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Prasad House

Deo Prasad

Figure 1: The rear western side of the house. The owner wanted to retain the west-facing views, so unwanted summer sun is controlled by drop-down external shading.

ABSTRACT

The design of the Prasad house renovation evolved from a fusion of the owners' commitment to green design, the needs of the occupants, and a staged experimental approach to alterations. This is not a 'cutting-edge' design, but one that balances no-cost passive solar features, low-energy appliances and the on-site generation of energy. Material reuse and recycling, and water demand minimisation, collection and reuse are part of the strategy.

Professor Prasad espouses what he calls 'practical sustainability' – aspiring for measurably zero carbon and sustainable outcomes but at an affordable pace, which differs for every case.

His house is envisaged as an ongoing experiment of thermal performance, with increasing amounts of thermal mass, insulation etc. to be added progressively to optimise performance. Energy use, temperatures and humidity are measured to provide feedback on thermal comfort.

Because of a limited project budget, the design also caters for the future addition of technologies such as photovoltaics and other solar collectors.

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PROJECT DETAILS

Client: Deo and Latika Prasad

Architects: Concept design, Lindsay Clare; project design, Deo Prasad; Design documentation, Troy Zwart

ESD Concepts: Deo Prasad

Year of Completion: 2003

Building Type: 296 square metres, two storeys, 4 bedrooms plus a study area on mezzanine. Swimming pool

Occupancy: It is a household of four people, with two adults and two children. The house is generally unoccupied between 8:30am and 6.00pm weekdays.

Award: Inaugural Randwick City Council Urban Design Award: Sustainable House

Location and Climate: The house is situated on a quiet street in a low-density eastern suburb in Sydney with a site area of 596m^2. The suburb is fully developed and in close proximity to a number of shopping areas, public transport, and the University of New South Wales (minimising travel distance to work). The site offers panoramic views of Botany Bay and the CBD towards the west and north.

Sydney has a moderate climate with an average daily maximum temperature of 25.5C in peak summer months and an average daily minimum temperature of 8.6C in peak winter months. The humidity levels are generally quite high. In winter the wind direction is predominately from the west and in summer there are prevailing easterly afternoon breezes.

Introduction

Before it was refurbished, the Prasad house had conventional patterns of resource consumption – much to the dismay of its environmentally responsible owners. In addition, the growing needs of the household meant that an overhauling of how the house functioned was required. The renovation design therefore was aimed at catering for the growing needs of the family, while at the same time capitalising on the opportunity to become a more sustainable household.

Figure 2: Main entry of the house

The existing house demonstrated conventional patterns of space utilisation, resource use and indoor air quality in a typical suburban context. The decision to refurbish was driven by the need for functional improvement and spatial changes to the house. The renovation also presented an excellent opportunity to integrate sustainability principles into the design. A key goal was to arrive at a balance between realtime resource efficiency (energy efficiency, material reuse/ recycle, water and waste efficiency), good design, appropriate land use and lifestyle choices (behavioural issues including actual energy reductions, integrated gardening, composting, waste reuse). While the house may not demonstrate cutting-edge technology it does demonstrate achievable benefits for sustainable renovation of a typical suburban site.

Design Philosophy

In contemporary green residential developments, where there is an increasing emphasis on resource consumption and indoor comfort, environmental performance cannot be gauged by isolated components. A residential building can function sustainably only when it is driven by the collective effect of all aspects of living.

Environment, architecture and lifestyle in no particular order, but a fusion of all three elements constitute the essence of the Prasad house. The house isn't meant to be a showcase for green strategies, but rather a balance between the three paradigms achieving a practical solution within a limited budget. The design employs an approach where each of these elements is addressed in a way so that the whole is greater than the sum of the parts.

Design Intentions

The decision to renovate the existing house rather than rebuild was the first step towards achieving a sustainable outcome, through reducing resource use and offsetting the numerous environmental impacts associated with producing new materials. Nonetheless, often a renovation design is governed by constraints. Therefore, intelligent design solutions were required to improve the functionality of the house. Such challenges are not uncommon, but what was notable in this case was the integrated effort of both the occupants and the architects, coupled with the owner's extensive experience in sustainability, to achieve an outcome that suited the needs of the occupants.

