Improving Water and Energy Efficiency: Case study of an 1890s cottage

Broderick Street

Abstract

For Broderick Street and his family incorporating water- and energy-efficiency into the renovation of their 1890s house in Hawthorn, an inner suburb of Melbourne, was an important goal. This has been achieved through an approach that maximises the embodied energy in the existing building, reducing demand for energy in use by optimising the performance of the existing structure, in combination with passive design strategies and appropriate use of new technology. This case study illustrates the opportunities that exist within the older building stock, affirming that heritage buildings can offer ‘liveable’ family homes that also consume fewer resources whilst retaining heritage significance, thereby providing significant environmental and social benefits.

Introduction

This paper provides practical information on water and energy efficiency achievements made possible by a heritage sensitive alteration to an 1890s dwelling. The overall approach to combining improvements with retaining heritage significance and character are of particular interest to readers, as well as strategies which demonstrate significant environmental and social benefits over the remaining life of the home.

A case study of a single-fronted brick house located in Hawthorn Victoria illustrates the outcomes from energy and water saving technologies and design elements. The house is representative of worker cottages built shortly after the sub-divided land auction in 1885. Although the dwelling had been significantly altered, it is located in an area where the heritage theme of late nineteenth century workers’ cottages is particularly well illustrated. The street was assessed as having local to regional heritage significance (Gould 1993).

Heritage policy

The local planning policies in the City of Boroondara Planning Scheme set out the heritage objectives to guide planning decisions. Two key objectives that relate to alterations to an existing house are:

- To encourage the retention and conservation of all ‘significant’ or ‘contributory’ heritage places in the Heritage Overlay
- To ensure that works, including conservation, alterations, additions and new development, respect the cultural heritage significance of the heritage place (City of Boroondara 2010).

An important requirement in heritage planning overlay areas is that a planning permit is required if rainwater tanks or solar panels are visible from a street. This does not apply to sites when viewed from a laneway or a public park. In this case study all heritage requirements were satisfactorily met with guidance from the City of Boroondara’s heritage advisor.

Urgent need to improve sustainability performance of older homes

We purchased the semi-detached cottage in Hawthorn in 1994. The narrow street frontage of 6.5 metres faced south and the rear northern orientation offered the opportunity for the placement of an extension based on passive solar principles to look over a backyard with excellent solar access. From the earliest period of ownership, we realised there was an urgent need to act to improve the energy and water performance of an old building and we recognised the community benefits in reducing greenhouse gas emissions. The majority of existing housing was built before energy efficiency was regulated. It was not until 2005 that major alterations to existing houses in Victoria required new works to achieve at least a five star energy efficiency performance rating. We were aware it is more costly to improve the energy efficiency of homes after they are built compared to building in efficiency at the planning stage.

Brief history of domestic energy consumption

Homes built up to the 1950s used little electricity compared to a house built under current building standards. A typical home contained one power point and a single ceiling light in each room. However, other forms of domestic energy use were inefficient by today’s building performance standards. The heat from a wood burning open fire place is very energy inefficient with 85 per cent of heat lost up the chimney (Energy Australia 2007).

A letter from Mrs. Osbourne to the State Electricity Commission in 1927 provides a record of how electrical appliances started to populate dwellings in the early twentieth century. Mrs. Osbourne wrote about her home at 54 Wilson Street, Moonee Ponds as part of the 1927 All-Electrical Exhibition (State Electricity Commission 1927). Her family used 0.6 kWh of electricity per day for lighting and ironing. After purchasing a vacuum cleaner and electric oven their daily electricity use doubled to almost 2 kWh per day. Today the average Melbourne home with gas uses 16 kWh of electricity each day. Standby power consumption in many Melbourne homes is equivalent to Mrs. Osbourne’s total electricity use.

Before alteration

A semi-detached house, the main building materials used in the original double brick house were Hawthorn bricks, made from the rich seams of alluvial clay available in Hawthorn (Ringer 2008), timber floors, and corrugated iron roof. All fireplaces had been removed in the 1950s. Small sections of timber adornments on windows had also been removed, and the verandah (as shown in Figure 1) was a more modern addition. The original brickwork tuck pointing was in reasonable condition and this offered scope to improve the external character of the home to reflect its historical past. At the time of purchase the original brick section of the house contained two bedrooms, a dining room,
and a small living room. Attached to the rear were a kitchenette, laundry, bathroom, and toilet that shared a common skillion roof. The walls of the rear extension were constructed in the late 1950s using bricks from the demolished fireplaces. Internal heritage features had been removed including all doors, original gas light fittings (these were found under the house during construction works), wallpaper, carpets, and plaster cornicing.

The block is 6.65 metres wide and 30.5 metres long. The land area measures 203 square metres. Electricity, gas, and mains water are connected to the home. We could only enter the laundry, bathroom, and toilet from outside the main house. The entire dwelling did not contain any ceiling, floor or wall insulation. The home lacked any north facing windows to take advantage of winter sunlight. Therefore, it was a very cold and dark house. The fixed appliances were out-dated and none contributed to the heritage values of the dwelling. The gas storage hot water heater was 26 years old. The gas oven/cook top was not efficient and dated back to the late 1960s. A Vulcan gas room heater provided winter warmth to a living room of 9 square metres. Two people in full time employment used 1,600 kWh of electricity and 26,000 MJ of gas. We used 86,000 litres of mains water for all uses including a small rear garden.

