The Terraces and Sustainability

A Discussion Paper

Introduction

As Australia's population expands and our standard of living increases, individuals from all walks of life and government at all levels, are concerned about our impact on our fragile environment, our use of finite energy resources and the availability of water resources on the driest inhabited continent on earth.

One of the many approaches is increasing the efficiencies of our building stock, in particular housing: reducing our dependence on both energy and water resources. Recent amendments to the Building Code of Australia (BCA) reflect the higher standards required for domestic construction and individual States have established more specific umbrella legislation to ensure achievable minimum standards are met.

From July 2004, all proposed new housing and apartments in Victoria must meet the 5 Star Standard, collaboratively established between the Building Commission, Sustainable Energy Authority and the Plumbing Industry Commission. Building Authorities in other State have, or are in the process of establishing, similar standards.

The matrix of design measures used to meet these requirements can include orientation, building materials, window glazing and shading, insulation and water saving features which can be manipulated in many different ways to comply with the 5 Star Standard. The end result is a more comfortable home with reduced energy and water usage, saving both the household money on utility bills and benefiting our environment.

In Victoria, while the 5 Star legislation applies only to new residential buildings, The Terraces provides an excellent opportunity to demonstrate that many of the design and elemental features can be applied successful and cost-effectively to renovation and upgrade projects. As the number of building permits issued in Victoria each year for home renovations almost equals the number issued for new homes, each renovation presents an opportunity to improve the overall sustainability of our existing building stock.

With The Terraces, our architects have achieved excellent energy ratings – both have reached 6 Stars. This discussion paper outlines the general design principles and the innovative and creative solutions our individual architects applied.

As The Terraces are a specific residential example, this paper will also discuss options where considerations such as space, orientation, locality and household size, may vary, providing a broader level of relevance to other building and renovating situations.

Useful References

This discussion paper provides a basic summary of the design considerations and options adopted at The Terraces. Readers will benefit from referring to the following web sites for further information:

Good Residential Design Guide Your Home, (www.greenhouse.gov.au/yourhome)

Prepared for the Commonwealth of Australia by the Institute of Sustainable Communities and the University of Technology Sydney, Your Home is a suite of consumer and technical guide materials and tools developed to encourage the design, construction or renovation of homes to be comfortable, healthy and more environmentally sustainable.

Energy Smart Housing Manual *(*www.seav.vic.gov.au/buildings/housing_manual.asp)

Prepared by Sustainable Energy Authority Victoria, the *Energy smart housing manual* will enable builders, designers and home owners to maximise the energy saving potential of any property or house design.

5 Star Houses are Better Houses (www.5starhouse.vic.gov.au)

A summary of the 5 Star Standard for Victoria prepared by the Building Commission

***Your Home* – Sustainable Energy Info** (www.sustainable-energy.vic.gov.au/SEInfo/your-home/index.asp)

A web based information resource prepared by SEAV containing comprehensive information and advice on energy efficient design, appliances and simple practices that will reduce your energy bills and make your home comfortable year-round.

Residential Sustainability Measures Practice Notes
(www.buildingcommission.com.au/asset/1/upload/Residential_Sustainability_Measures_1_July_04.pdf)

To be read in conjunction with the 5 Star Standard

Residential Sustainability Measures Technical Sheet (www.buildingcommission.com.au/www/default.asp?casid=2843)

To be read in conjunction with the 5 Star Standard

Live Energy Smart, (www.energysmart.com.au)

A NSW Government Initiative containing tips and information for making your home energy smart.

Energy Smart Home *(*www.energysmarthome.com.au)

A Web Site initiative of the NSW Department of Energy, Utilities and Sustainability (DEUS)

Selecting an Appliance (www.energyrating.gov.au)

Developed by the Australian Greenhouse Office, this web site provides a full list of products regulated for energy efficiency in Australia, to assist in the choice of energy efficient appliances.

Gas appliance star ratings (www.gas.asn.au)

Australian Gas Association

Water Conservation (www.wsaa.asn.au)

Water Services Association of Australian including information on the National Water Conservation Rating and Labelling Scheme

Local Councils, water retailers and utility service providers may also have individual by-law requirements, guidelines or useful information. Refer to their web sites or contact the relevant authority directly.