Sustainable Objectives

The renovation, in construction and operation, aimed to reduce resource consumption and provide a quality indoor environment. Occupants also adopted more environmentally sustainable behaviour. Throughout the project, the main goals were:

- Experimental approaches to building alterations
- Energy conservation by passive means, using onsite generation and energy efficient appliances
- Water conservation by using low water appliances, rainwater collection and greywater collection for garden irrigation
- Material selection for better indoor environment by using low off-gassing carpet and finishes
- Construction waste minimisation by reusing all of the existing material
- Household waste minimisation by recycling most of the packaging and composting kitchen waste
- Efficient operation of the house by the home's occupants

Design and Construction

In some instances an experimental approach was used for making design decisions. For example, the house demonstrates a lack of thermal mass; the idea was to monitor how the house behaves thermally and then introduce more mass to see what difference it made. In addition, once energy consumption patterns have been established, more photovoltaic panels will be added.

Figure 3: The house (with one of its occupants) seen from the front

Renovation Features

The existing house was a two-storey, four-bedroom, dual occupancy converted into a four-bedroom single occupancy. The building orientation was fixed, but the existing house was reconfigured to place key living areas to the north, bedrooms to the east and the kitchen and pantry storage and bathroom to the south.

The overall building envelope of the existing building was largely maintained. The major changes were carried out in such a way to ensure the house met lifestyle needs, passive design requirements and architectural aesthetics.

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The whole roof was redesigned with a lower pitch to suit the architectural character of the house. The roof has solar photovoltaic panels on its northern slope. To ensure good daylighting, natural ventilation and spatial character, a dormer roof that is higher than the rest of the roof was added in the middle portion. This allowed room for a small mezzanine housing a useful library/ study area that overlooks the kitchen, dining and living areas. The additional roof height also meant that a row of small windows could be positioned to enhance natural ventilation in summer.

Part of the balcony has been converted into a bay window on the west façade that looks out to the city skyline. This adds architectural character as well as increasing daylight and sunlight in winter. Bringing part of the balcony inside means that the neighbours are better protected from any potential noise. A similar bay window has been added on the east façade in the master bedroom, capturing morning sun.

The stairs on the north side have been relocated on the east side for better integration into the overall design, reducing noise to neighbours and improving the architectural presentation of the façade.

Construction waste was minimised by reusing all existing material for the envelope and interior. Demolition of any component (mainly roof) was carefully salvaged so that it could be reused or used in other projects. The roof was the only major component that was replaced, but the tiles were provided to another project for reuse and the framing was also reused for the patio structure.

All walls were retained. On the first floor walls an additional layer of cladding was fixed and painted for aesthetics and thermal performance reasons.

Restricting the design to simple forms optimised the use of materials.

Landscape and Land Management

One of the highlights of the house is its garden, which was implemented by the 'Better Homes and Gardens' team in collaboration with the Cool Community team from the Ecoliving Centre at the University of New South Wales. The garden is simple in design and incorporates native vegetation that requires low irrigation and suits the soil conditions, and a converted old cubby house that houses four chickens.

Plants and trees were selected in order to meet the household's requirement for various herbs, vegetables and fruits. Citrus and banana trees were used for shade and privacy, while mango and avocado trees were planted in the chook yard. Sandy coastal soils and full sunshine called for a combination of native grasses such as lomandra, kangaroo paw and shrubby wetringia. Santolina was planted as a low border. All these plants survive on minimal watering.

The garden integrates the existing trees in its design and also provides interesting outdoor seating for the occupants. It boasts two green waste recycling systems: a compost heap and a chook shed. All fresh fruit and vegetable scraps are fed to the chickens, with chicken waste being recycled as manure for the garden. The rest of the green waste is composted for spreading on the garden. Organic garden and eggs are a key feature of the occupants' lifestyle.

Figure 4: Drought tolerant and soil appropriate plants were selected.

Irrigation

The garden is irrigated by a 2500L rainwater tank and greywater that has been diverted from the laundry. The tank is positioned in such a way that it doesn't require an energy-consuming pump. The next stage of development includes increasing the rainwater collection capacity, and will occur after a period of monitoring.

Diverted greywater from the kitchen is also utilised for irrigating the garden after solids are filtered. This was implemented as part of the garden design and pipes have been laid. While this is legal in the municipality, recent concerns about leakage of oils and soaps has led to more careful consideration of cleaning agents, taking into account phosphorous content.

A cover is used on the swimming pool reducing evaporation, conserving heat and preventing impurities from entering the pool water. Pool heating is from solar tubular collectors that are placed on the roof.

Environmental Control Methods

Ventilation and Sun Control

All year round the house enjoys the benefits of passive solar design including solar gains, daylighting, thermal comfort control and ventilation/infiltration. This substantially reduces the heating and cooling requirements of the house and therefore its overall energy consumption.

