House – temperate
Sydney coast

This home shows how awareness of environmental factors, when positively embraced, can have a very beneficial impact on design. It is important that designers of high-budget houses take a lead in this area and move away from reliance upon mechanical means for indoor temperature control and comfort.

Passive design techniques can provide comfort within a beautiful building envelope, as this case study shows, using materials selected for suitability and longevity. The intent is to provide the inhabitants with great pleasure as well as ensuring a long and rewarding life for the building.

BUILDING TYPE: New home, high mass construction	
CLIMATE: Warm temperate - New South Wales	
Topics covered	Success Level
Orientation	Excellent
Passive solar heating	Good
Passive cooling	Good
Indoor air quality	Very good
Daylighting	Excellent
Efficient Water Use	Good
NatHERS rating	★★★½

* See comments under 'Energy and Appliances'

The brief was to design a contemporary light-filled family home that maximised the views to the east from every room. The owners are a couple with three young boys, and interstate families who visit for several weeks at a time. Generous proportions and informal living areas connected to the outside were incorporated, to accommodate the young family as they grow and their needs change over the next generation.

SITE AND CLIMATE

The house is located on a gently rising escarpment with expansive views to the east over Manly and Sydney harbour.

The climate is mild to warm temperate, with temperatures moderated by ocean breezes. [See: Design for Climate]

The sweeping form of the house has been generated by the desire for all the living rooms to have good solar access, to make the most of the eastern views, and to channel cooling north-easterly summer breezes through the house.

The site is long and narrow (60 metres by 16 metres) with an ideal east-west orientation. It rises up from the street to a rear garden with beautiful sandstone outcrops and native vegetation. [See: Choosing a site, Orientation]

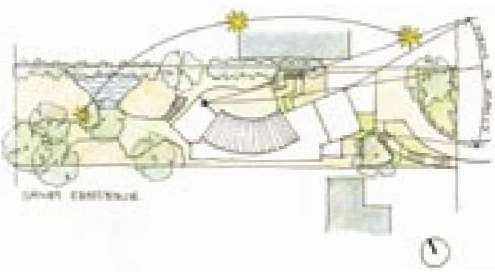
Solar access is good on the longer northern boundary. A house to the north has a small impact upon solar access to the front of the site. [See: Passive Design Introduction, Passive Solar Heating, Orientation]

Access to cooling breezes from the north-east is completely unobstructed. It was important to be able to control these breezes, as they can be overwhelming on some days. The site is sheltered from the southerly conditions by the natural form of the land and vegetation, and by the adjacent houses. [See: Passive Cooling]

The original house was badly located on the block and made little of the northern orientation, the views or the wonderful site. It was built from ugly red bricks and had been added to unsympathetically over the years. It was demolished and rebuilt so as to realise the wonderful opportunities of the site. In cases like this, recycling and re-use of demolished materials is a good way to reduce the environmental impact of a new building. [See: Waste Minimisation]

Design response

The building volumes, starting with the rectilinear volumes aligned to the street, step over and around each other up the slope to the rear section.



The plan arcs along the east-west axis, simultaneously ensuring maximum exposure to the easterly views and cooling north-easterly summer breezes, and solar access for the north-facing living areas and bedrooms. The building section and material detailing are intended to provide appropriate passive performance throughout the year. The service areas are located on the south, providing a buffer from the elements and a visual anchor to the curved volume. [See: Passive Solar Heating]

The internal planning reflects the current and future requirements of a growing family. The formal rooms are located to the front of the house making the most of the views and opening onto an elevated terrace over the garage. The family rooms are located centrally on the site, opening directly onto a courtyard that fills the space created by the arcing form of the house.

In this case study, separate formal and casual living areas were necessitated by the space requirements of the large, young family and their frequent visitors. Many home designs follow this pattern without questioning the value of the additional space. This often results in precious budget being diverted away from other sustainable features which would improve the comfort of the home without adverse impact on lifestyle.

The balance between quality and quantity of living space is now being carefully considered by many households in order to get the best performance from their home. The smaller the building, the less impact it will have upon the environment and mortgage repayments. [See: Choosing a Site; Materials Use]

Zoning in the living areas – for both thermal and acoustic purposes – is achieved by a combination of large cavity sliding doors and a hardwood framed glass pivot door.