Energy Efficiency Design Approach

Making full use of the preferred northerly orientation both architects have established the living areas to the rear. The terrace form, with a common boundary wall with the neighbouring property on both sides, already improves the building fabric's thermal performance, limiting the building perimeter exposed to the weather, and ensuring a limited window to floor area ratio.

However, from this point, the designs of T1 and T2 diverge.

	T1	**T2**
Orientation	The Living area is oriented towards the north on the upper floor of the building. A wide, upsweeping roof over the verandah, provides weather and sun protection in the summer months while allowing the lower angled winter sun to penetrate. A solid wall to the east and timber battened screening to the west provide additional sun shading as well as privacy The downstairs rear bedroom is shaded by the living room verandah above. The highlight west windows are protected by a deep eave.	The Living area is oriented to the north on the ground floor of the building. It is set back under the line of the first floor over. The north facing first floor bedroom windows are shaded by a wide overhanging eave The east oriented light well and the windows facing into it are protected from the summer sun by a shade and privacy screen on the boundary.

The living areas in any home are the spaces used most consistently during the day. Positioning the living areas with large windows to the north takes maximum advantage of the natural light throughout the year and the natural heat from the sun during the winter months. However, direct sun on window glazing during the summer months can quickly cause serious overheating and summer discomfort unless the windows are adequate shaded. As the summer sun follows a high arc through the sky from east to west, inexpensive fixed shading by means of eaves, pergolas, screening or adjustable external blinds or louvres can be designed as part of the building fabric, set up at the correct angles to shade the windows during the hotter months while still allowing maximum solar penetration during the cooler periods. Careful selection of plants, trees or landscape elements can achieve a similar effect.

References:

Using Passive Design – Good Residential Design Guide - *Your Home* - Consumer Guide (www.greenhouse.gov.au/yourhome/consumer/cg4.htm)

Passive Design Introduction – Good Residential Design Guide - *Your Home* - Technical Manual (www.greenhouse.gov.au/yourhome/technical/fs10.htm)

Siting and home orientation – Sustainable Energy Info (www.sustainable-energy.vic.gov.au/seinfo/your-home/Home%20building%20and%20design/Energy%20efficient%20design/siting.asp)

Better – 5 Star Houses are Better Houses (www.5starhouse.vic.gov.au/5_star_house_better.htm)

	T1	T2
Windows	Double glazed aluminium framed with weather Low emissivity glazing to western highlight Double glazed skylights	Double glazed timber framed with weather seals Double glazed skylights

The second law of thermodynamics is important – heat passes spontaneously from a hotter to a colder body.

Glazing types: Heat passes through glass in two ways;

- by conduction, ie warm air on one side heats the glass which in turn heats the air on the other (cooler) side. This can be controlled through insulation such as double glazing (2 sealed panes separated by an air gap), tight fitting blinds, heavy weave or reflective curtains with pelmets;
- radiation, ie radiant heat from the sun passes through clear glass almost unimpeded. Once the energy is absorbed inside, heating up objects and air, it is in a form that cannot pass back through the glass - the greenhouse effect. This heat can be controlled through shading – preventing the solar radiation from actually hitting the glass, or by using specially designed high performance glass with either coatings or layers that reflect solar radiation before it passes through the glass.

Choice of window frames is also important. Aluminium framing, whilst relatively maintenance free and inexpensive, is a good conductor of heat and if poorly sealed will also allow the movement of heat via air penetration. Aluminium framed windows can be readily 'improved' with the fitting of a thermal break between the glass and the frame to minimise heat loss (or gain). Performance can be improved by building the frames into timber reveals.

Timber and PVC are poor conductors of heat and therefore good insulators.

Confirm the Window Energy Rating (WER) of your selected window frame with the window manufacturer.