Figure 5: Extended overhangs for effective sun shading

The house relies completely on natural ventilation, with openable windows located on opposite walls to maximise natural ventilation. The open-plan design also promotes airflow throughout the house. In summer, the double-height living area and openable windows placed up high in the wall work together to siphon out the hot air, allowing fresh air to enter from a number of cross windows. In winter, the east, north and west façades allow heat gains through the windows and ceiling fans are used to ensure the warm air is shared between the two levels of the house. No active heating is utilised at this stage. In winter, the living area enjoys sun all day long from the north western façade. The use of throw blankets in winter by the occupants also offsets the need for heating. With no cooling and heating requirements, the house uses 40 per cent less energy overall. Performance monitoring was carried out in both summer and winter to verify this.

As of July 2011, after the installation of additional Photovoltaics (total 4.1 kWp system) the household is headed towards a zero net energy performance. With increasing electricity costs now and in the future and with net metering it is anticipated that the system cost for the PV will be recouped in under six years.

Sun Shading

Sun is utilised throughout winter for direct heat gain, and throughout the year for daylighting. Patios have been added to ensure summer sun control and the roof's eaves have been designed to block out summer sun and maximise winter gains.

Caption: Mezzanine overlooking livingroom and kitchen

The owner wanted to retain the west-facing views, which included outlooks to the garden, so unwanted summer sun on the west façade was controlled by installing drop down external shading that the occupants could operate as required.

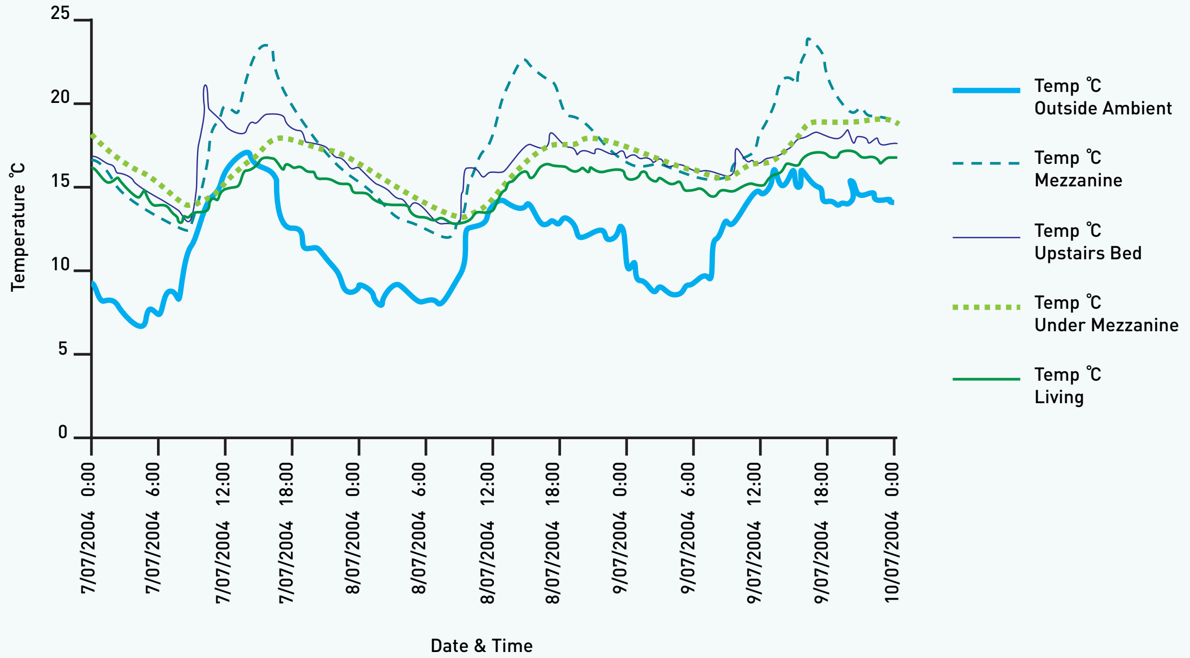

Figure 6: Temperature data for cold days

Health and Wellbeing

Low-VOC and low-static carpet were chosen to reduce dust mites and offgassing. Carpet has been used in the bedrooms and hallways, while the living rooms have recycled plantation timber floors.

Practically all enclosed spaces have been provided with an openable window and daylighting. This significantly enhances an occupant's general indoor experience and, wherever possible, distant views and a leafy green outlook have been provided for visual comfort.

Energy Management

Appliances

All appliances are energy efficient, achieving a 4 to 5 star rating. All rooms have compact fluorescent lights. The lighting design places a high emphasis on daylighting and high efficiency lamps.