### Alteration and extension

The original dwelling was not considered suitable to raise a family and the arrangement of rear rooms all separated by thick brick walls was a wasteful use of space. As noted above the small kitchen was only large enough for one person and privacy was a concern when using the bathroom and the toilet as these could only be approached from the back yard within view of neighbours’ windows.

In 2001 permission was sought from the City of Boroondara to part demolish and extend the dwelling. The original two front rooms were retained, and the rear rooms demolished with all bricks, floorboards, and windows salvaged. Over three thousand bricks were cleaned for reuse into the new extension and the construction of a small rear brick shed, which now supports a permanent green roof vegetable garden. The retention of bricks reduced the use of primary energy in construction materials and lowered the carbon footprint of the building works.

The architect-designed extension involved a new bathroom/laundry, kitchen, living area, and a small mezzanine study. Electrical wiring, plumbing and roofing was renewed throughout the entire dwelling.

### Design sympathetic with the original building

The fundamental objective in altering the rear of the existing house was to open up the home to sunlight. A key design principle in building a passive solar living room is to store sensible heat in the inert building materials, primarily the concrete slab floor. When the concrete floor is heated its temperature rises as heat is added. This increase in temperature is called sensible heat. On the other hand heat that causes a change in state, liquid to vapour, without a rise in temperature is called latent heat (e.g. boiling water at 100° C does not change temperature).

An advantage of sensible heat storage is that the concrete and other building materials can be used both for the storage of heat in winter and the storage of ‘cold’ in summer (Giovani 1976).

Changes to the building and surroundings required considerable thought when taking on the challenge of utilising the house and shed roofs to provide energy, water, and to safely support green roofs. The first heritage consideration was how to deal with the external interaction with the public view and the second, being mindful of how the old and new architecture would blend to create an elegance of effect, rather than create a jarring of materials, proportions, colour, sound, and light.

The experience of space, including being aware of stillness and reduced external noise, could be achieved through the use of high thermally-rated ceiling and wall bulk insulation and double glazed windows. We enjoyed the benefits of a double brick house being less susceptible to sounds from the street and adjoining properties and this was an important consideration in the design of the passive solar extension.

### External design

Discussions with the architect to explore how to integrate so many new sustainability measures centred on both efficient use of space and seclusion of panels and tanks so that visitors would be unaware the house is an eight star rated energy efficient dwelling that taps into mains water only when rainwater tanks are dry. A feasibility study involved testing building footings, the selection of a site for 9 kL of rainwater storage, a solar water heater, a 1.35kW photovoltaic system (eighteen panels) and a 1 kL greywater treatment system.

The City of Boroondara heritage advisor was able to assist in various fence and verandah options. The new works also addressed the removal of heritage features in the 1950s. While
the style and colours were important to the front of the house we noted at the time that there was an absence of heritage advice on the environmental credentials of various building materials. In 2002 there were few commercially available heritage verandah posts that used recycled or sustainable timbers. In order to avoid rainforest timbers, the most common available, the builder obtained recycled ironbark and these were turned by a local wood turner to match closely the heritage advice from the Council.

As the original verandah tessellated tiles were long gone a decision to build new decking allowed the removal of soil underneath for the storage of nine 1,000 litre rainwater tanks (as shown in Figure 3). The decking was milled from Monterey Cypress, Cupressus Macrocarpa, sourced from farm wind break plantations in Victoria.

The private water supplies, rainwater, and a grey water treatment system are all hidden below ground level. To comply with the planning heritage policy the solar hot water system consisting of three panels and eighteen solar photovoltaic panels are not visible from the street. To avoid some visual impact to one neighbour from solar photovoltaic panels, mounted on frames, these were installed as close to the adjoining wall (party wall) where the existing buildings and walls created a natural visual screen.

Internal design

The original architectural features underwent considerable changes in the 1950s, including removal of fireplaces. While this might have impacted the heritage integrity of the dwelling, it created an energy efficiency gain given that there were no open chimneys that would have created heat loss in winter. For the internal design we were guided by an architect. The following points proved to be a solid approach to avoid the new extension looking out of place with the original rooms:

- New ceiling heights built to similar levels to the adjoining hallway
- The avoidance of ornate ceiling or cornicing with a preference for simple lines
- Extensive use of recycled timbers including use of salvaged Baltic floorboards into part of the new extension to match existing hallway floor. In particular the use of metals including aluminum windows was avoided, with a preference for unpainted timber double glazed windows
- Minimal use of modern down lights and installation of pendulant lights in the old hallway and new extension.

Siting of solar panels

An often controversial topic for heritage buildings is the addition of collectors and associated support frames for both solar thermal and solar photovoltaic systems. The former, which uses solar energy to store sensible heat in water, is in fact an old technology. Commercial solar water heaters were available after 1891 in California (Szokolay 1980). The first authoritative consumer guide to solar water heaters in Australia was published by the CSIRO in 1964.