References:

Glazing - Good Residential Design Guide - *Your Home* – Technical Manual (www.greenhouse.gov.au/yourhome/technical/fs18a.htm)

Window Energy Rating Scheme - (www.wers.net/index.htm)

	T1	T2
Insulation	Reflective foil with 50mm layer fibre glass blanket insulation (R1.5) and R3 polyester batts in ceiling. Reflective foil and R2.5 polyester batts in walls.	Reflective foil with 50mm layer fibre glass blanket insulation (R1.5) and R2.5 [polyester batts in ceiling. Reflective foil and R2.5 polyester batts in walls. R1.6 (acoustic) insulation batts in internal walls and R3 (acoustic) between floors. Installed primarily for acoustic performance but also increases thermal performance.

Insulation products reduce the flow of heat through material. There are two main types of insulation products on the market; bulk and reflective.

Bulk insulation is manufactured from material with a low heat conductance value (metal has a high conductance value), and contains a large amount of trapped air or gas. Still air is also a poor heat conductor; heat is transferred through convection or air movement. The thermal performance of insulation is given an R rating: the higher the rating the more resistance the material has to the flow of heat. Moisture may affect some forms of insulation and a sarking (moisture barrier) is usually installed in conjunction with the insulating material to maintain its effectiveness.

Reflective insulation is a thin layer of material sheeted one or both sides with highly reflective aluminium foil. The foil reduces the radiant heat flow, reflecting the heat back towards its source, much as a mirror reflects light. In winter, where the heat is generated within, the foil reflects the heat back into the building; in summer, where the heat comes from outside the building, the heat is reflected back out.

A number of insulation products combine the features of both of the above.

Some insulation products require special personal protective clothing or equipment for installation such as gloves, respirators or masks.

References:

Insulation - Sustainable Energy Info – Your Home, Designing or Building an Energy Efficient Home (www.sustainable-energy.vic.gov.au/seinfo/your-home/Home%20building%20and%20design/Energy%20efficient%20design/insulation.asp)

Insulation - SEAV Energy Smart Housing Manual (www.seav.vic.gov.au/buildings/housing_manual.asp)

Insulation - Good Residential Design Guide - *Your Home* – Technical Manual (www.greenhouse.gov.au/yourhome/consumer/cg4b.htm)

	T1	T2
Building Fabric	Solid brickwork to the existing south wall and for part (existing) west wall with new solid blockwork along the remaining ground floor (new section) of the west and adjoining east. Block veneer to the new section of the upper west wall. Solid blockwork to the north wall with a decorative external cladding. A mix of bluestone pavers and hardwood timber flooring on battens over the concrete slab on the ground floor. Non-structural polished floorboards over particleboard sheet flooring on open web, engineered beams to the first floor. Insulated, mono-pitch metal deck roof – no roof space.	Solid brickwork to the existing south wall and for part (existing) of the east wall and new solid blockwork along the adjoining west wall. North wall and part east is light weight, insulated, timber frame construction with cement sheet cladding. Tiles on concrete slab in living areas and hardwood timber flooring on battens over the concrete slab in the lounge. Carpet and non-structural polished floorboards over particleboard sheet flooring on open web, engineered beams to the first floor. Insulated, flat metal deck roof – no roof space.

The thermal mass of a building is an important tool in climate control and comfort. In general, where there is a wide variation between the maximum daily temperature and minimum nightly temperature, more thermal mass is required. Thermal mass stores heat; absorbing it from either by conduction from its warmer surroundings or via radiant energy waves, and radiating it out as the surrounding temperature cools. A house with a high thermal mass building fabric will maintain a more even internal temperature than one with a low thermal mass. Maximum benefit can be gained by the placement of the thermal mass within the building envelope. Ideally the mass should be located where it can be directly hit by the incoming sun, and preferably in the areas that will benefit from the heat gain during the winter day such as the floor of the living room receiving sun through a north facing window.