A solar air space heater is being designed now for installation very soon. This follows the past six years of monitoring the climatic parameters under normal passive operation.

The pool pump has now been changed to a Viron P300 and calculations show cost savings of $900 p.a. and CO2 emission reductions of 800kg p.a.

Energy Supply System

A mix of utility grid and solar energy has been used. A photovoltaic system of 4.1 KW output has been installed on the northern slope of the roof. The generated electricity is fed to the grid.

Instant gas heaters with electronic ignition (superior to solar with electric boosters in greenhouse gas emissions; see EDG 68 MH, 'Solar Hot Water') are used for all hot water requirements.

Building Performance

A number of data loggers were installed in the house for the evaluation of indoor temperatures throughout the day during the months of March and then again in August right through to October 2004. The evaluation was carried out to understand the various features of the house and how the design is behaving overall, and to improve operations and occupant control.

Overall, the house maintains net passive solar heating, achieving typical temperature increases of up to approximately 7˚C higher in the main living areas. However, on days when the external maximum is well below the desirable comfort range (18–22˚C), most parts of the house are quite cool by conventional standards. The exception is the mezzanine, which maintains comfortably warm temperatures from midmorning to a little after sunset.

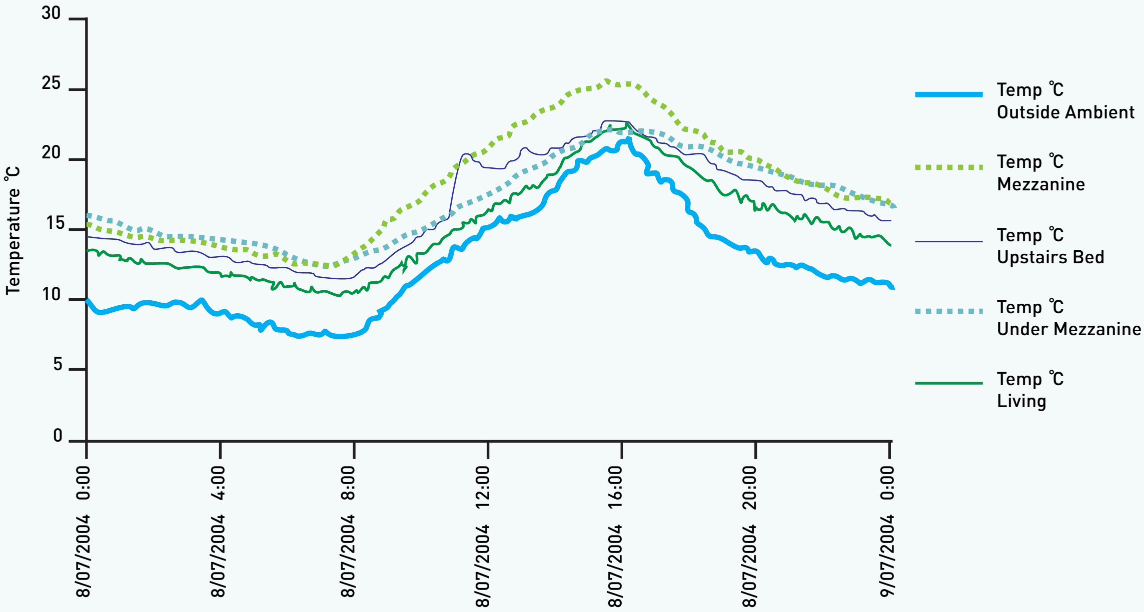

Figure 7: Stratification of temperatures

The upstairs bedroom shows the benefit of favourable window orientation, by heating up rapidly in the morning and maintaining slightly higher temperatures throughout the day. Less obvious, but quite important, is the lag between the outdoor conditions and those inside. Indoor temperatures are seen to follow approximately 3½ hours behind outdoor temperatures, with a compressed temperature swing. The consequence is that on the colder days the best conditions in the house generally begin around 4pm and are maintained until nearly midnight. This pattern fits well with the requirements of a working couple with school-age children.

Stratification

The expected strong stratification of temperatures between the general living areas and mezzanine showed clearly on most days. Figure 7 illustrates detailed monitoring, with five-minute logging intervals, for a typical clear winter's day. The mezzanine shows a direct response to solar gain shortly after sunrise, and exhibits a greater temperature elevation than the lower spaces. The temperature trace for the dining area can be seen to show the effect of two short periods of direct sun patches.

Indoor temperatures are seen to follow approximately 3½ hours behind outdoor temperatures, with a compressed temperature swing.