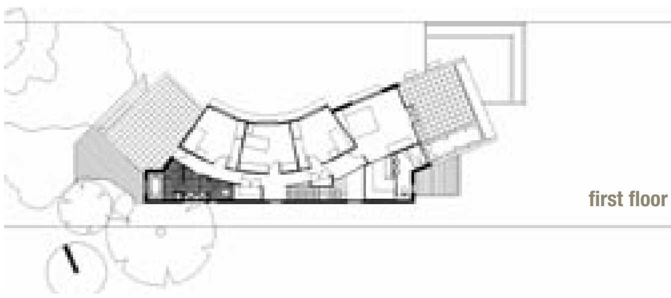
The landscaping was an important part of the brief. The house connects at all levels with the site. The living areas benefit greatly from the ease with which inside/outside living can occur. The wonderful backyard with its sandstone outcrops and native vegetation is now seamlessly connected with the house and appreciatively used.

ENVIRONMENTAL SOLUTIONS

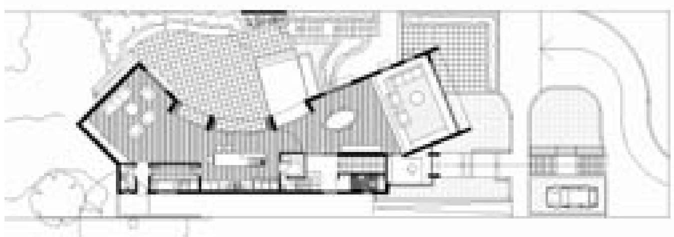
The plan, section, materials and detailing all work together in the following areas:

Orientation and views

The ideal site orientation has been exploited by maximising the amount of north-facing wall area along the long axis of the site. [See: Orientation, Passive Solar Heating]



first floor



ground floor

The plan has been designed to ensure all living areas and bedrooms are located on the north, with the service areas and stairs on the south side.

The angled and arced walls enable not only great solar access to the habitable rooms, they also provide view corridors through the centre of the house while ensuring that views from the rear sections to the east are maintained.

Ventilation

This was a key aspect of the design, and its success has enabled comfort to be achieved in the warmer months without air-conditioning, saving a considerable amount of energy. [See: Passive Cooling]

The orientation and shape of the plan ensure the cooling north-east breezes, that prevail throughout the summer, are channelled through the entire house.

Highlight louvre windows over the doors to the courtyard on the ground floor and over the corridor on the first floor can be adjusted to provide optimum airflow throughout the house whilst maintaining privacy. This is particularly important for assisting heat distribution in winter and allowing hot air to escape in summer.

Full-height sliding glass doors form the north-east walls of both the lounge room and parents' bedroom. The controlled use of these allows appropriate ingress of the breezes from this direction. Ideally these would be double glazed to prevent winter heat loss. Additionally, where ideal shading for summer conditions can't be achieved, the use of glazing with a high cooling performance would be beneficial. [See: How to use WERS (Window Energy Rating Scheme)]

Timber louvres over the doors to the children's bedrooms allow cross ventilation from their windows to the highlight windows over the adjacent corridor. The hottest air is always at the highest point in the room. Using normal height doors without louvres over them often traps it there, creating overheating in summer and cold rooms in winter.

Passive shading

The central section of the building has been designed so that the roof projects over the bedrooms, which in turn project over the kitchen/family rooms. The dimensions of these steps has been designed to allow the low winter sun deep into the rooms, while the higher summer sun is kept out. [See: Shading]

Extended steel lintels over the north-facing windows in the sandstone walls also provide solar control, but will admit some summer sun. To avoid all summer heat gain, the lintels would need to be deeper and extend further each side of the window opening. [See: Shading]

The north-east windows to the lounge room are stepped back from the face of the wall to provide some solar control as well as rain protection – especially important on hot rainy summer days.

Semi transparent blinds over windows in the living rooms can be drawn during the day to moderate the direct sun when it is unseasonably hot, without impacting too much on either the views or daylighting. Whilst these blinds have varying levels of success depending on their insulating and reflective properties (a wide range of choices are available), external shading is the single most effective measure against summer heat gain.

The only west-facing window in the house is in the upstairs bathroom. This has been included to allow a view from this room to the wonderful natural back garden.

The courtyard off the kitchen and family room is unshaded and can get hot in summer. It is planned to overcome this with a sail, which can be removed in winter and is sympathetic to the design.

Daylighting

Every room achieves a high level of natural lighting by well-positioned and suitably sized windows. This includes the upstairs corridor, which also ensures the stairs are naturally lit.

