separate living area.

It is built out of Thermacell (polystyrene blocks filled with concrete) and all windows are double-glazed. The home is sealed to prevent air leakage and a ventilation system is used to filter and add fresh air into the home. Another benefit of the ventilation unit is that it circulates winter warmth from the northern side throughout the home.

This home achieved a five star energy rating, (49 points on the First Rate energy rating software).

HOUSE – COOL TEMPERATE – CLEMATIS

This is a four-bedroom family home on a gentle sloping site in the Dandenong Ranges on the outskirts of Melbourne. It is a luxury, professionally designed home that represents best practice in a semi rural context.

The dwelling achieves an impressive 70 points on the HERS software, using 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.

In addition to operational energy efficiency measures, the dwelling is constructed with low embodied energy materials and is designed to be autonomous in water collection and waste management.

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 high level roof windows to create a thermal stack effect and flow through ventilation.

HOUSE – COOL TEMPERATE – KAWANDA MUNA

Kawanda Muna means *"North-in-front"*, which highlights the most important part of the design.

The home is a comprehensive attempt to address sustainability through building design. It is set in the Adelaide Hills and is largely water and energy self-sufficient.

The upper, bedroom/bathroom zone is sited to the south and the open, living zone to the north.

Energy efficiency is further increased by a solar hot water system, a photovoltaic electricity generation system, an efficient Eureka slow combustion stove and AAA rated appliances.

Walls and roofs are insulated with R2.5 and R3.5 fibreglass batts respectively and double glazing has been achieved cheaply using easily applied, shrink-wrap plastic which gives insulating effect of approximately R0.4 by trapping still air between the glass and the plastic film.

Rainwater is collected and pumped by a solar pump 12m up to a tank-stand at the rear of the garage. The house runs comfortably on collected rainwater, with sufficient surplus for spa baths.

A Dowmus wet composting blackwater treatment system is used. Recycled materials were used extensively in construction to reduce embodied energy. The owners are pleased with their new home.

"The proximity of the outdoors, especially the trees, sunsets, moonrises and abundant wildlife all work to remind us pleasantly of our parts in the web of life."

ECO HOME – NEWCASTLE

The Newcastle EcoHome demonstrates how, with a little effort and a lot of conviction, householders have minimised their Ecological Footprint. The home is a low cost realization of sustainability that relies more on lifestyle changes than expensive technology.

The EcoHome uses 100 percent green power. Water is heated by solar power with a gas booster. Boosting is minimised by showering at night after a full day of sun, rather than in the morning.

The northern face of the house uses passive solar heating to warm the main living space. The need for heating and cooling is minimised with simple passive features such as the grape vine covered pergola and efficient insulation.

Indoor water use is minimised by efficient AAA rated appliances and fittings. Rainwater is directed to a small corrugated iron rain tank on the side of the house and used for garden watering.

Greywater is also diverted directly to the garden from the shower and laundry. A large volume pipe provides 200 litres of storage and feeds the leach field between two fruit trees.

The Newcastle EcoHome has reduced its Ecological Footprint by 60 percent when compared to an average Australian home.

HOCKERTON HOUSING PROJECT

Hockerton is in England. This Case Study was chosen to demonstrate that, even in a climate considerably colder than any found in Australia, homes requiring no energy from an external source can provide year round thermal comfort and a healthy environment for occupants.

The case study also demonstrates how almost every recommendation in the fact sheets has been applied in a single project built at reasonable cost.

The brief was to design and build a terrace of five earth-sheltered zero-energy houses. The five houses are built into a slight south-facing slope (towards the sun in the

northern hemisphere). The earth that was excavated for the construction of the houses was put back on the roof.

Ventilation is provided by opening windows in the external wall, glazed roof windows in the conservatory plus opening windows and glazed doors between the house and the conservatory. In addition, each house has a mechanical ventilation heat recovery system that supplies fresh air to the living rooms and bedrooms and extracts from the kitchen and bathroom areas.