Overheated Period

A period of three days in October exhibited strong overheating, bracketed by more typical slightly cool days (see Figure 8). The records of this period served to clarify the role of generous ventilation in a generally lightweight dwelling in the Sydney climate. The house shows net passive solar heating on cooler days. But as soon as temperatures are anticipated to be above the comfort zone, generous ventilation is employed by the occupants. Internal conditions then more closely follow the external ambient. A small but significant time lag develops between the rate of rising external temperatures and those in the house. The mezzanine, being the space more closely coupled to ambient, peaks at a maximum temperature approximately 1.5˚C below the ambient peak, while the lower spaces topped out at approximately 5˚C below the external peak. When the cool change arrived suddenly at around 1pm, on the third day, the whole house responded rapidly to the availability of the cooling breeze.

User Behaviour Assessment

One of the key tasks in ensuring low consumption and waste was educating all the inhabitants. The two adults were committed to a sustainable lifestyle, but the two children took a month of constant reminders during the first winter period. In time they began to use throw blankets, or put on extra clothing instead of turning the heater on. In the second winter no one used any heating. The children have been given the responsibility for waste recycling/reuse, looking after the chickens and collecting eggs, and keeping lights and standby power off, which seems to have empowered them into being responsible for their actions.

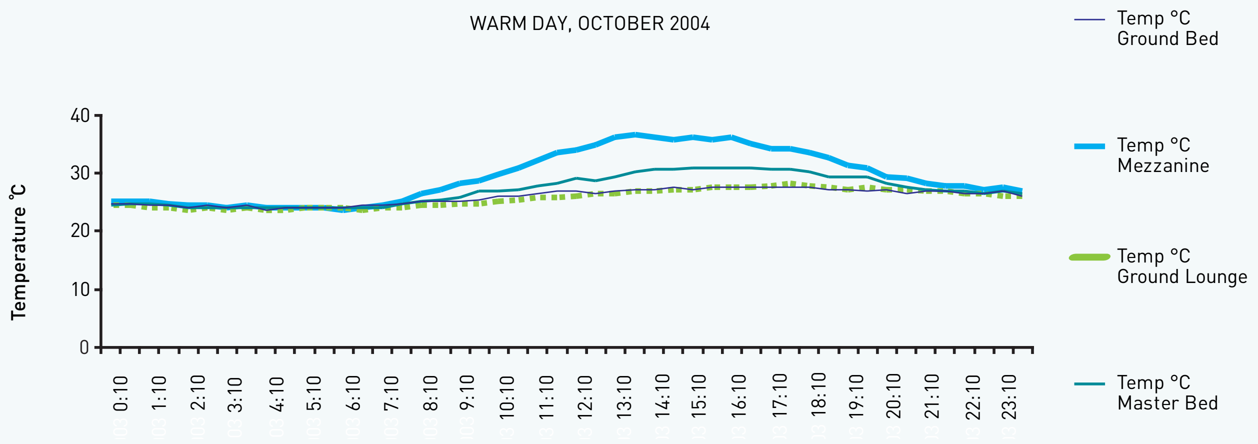

Figure 8: Temperatures for an overheated period

The Economics

Since the renovation the annual energy costs have dropped from about $A1000 to about $A400. The energy generated by the rooftop solar module is sold back to the grid. The total cost of the environmental renovation of the house is put at $A200,000, including design, construction and approval costs, but excluding landscaping, appliances and furnishings. Although it seems to be a significant capital cost, most of the cost is due to replacing old fittings and fitouts. The owner believes the ecological features have also added a commercial value of between 5 and 15 per cent to the home, but says it is difficult to verify this estimation with valuers because their training does not currently include valuing 'externalities'.[1]

Conclusion

This project started with an experimental approach evaluating changes to the house and grew into a major renovation. The owners knew that the lack of thermal mass in key areas of the house would be of concern and limit passive performance. This will be dealt with after ongoing monitoring (and budget availability). The owners also plan to introduce integrated solar space heating, additional photovoltaics, and water collection/reuse until the highest levels of practical autonomy are achieved.

1 This could be expected to change under a Residential Mandatory Scheme similar to the one operating in the ACT or being explored by COAG for national rollout at the time of writing.

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About the Author

Dr Deo Prasad, BArch, MArch, MSc, PhD, FRAIA is Director of the Centre for Sustainable Built Environment (CSBE, incorporating SOLARCH) at the University of New South Wales. He has a longstanding international reputation for research in the field of sustainable buildings and has been Director of the UNSW Centre for a Sustainable Built Environment and published in excess of 200 key publications in this area including five books.

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