Thermal mass and structure

Masonry walls and concrete floor slabs were chosen not only for their thermal qualities but also for their acoustic properties and durability. Timber framed walls were used only to create the curved walls around the children's bedrooms. [See: Thermal Mass, Passive Solar Heating]

Concrete floor slabs were covered with battened timber flooring or carpet. Although these coverings were selected for practicality and appeal, they diminish the performance of the thermal mass of the slab because they effectively insulate it from the room interior and the diurnal temperature variations it would otherwise moderate. Ideally, in rooms with good solar access, an exposed slab with either a tiled or polished concrete finish will produce the best result thermally. [See: Passive Design]

Material selection

Longevity and suitability for the task were the dominant criteria for selection of the materials throughout the building, as this house has been designed to last a long time. These are important aspects of sustainability as materials that need constant maintenance and/or replacement are not really beneficial in the long run. [See: Materials Use Introduction]

Sandstone walls were chosen for the external skin for the living rooms and main bedroom. Not only will this material last a long time with little maintenance, it will look beautiful and connect the house to the local environment, which is full of sandstone outcrops.

Ideally, external masonry walls should be insulated on the outside to maximise the benefit of the thermal mass by isolating it from external temperature extremes. In Sydney's benign coastal climate, uninsulated thermal mass walls at minimum 300mm thickness perform quite well thermally. In more extreme climates (eg Canberra, Melbourne or inland Sydney) they become a thermal liability.

Rendered brick walls were chosen for the garage and service spine as a serviceable counter-material to the sandstone.

Timber framing was chosen for the curved bedroom walls for ease of construction and its ability to achieve good insulation values. It was also used for the roof framing to the upper floor. Plantation timber was used. [See: Biodiversity Off-site]

Glass mosaic tiles (over FC cladding) were chosen for their ability to follow the curved walls of the children's bedrooms. They also have great longevity and low maintenance characteristics. In an external application, the higher embodied energy of a tiled finish is offset by savings in maintenance energy use.

The exact saving is dependent on the life of the finish. If the tiles were considered unfashionable and replaced after 20 years, the embodied energy cost would be high. In a 50 year life span, a painted finish may require re-coating up to 10 times. In this scenario, the tiled finish would be "environmentally preferable". [See: Embodied Energy]

Zinc sheeting was chosen for the curved roof, as it is ideal for such a shape. Standard colourbond roof sheet was chosen for the remainder of the house.

Zinc sheeting has high embodied energy and other detrimental environmental effects occur during its extraction and refinement. Its use was therefore limited to areas where its specific properties were required by the design.

Powder coated aluminium windows were selected for their ability to endure the marine environment with a minimum amount of maintenance. Although the embodied energy of aluminium is generally very high, these were made in New Zealand using hydro electricity and shipped to Australia by boat. Using renewable electricity for the manufacturing process substantially reduces the embodied energy. (Transportation distance and method also have a bearing on embodied energy, but in this case the benefits of renewable energy use in manufacture far outweigh the impact of the shipping).

Insulation

Cavity insulation was initially designed to be included in the double-skinned masonry walls. Unfortunately this was omitted, as the designer was unable to demonstrate a payback period that was acceptable to the client.

Double-glazing was initially designed to be included in the windows to all living areas. Unfortunately this was omitted for similar reasons. This will lead to unwanted heat loss and increased energy bills in winter, and illustrates the need to consider design from a 'life cycle' perspective. [See: Glazing Overview]

The additional investment in an energy saving feature such as double glazing, when added to the overall mortgage repayments, is not a significant extra - yet it will start to produce savings as soon as the building is occupied, which will continue for the life of the building.

A rigid insulation system was incorporated under the concrete slab terraces to the lounge and family rooms to reduce heat loss or gain.

Polyester blanket insulation is included to all framed walls (R2.5) and ceilings (R3). [See: Insulation Overview, Insulation Installation]

Landscape

Connecting the house with the site was a key requirement of the brief. It is also fundamental in developing a keen sensibility of and respect for the environment we live in. [See: Sustainable Landscape]

The arced plan allows a generous courtyard to fit neatly into the central section of the house, with the kitchen and family rooms connecting to the courtyard through concertina doors that open up completely. This area was paved with reconstituted concrete/sandstone pavers as it is heavily used by the children for playing.

The formal lounge room and main bedroom open onto terraces facing towards the view. These have planters on the edges to provide some privacy as well as a softer visual edge.

The upper corridor, from the children's bedrooms, opens directly onto an upper terrace that then connects immediately to the rear garden.

The planted areas have an important role in absorbing stormwater on-site, which prevents excessive amounts of stormwater being discharged to waterways. Absorption of stormwater on-site could be further increased by the use of pervious paving. [See: Stormwater]

The small pool was included in the main courtyard area so that it would be easily seen and therefore used a lot. The glass pool fence not only provides the required safety in a visually minimal way; it also assists in moderating the north-east breezes in this outside area. The 'wet-edge' effect helps to provide evaporative cooling to the lower courtyard, which has less access to cooling breezes. [See: Passive Cooling]

A combination of native plants and imported species were selected for the new garden areas. The latter were chosen for visual and aromatic highlights. Plants native to the area are preferred for their role in preserving biodiversity and for their low water requirement. [see Biodiversity On-site, Outdoor Water Use]

SERVICES AND APPLIANCES

Heating and cooling systems

Space cooling is achieved entirely by natural means, relying on cooling sea breezes and thermal mass.