References:

Thermal Mass - SEAV Energy Smart Housing Manual (www.seav.vic.gov.au/buildings/housing_manual.asp#chapter6)

Thermal Mass - Good Residential Design Guide - *Your Home* – Technical Manual (www.greenhouse.gov.au/yourhome/technical/fs17.htm)

Thermal Mass - Sustainable Energy Info – Your Home, Designing or Building an Energy Efficient Home (www.sustainable-energy.vic.gov.au/seinfo/your-home/Home%20building%20and%20design/Energy%20efficient%20design/materials.asp)

	T1	T2
Ventilation	The form of the building, with its sweeping raked roof draws the design, directs the naturally rising warm air out the openable highlight windows on the western and northern walls. Cross flow ventilation is achieved by drawing air through the roof space above the front bedroom to the upper level. Ceiling fans will assist in air circulation for both summer and winter.	The central light well acts as a chimney, drawing the heat from the lower level naturally via convection. During the summer months this movement will be fan assisted and the warm air drawn out of the building through a rotating air cowl. In the winter months, the outside flow will be sealed and the fan will force the warm air down, reversing the chimney effect, reducing drafts and retaining the heat. Cross flow ventilation is achieved by drawing air through the roof space above the front bedroom to circulate through the upper level. Ceiling fans will assist in air circulation for both summer and winter.

Ventilation is the deliberate movement of air, drawing in fresh outside air to replace that inside. This is not to be confused with air infiltration, which is the uncontrolled entry of air into a building through gaps around doors, windows and other unsealed openings. Air infiltration reduces one's control of the temperature of the internal environment. Ventilation assists one's control.

Ventilation is necessary to replace used air that contains odours, high levels of carbon dioxide (a natural bi-product of breathing), water vapour and contaminants. Air flow through a building, assists in reducing body temperature through evaporation of moisture (perspiration) on skin. Air flow through a building can also cool the building fabric itself during the summer.

Natural ventilation can be assisted by good design, locating openable windows and adjustable vents where they will have the optimum effect, and with the use of ceiling sweep and exhaust fans.

References:

Ventilation and air movement - Sustainable Energy Info – Your Home, Designing or Building an Energy Efficient Home (www.sustainable-energy.vic.gov.au/seinfo/your-home/Home%20building%20and%20design/Energy%20efficient%20design/ventilation.asp)

Air Movement - SEAV Energy Smart Housing Manual (www.seav.vic.gov.au/buildings/housing_manual.asp#chapter8)

	T1	T2
Energy Rating	6 Star – 20.7 points	6 Star – 31.2 points

From July 1 2004 all new Victorian homes will require, as a minimum, either:

- a 5 Star rating for the building fabric, or
- a 4 Star energy rating for the building fabric and either a solar hot water system or a rainwater tank for toilet flushing.

From July 1 2005, all new homes will require a 5 Star energy rating for the building fabric and either a solar hot water system or a rainwater tank for toilet flushing.

The 5 Star ratings must be certified by an accredited House Energy Rater

Whilst there is no limit on the efficiency of a house and the number of points it may rate, the FirstRate software at present can only register a star rating up to 6 Stars.

Other States have similar requirements. Your Architect will be able to provide appropriate advice.

References:

5 Star Standard - (www.buildingcommission.com.au/asset/1/upload/Residential_Sustainability_Measures_1_July_04.pdf)

	T1	T2
Hot water	Gas boosted hot water system; roof mounted solar panel with attached 220 litres storage/booster tank.	Gas boosted hot water system; roof mounted solar panel with attached 220 litres storage/booster tank.
	The model was selected to deliver premium performance in areas with medium high to solar radiation. The storage tank is mounted horizontally on top of the collectors, on the roof, saving much needed outdoor space at ground level. The tank is boosted by a gas burner mounted inside the storage tank.	

Solar hot water systems generally comprise a collector panel or series of collector panels, a storage tank and a booster boiler. Water flows through the panels and is heated by the natural concentrated energy of the sun. The heated water is stored in a cylinder, much as a standard gas hot water service. If the water within the cylinder falls below the preset temperature, the booster boiler activates raising the water temperature.

The booster may be integrated within the storage cylinder or a small stand alone boiler which can be more remotely located. The booster may also be an instantaneous type, heating the pre-warmed solar heated water only when the hot water is used within the house.