The houses have no heating or cooling systems, not even plug-in heaters. The indoor temperature falls to 18^{o}C in the winter and rises to a maximum of 23^{o}C in the summer. The high thermal mass means that the temperatures remain even throughout the day, with variations of less than half a degree.

All the energy for these houses comes from a communal grid-connected wind turbine making it a zero greenhouse gas emission development.

Rainwater is the only water supply to the houses. It is collected from the glass roof of the conservatory for drinking water supply. For all other purposes water is collected from the site and pumped to a purpose-built reservoir pond above the houses.

Part of the lease that the cooperative has agreed with its members is that no household may have more than one fossil-fuelled vehicle. This is an attempt to reduce the transport emissions associated with the Project. The group shares a communal four-seater Peugeot 106 electric car. They use the car for local journeys – it has a range of about 100km.

The cost of the houses was comparable to a conventional house in the same part of the country. The clients appear to be very happy with their houses and their community.

ALTERATION – MELBOURNE

This extensive renovation of a 1930s duplex home in Melbourne incorporates the latest in solar efficient design, water collection, greywater reuse and photovoltaic grid-interactive power systems. The construction also incorporates forest friendly timber products and low toxicity finishes.

The owners, a young couple, wanted to renovate and upgrade their existing home (which was a small maze of pokey rooms) to a solar efficient two bedroom home with large living areas. Sustainable home design was a priority.

The extension was built with a suspended concrete slab for thermal mass and AAC (autoclaved, aerated concrete) blockwork external walls for their excellent fire rating and sound insulation properties. Courtyards were located to the north of the building to maximise solar gain, with an extensive area of double glazing in the roof over the dining/living area.

Maximum cross-flow ventilation was achieved with carefully positioned windows. Double glazed insulating glass units were used for all windows and glazed doors. An adjustable shading system provides flexibility for Melbourne's unpredictable autumn and spring weather. No supplementary cooling is required in summer.

The house received a four star rating using FirstRate.

HOUSE – HOT HUMID – BRISBANE

This family home in Brisbane is a good example of a low cost, energy efficient and environmentally friendly home. The clients wanted a home which looked 'conventional' but which had good environmental credentials.

The house is on a steeply sloping site in suburban Brisbane. A mostly suspended concrete slab is the platform for the house and provides thermal mass. The house is divided into a 'lightweight' section and a 'thermal mass' section. Each can be sealed off from the other. This design improves energy efficiency in very hot or cold weather and provides flexibility of use.

Use of conventional materials combined with standard yet simple construction techniques meant construction costs were low. Material costs were reduced by clever design of the internal space.

The house is oriented with the long side facing north to maximise winter sun. The eaves are wide to prevent excess heat gain in summer. Small windows combined with clerestory panels in the ceiling allow enough natutal light into the rooms.

The house achieved a five-star rating on the BERS software.

HOUSE – TEMPERATE – SYDNEY-COAST

This contemporary beachside family home in Sydney is a good example of how awareness of the surrounding environment can benefit design. The clients wanted a light-filled home that maximised views to the east from every room, and which could accommodate their changing needs.

The house is located on a gently rising escarpment with views over Manly and Sydney Harbour. Masonry walls and concrete floor slabs were chosen for their thermal qualities, and for their acoustic properties and durability.

The ideal site orientation has been exploited by maximising the amount of north-facing wall area along the long axis of the site. The orientation and shape of the plan ensure that cooling north-east breezes are channelled throughout the house.

Space cooling is achieved entirely by natural means, relying on breezes and thermal mass, while the house is warmed with passive solar heating and a central gas system.

The house functions well and the owners are very happy living here. The greatest success of this house is that it shows how good design can visibly celebrate environmental features.

HOUSE – TEMPERATE – NEWCASTLE

The NSW Government's agent for land development, wanted to build an energy efficient, environmentally friendly, inexpensive display home. The home had to appeal to the mainstream home buyer. This project home which utilises simple energy efficient design techniques and technologies is the result.