Space heating is achieved by passive solar heating (solar access and thermal mass), and supplemented by a central gas heating system with three separate zones. [See: Heating and Cooling]

Water heating is provided by the gas hot water service that was salvaged from the previous house. When this system is no longer useful it will be replaced by an instantaneous gas hot water heater. [See: Hot Water Service]

The swimming pool is heated by gas so that the children can swim throughout the year. Unfortunately this results in high gas consumption. One way of overcoming this in the future would be to install a solar pool heater. Solar pool heaters have an excellent payback period and save significant quantities of greenhouse gas emissions during their lifetime.

Lighting

Natural daylight levels are high in the house.

Night lighting is provided by a combination of low voltage down lights, incandescent lights, and energy efficient fluorescent lights. Dimmers have been included throughout. The home management system has also been set up to assist in efficient management of the lighting.

The current range of low voltage lighting is quite energy inefficient and downlights require ceiling penetrations that need careful detailing to avoid heat loss and draughts. More energy efficient replacement globes for these lighting systems are currently being developed in the US. [See: Lighting]

Task-specific lighting is used in the study and bedroom areas.

Energy supply and appliances

The house is connected to the electricity grid and natural gas.

The curved roof over the children's bedrooms has been designed to accommodate a PV array for on-site renewable power production. This might be included in the future. [See: Photovoltaic Systems]

New appliances are 5 star rated where appropriate. A number of existing appliances were incorporated into the house. [See: White Goods]

The house received a 3.5 star rating using NatHERS. NatHERS has some limitations in modeling the benefits of stack or convective ventilation and can over-estimate the cooling requirements for a house designed to be cooled in this manner - especially when the site is very close to the coast and exposed to reliable sea breezes.

NatHERS assumes that when the internal temperature gets to a pre-determined level, mechanical cooling will be turned on. Currently, this rarely occurs in a beachside environment in Sydney, although the rapid uptake and use of air-conditioning to achieve greater levels of comfort is of significant concern for the future. [See: Rating Tools]

Water use

3/6L dual-flush systems are incorporated into the sewer-connected WCs. AAA rated equivalent showerheads and mixers are fitted throughout. [See: Water Use Introduction]

EVALUATION

The greatest success of this house is that it shows how good design can be positively influenced by, and also visibly celebrate, environmental factors.

The house is working well and the owners are very happy living in it. The house is warm in winter and cool in summer. The design allows the family to easily enjoy the beautiful site and external environment. In addition, they are really pleased with the views available from every room.

Passive performance could have been further improved by the use of double glazing to reduce winter heat loss. This is particularly important in homes where a large amount of glazing is used. Optimum ratios of glass to building mass vary with climate and design. [See: Glazing Overview, Passive Solar Heating]

Utilising the thermal mass of concrete slabs with good solar access, by using tiled or other non-insulative finishes, would help to further stablise day/night temperatures. [See: Thermal Mass]

The use of photovoltaic panels, if incorporated in the future on the specially designed roof, will greatly reduce the environmental impact of the home. Electricity use creates up to 85% of an Australian household's greenhouse gas emissions (unless it is 'Green Power' from renewable sources). Similarly, although gas is preferable to electricity for the hot water service, use of a solar hot water service would save energy and further reduce greenhouse gas emissions. [See: Energy Use Introduction, Photovoltaic Systems, Solar Hot Water]

This case study raises an important issue about the dilemma that many designers face in trying to take a 'leadership' role towards encouraging sustainable practice. Despite the designer's sincere commitment to sustainability, the current market emphasis on 'initial investment' rather than 'life cycle cost' meant that some of the proposed sustainable features were deleted.

Other issues can be the differing expectations or priorities of clients, and the desire for sites to be developed to their full 'economic potential', which can sometimes work against the sustainable principle of 'less is more'.

There is no simple solution to these issues, but it highlights the increasing need for designers to work towards developing a high level of knowledge and skill in order to successfully promote the benefits of sustainable design.

PROJECT DETAILS	
Architect	Caroline Pidcock, Steve Loo, Natasha Marshall, Caroline Pidcock Architects
Builder	Sandlik Constructions
Landscape	Kristen Martin, Kristen Martin Landscape Architects
Engineer	Phil O'Hara, Northrop Consulting