A particular challenge faced in this instance was trying to accommodate a 1.35 kW photovoltaic system, with eighteen solar panels using the available roof area that offers optimal conditions for sunlight. This in itself took up the majority of the new roof addition (as shown in Figure 4). The roof over the living/kitchen area was built purposely for solar photovoltaic panels. It has a slope of 4 degrees and an area of 39 square metres. The solar radiation falling on this roof area over a year is 4.3 kWh/m²/day. An alternative west facing roof area at less than 4 kWh/m²/day was not ideal for solar PV, therefore the solar water heater was located on the west orientated roof. Poor year-round solar orientation was partly overcome by incorporating a third solar absorber plate to service a 305 litre solar hot water tank.

The achievement of high levels of energy efficiency

Heating and cooling

The original two rooms, functioning as bedrooms, contain heavy mass walls with an external double brick cavity wall which is not insulated. The ceiling is insulated, as is the original timber floor with air cell blanket insulation stapled under the floor joists. Heating these rooms in winter with artificial heating would be wasteful given the high thermal mass walls.

The front bedrooms (comprising the original portion of the dwelling) are heated over long periods by solar energy from the passive solar extension. A concrete slab covered with Marmoleum (linoleum) is exposed to winter sunlight through

Figure 3. Concealment of rainwater tanks in front verandah
(Source: author)

Figure 4. Purpose built roof with a slope of 4 degrees for eighteen solar panels (Source: author)
double glazed windows to the north. Heat is stored in the concrete floor during the day and is released as the internal room temperature falls during evenings and rises to a mezzanine study. Heat is transferred to warm the bedrooms for short periods in the evening through a heat shifter duct system operated by a manual switch.

In summer the thermal mass of the walls allows a very long lag time before the internal temperatures reach uncomfortable levels. There is an excellent thermal balance in summer from the old house thermal mass and the lighter constructed new extension. The hallway can be securely ventilated on summer nights and a thermal chimney effect through the use of high windows in the living/mezzanine rooms.

**Placement of windows**

The house performs well in hot summer periods due to the absence of west facing windows (refer to Table 1), and the use of high secure windows being left open at night to purge the house of heat stored in the concrete floor and brick walls. The original glazing was removed from the front two bedrooms and replaced with ‘Comfort plus’ thermal efficient glass. This was not a significant change to the heritage values as no routing of timber was required and there is no perceptible change in the look of the windows.

A downside of this product is the condensation on the inside of the pane and also the extra weight of the window when opening. The use of double glazing would overcome the condensation from differences between internal water vapor pressure and the external environment. Yet it is recognised that this may have an adverse impact on the heritage significance of the dwelling as the most energy efficiency air space in double glazed windows is 16 mm, which presents a totally different window construction.

**Quantification of savings**

The annual savings as a result of altering the 1890s dwelling are outlined in Table 2. Over the entire life of the alteration 535,000 litres of mains water have been saved. Greenhouse gas emissions from the stationary use of energy have been reduced by 78 per cent from 3.2 tonnes per annum (two people) to 0.7 tonnes per annum (three occupants).

<table>
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<th>Window orientation</th>
<th>Comfort plus1 (m²)</th>
<th>Double-glazed (m²)</th>
<th>Total (m²)</th>
<th>% of total glazed area</th>
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<td>0</td>
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<td>4.8</td>
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<td>28.6</td>
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Notes: 1. Pilkington Comfort Plus glass is 6.38 mm thick and has a U Value of 3.9 compared to standard 3 mm glass which has a U value of 5.9 W/m²K.

Table 1. Window area and orientation are critical to achieving excellent thermal performance

**Other benefits**

One of the key benefits of a passive solar extension onto the remaining brick rooms is the year round comfort levels. In winter the home is warmed by the sun. In summer the living room temperature rarely exceeds 30° Celsius, as noted elsewhere this is achieved in part by extensive thermal mass of the original brick rooms. A considerable cooling effect is also achieved by the original high ceilings in the hallway that permit late afternoon summer breezes throughout. The avoidance of a large roof mounted evaporative cooler or other forms of air-conditioning is therefore very achievable in Melbourne.

Improving the aesthetic qualities of the building that contribute to the heritage streetscape goes beyond the mere consideration of capital improvement of the house (as shown in Figure 5). The sustenance of health and wellbeing through building better homes is pure common sense and working with older homes is a major part of reducing our harm to the global environment.
Conclusion

The alteration of existing homes to be resource efficient and thermally comfortable year round requires considerable thought to the choice of materials, technologies, and the balancing of building and planning requirements. Tackling a house in a heritage conservation area does add to the matters for architects and designers to consider, however, our love of old homes must address greenhouse gas emissions and the wasteful use of energy and water. This case study has shown how innovative use of space and good design can achieve excellent results for heritage conservation.

References


CSIRO. 1964, Solar water heaters, Circular no.2, CSIRO Division of Mechanical Engineering, Melbourne.


State Electricity Commission. 1927, The all-electric home, SEC, Melbourne.