The current 5 Star Standard requires a gas boosted system to be installed where a reticulated gas supply is available. An electric booster is acceptable only where a reticulated gas supply is unavailable. Because an electric boosted solar hot water system produces approximately the same level of greenhouse gases as does a mains pressure gas hot water system, there is no environmental value in installing one where gas is an option.

References:

Solar Hot Water - Good Residential Design Guide - *Your Home* – Technical Manual (www.greenhouse.gov.au/yourhome/technical/fs43.htm)

Services Lighting & Appliances - SEAV Energy Smart Housing (www.seav.vic.gov.au/ftp/buildings/5starhousing/ESHousingManualCh09.pdf)

Hot Water - Sustainable Energy Info – Your Home, Designing or Building an Energy Efficient Home (www.sustainable-energy.vic.gov.au/seinfo/your-home/hot%20water/index.asp)

Guidelines for Solar Technology Installation, City of Melbourne (www.melbourne.vic.gov.au/rsrc/PDFs/EnvironmentalPrograms/solarguidelines.pdf)

Solar Hot Water Information, GreenPlumbers (www.greenplumbers.com.au/index.php?pageID=7)

Water Conservation Design Approach

Both properties have been designed using water conservation and reduction measures. Usage within the home is reduced through the use of water efficient fittings and pressure reducing valves which restrict the pressure of water from the mains. Water is collected for reuse from the roofs; a collection area of approximately half the available property area. Waste ground run off is minimised with the paving treatment of the open ground to the rear ensuring a degree of water permeability.

	T1	**T2**
Reduce:		
Fittings and Fixtures	• AAA shower head and tapware • 3 / 6 litre dual flush toilet suites	• AAA shower heads and tapware • 3 / 4.5 litre dual flush toilet suites
Water Supply	Pressure limiting valve at point of entry, limiting pressure to a maximum of 500KPa.	Pressure limiting valve at point of entry, limiting pressure to a maximum of 500KPa.
Reuse:		
Roof water	Collecting rainwater flow-off from all new roof area – approx 50m2, storing in a 1000 litre tank located on platform within roof space over front bedroom. Tank water is pumped to header tank for toilet flushing. A sensor detects when the tank has insufficient water remaining, at which point the mains supply automatically takes over. Water feature in rear garden uses and recirculates rainwater. The recirculating pump is powered by a photo-voltaic cell mounted on the roof.	Collecting rainwater flow-off all new roof area – approx 50m2, storing in a 2000 litre tank located at the rear. Tank water is pumped to header tank for toilet flushing. A sensor detects when the tank has insufficient water remaining at which point the mains supply automatically takes over. Water feature in light well uses and recirculates rainwater. The recirculating pump is powered by a photo-voltaic cell mounted on the roof.
	With an approximate catchment area of 45 m2, a two person household and typical (3/6 litre) cisterns, the rainwater collected can be expected to supply enough water to meet approximately 87% of that required for toilet flushing, given the variability of rainfall throughout the year. (During dryer summer months, supplemental mains water may be required). This represents a saving of more than 22,000 litres per year.	

Recycle:	
Grey water	Limited garden and outdoor area prevented the development of grey water or light grey water recycling systems for either property.

The 5 Star Standard requires rainwater harvesting for storage and use in toilet flushing. However, should the property be able to collect more rainwater than required for toilet flushing, or should there be another source of water available, other than from the supply mains, there are other alternatives.

- With excess rainwater collection, rainwater can also be used to supply the hot water system. This is common practice in country areas.
- An alternative source of non-potable water can be created by the appropriate treatment of grey water. This non-potable water can be used for toilet flushing, freeing the higher quality rainwater for use in the hot water system.
- Appropriately treated grey water can be used to water the garden.

To determine the most appropriate use for a particular mains water supply substitute, refer to the 'fit for purpose' table below.