The house has large windows facing north to catch winter sun, with larger than normal eaves to block out summer sun. The thermal mass of the concrete slab on which the house is set helps to regulate the internal temperature. The louvred windows have 100% openable area, and are placed so as to maximise cross ventilation. In cooler weather, the house can be divided into separate zones and the front entrance has an air lock to prevent heat loss. Each room is fitted with efficient gas heating.

Skylights and compact fluorescent bulbs help keep lighting costs low. A solar hot water system has also been installed.

All the water that falls on the roof is caught and stored in three large tanks on site.

The home achieved a five star rating from NatHERS, and has been calculated to achieve a 32% reduction in the energy bills of an average family.

HOUSE – TEMPERATE – SOUTHERN NSW

This fully autonomous home on the New South Wales far south coast generates its own power, provides for its own heating and cooling, harvests rainwater and recycles wastewater. The owner, a renowned artist and academic, wanted a house that would accommodate his studio, as well as frequent visits from his extended family and friends.

Innovative use of materials and construction techniques has long been an interest of the owner, and he was keen to use the house as a 'test case' for prefabricated materials, to minimise on site waste and to explore passive solar design responses using low cost construction.

The design concept involves a long, thin 'string' of indoor and outdoor rooms, which all face north for maximum passive solar gain. The kitchen/living/dining area and bedrooms are grouped into separate 'mini houses' with courtyards between each.

Modular components were used in the design, fabricated offsite to minimise waste and allow speedy erection of the house. The floor throughout is a concrete slab, and the walls and roof are constructed from prefabricated panel systems. Cooling is by natural means only and the house is fitted with two composting toilets.

The house received a five star rating using First Rate.

HOUSE – COOL TEMPERATE – ACT

A Canberra family wanted to build their dream home with the highest possible environmental credentials. The architect has designed a building which sets a very high standard for autonomous, low embodied energy buildings.

A passive solar dwelling of very high thermal mass was the starting point for design. Locally made mud bricks and recycled timber were used in construction. These materials were erected on an insulated concrete slab. Extensive north facing double glazed windows, a large PV solar array with backup gas generator, and a unique biological sewage treatment plant add to the credentials of the house. A 20,000 litre tank stores all captured rainwater.

Polyester eco-batts were used in the roof and rock wool was used in the wider than standard wall cavities.

Natural organic paint was used internally and no reconstituted wood products were used anywhere in the house. As a result, there are very low levels of potentially toxic volatile organic compounds (VOCs) present.

The house achieved well in excess of a five star energy rating, with a score of 67 points. 30 points is the minimum for a five star rating.

HOUSE – TEMPERATE – BAIRNSDALE

The architect of this house strived to create a building which is part of the landscape. He spent time determining the ideal position for the 'axis mundi'. This vertical axis was the starting point for a 'spine' and 'ribs' which form the structure of the house.

The house itself is completely self contained and autonomous. It has a grid connected solar array, captures rainwater for drinking, and treats wastewater for irrigation on-site. There are two sheds (used for woodworking and as an artist's studio) and a large garage.

High thermal mass is used in the house. The floor is an insulated concrete slab and the walls are rendered concrete brick. Windows are double glazed and low–e coated. The roof is insulated with a roofing blanket and eco batts made from recycled plastic bottles to an R value of about 6.5.

The house achieved a five star rating using FirstRate.

HOUSE – COOL TEMPERATE – LAUNCESTON

This family home in north-eastern Tasmania is an example of a physically beautiful building interacting with and becoming part of the landscape in which it is set. This has been achieved with few compromises in energy efficiency.

The design is essentially passive-solar, with very high thermal mass in the floors and southern walls. The northern walls are lightweight and contain large areas of glass. They act as collectors, allowing the sun to reach the thermal mass.

The floor is an externally insulated concrete slab-on-ground finished with terracotta tiles. It is linked to the southern wall, which is made from concrete blocks and internally bagged to increase surface area and therefore heat transfer.

The form of the house allows almost all living areas to have north facing windows. The rooms without windows have skylights. Single glazing is used throughout.

All power for the house comes from hydro electricity, making for a very low emission building. Overall, this house demonstrates the compatibility of beautiful form and energy efficient functionality.

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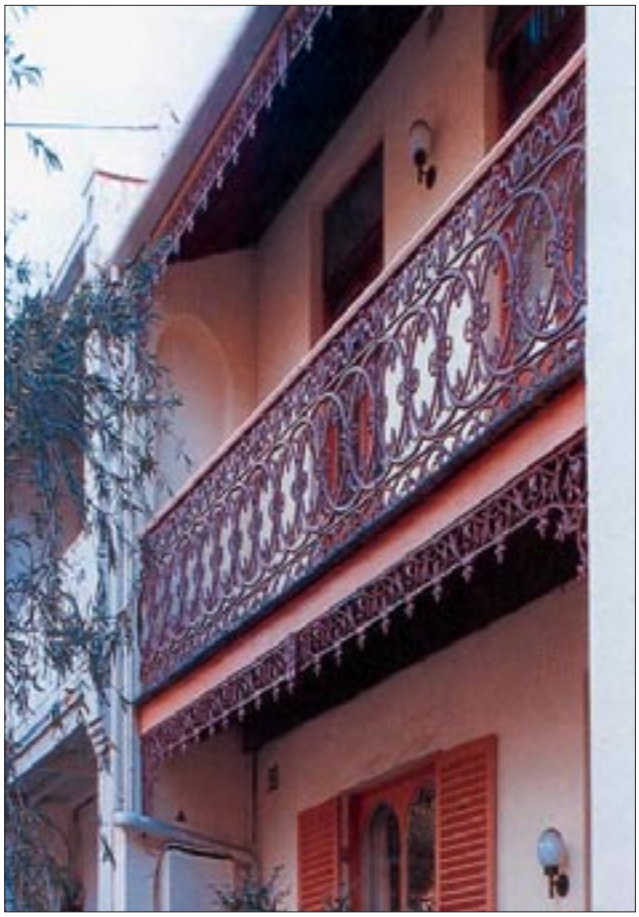
ALTERATION – TEMPERATE – INNER CITY SYDNEY



This 1996 renovation of an inner city Sydney terrace dwelling is one of Australia's best-known examples of sustainable urban living. Situated in a heritage sensitive zone, the owners' aim was to adapt the existing house to generate most of its own electricity and hot water from renewable sources, collect its own rainwater as well as recycle its wastewater, all without having to significantly change the structure of the existing building.

The result was 'The Sustainable House', a home that looks and feels like any other terrace house in the neighborhood, but with only a fraction of the environmental impact. Although the improvements to the house were made primarily by applying hi-technology design solutions, such as photovoltaic arrays and a special wastewater treatment system, the owners estimate significantly lower costs for this equipment if purchased today, given increased availability of products and technology improvements.

Highly efficient household appliances were installed throughout the house in order to reduce the energy production required by the photovoltaic system. Together with the solar hot water system, this combined to reduce household energy bills by $1400 annually without any negative impact on the householders' lifestyle or comfort.

HOUSE – TEMPERATE – PERTH HILLS

This Perth Hills home is an example of a simple and inexpensive dwelling that takes advantage of the free resources of solar energy and cooling breezes to maintain all-year round comfort with low environmental impact.

The house incorporates all the basic rules of solar passive deign, including majority north facing windows, shading for exclusion of summer sun/inclusion of winter sun as well as appropriate roof and wall insulation for the specific climate.

Faced with a sloping site, the owners were particularly concerned with protecting as much of the existing vegetation as possible, and so opted for a partially elevated concrete slab to minimise site disruption. A reverse brick-veneer construction system was adopted to increase the amount of thermal mass on the interior of the building, where it can better regulate the temperatures for greater comfort. A 'breeze trap' designed in the southwest corner of the house allows cooling breezes to move through the house on even the stillest of days.

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