'Fit for Purpose' - Compatibility of water source (and typical quality) and appropriate use

	Garden	**Kitchen**		**Laundry**		**Toilet**	**Bathroom**	
SOURCE		Cold	Hot	Cold	Hot		Cold	Hot
Potable	3	1	2	1	2	3	1	2
Wastewater								
Treated Black	1	4	4	4	4	1	4	4
Grey water	2	4	4	4	4	2	4	4
Stormwater								
Roof	2	2	1	1	1	2	2	1
Non-roof	2	4	4	4	4	2	4	4

1. Preferred Use; 2. Compatible Use 3. Non-preferred Use 4. Not Compatible

Table provided courtesy of Ecological Engineering Pty Ltd

Grey water systems can be divided into light grey water – using water from showers and hand basins and dark grey water which includes laundry waste. Black water refers to waste from toilets and kitchens. (Kitchen waste water is not recommended for reuse as it contains a high level of biological matter from cooking and food fats, oils and other food matter, requiring more intensive or additional treatment, beyond that currently practical for self contained residential properties.)

An appropriate and relatively simple light grey water treatment is to filter the waste water through a small reed wetlands. Any solid matter is filtered by the coarse bedding mix – usually a stone and gravel mix, while the root system of the plants absorb the biological matter, leaving relatively clean, treated water to be collected near the surface for storage in a small tank. Additional disinfection may be required to keep the tank and pipes clean. This treated water is pumped to a header tank to supply the toilet cistern. The tank must be flushed out every 24 hours.

Whilst the reed area required for such a system in The Terraces is only approximately 1.5 m2, with the competing demands on outdoor living space and car parking, this space was unavailable in a location that would ensure enough sunlight for healthy plant growth and effective light grey water treatment.

Caution must be taken when dealing with the reuse of grey water.

Grey Water Use Guidelines

- Untreated grey water should not be stored. Even treated grey water should not be stored for longer than 24 hours to prevent algae and bacterial growth. Any unused grey water, treated grey water or system overflow must discharge directly into the sewer system.
- As it is classed as on-site disposal, EPA approval must be sought when reusing grey water for garden use. Local Councils may also exercise controls.
- Grey water should not be allowed to discharge or seep into the storm water system.
- Grey water should not be allowed to pond or over-saturate the ground.
- Grey water should not be used to water vegetables.
- Do not allow children or pets to come into contact with it, or inappropriately protected adults for that matter. While the inherent design of sub-surface systems reduces potential health risks, additional access restriction measures should be adopted.
- Grey water should not be allowed to discharge or seep onto neighbouring properties.
- Grey water diversions should only be undertaken by licensed plumbers.
- Consultation with all relevant authorities is recommended prior to installing waste water treatment or recycling systems.

References:

Water Use - Good Residential Design Guide - *Your Home* – Technical Manual (www.greenhouse.gov.au/yourhome/technical/fs20.htm)

Savewater, Department of Agriculture & Fisheries (www.savewater.com.au)

Household Water Usage Calculator, City of Melbourne (www.melbourne.vic.gov.au/rsrc/PDFs/Water/CalculatorWaterMark.pdf)

Recycled Water Plumbing Guide, Plumbing Industry Commission (www.pic.vic.gov.au/tech_file/91.%20Recycled%20Water%20Plumbing%20Guide.pdf)

Water Conservation, Plumbing Industry Commission Technical Solutions (www.pic.vic.gov.au/tech_file/5.%20Water%20Conservation.pdf)

Guidance on Use of Rainwater Tanks, EnHealth Council (enhealth.nphp.gov.au/council/pubs/documents/rainwater_tanks.pdf)

Reused Water information, GreenPlumbers (www.greenplumbers.com.au/index.php?pageID=90)

Greywater Reuse, EPA Victoria (www.epa.vic.gov.au/water/programs/reuse.asp)

Domestic Wastewater Management Series, Reuse Options for Household Wastewater – EPA Information Bulletin, Publication 812 (epanote2.epa.vic.gov.au/EPA/Publications.nsf/d85500a0d7f5f07b4a2565d1002268f3/7a4f9f7400a82b43ca256af600140478/$FILE/812.pdf)

The City of Melbourne is currently developing a number of information sheets and guidelines on water conservation. These will be accessible in the near future through the Environment and Waste, Environmental Programs menu.