

# **2004 Healthy House Project**

## **Energy Efficiency – Sustainability – Indoor Air Quality**

### **Building Specifications**

The **2004 Healthy House Project** involves a significant renovation and extension to a 100 year old weatherboard cottage (114 sq. metres). The project is located in Woodend, Victoria (Macedon Ranges), approximately 75kms northwest of Melbourne. This region is classified as a cool temperate climate with warm to hot summers and cool to cold winters with occasional snow falls.

#### **Style**

Two storey, 3 bedroom, Victorian style, weatherboard on raised timber floors.

#### **Dimensions**

- Existing weatherboard home – 114.91 square metres with 3 metre ceilings.
- Completed renovation/extension – 177.3 square metres with 3 metre ceilings. 2.4 metre ceilings on first floor.

### **Energy Efficiency Measures**

***The building design has achieved a high 5 Star energy efficiency rating through the Sustainable Energy Authority Victoria's FirstRate program.***

#### **Building Insulation**

In order to minimise heat loss and gain throughout the year, the building envelope will be insulated to a very high level greater than the Victorian minimum insulation regulations.

- **Ceilings** - R 4.0 – combination of R3.5 polyester batts and foils plus foil sisalation under the 'Colorbond' Roof.
- **Walls** - R 2.2 – combination of R2.0 wool-blend wall batts and 'Tyvek' housewrap.

The insulation of the exterior walls will be further enhanced by the use of a high-tech 'house-wrap' known as 'Tyvek' - a weather barrier that 'breathes' to prevent moisture being trapped within wall cavities. Trapped moisture within walls can lead to mould growth within exterior walls, which can be a detriment to the structure and a health hazard to the occupants.

Extra attention will be given to insulating those areas of the external walls, which are not accessible after framing and are not normally insulated, eg. external wall corners and where internal walls meet external walls.

- **Floors** – R1.5 – R1.5 fibreglass 'Pink Batts' recovered from parts of the existing structure will be recycled for underfloor insulation. The batts will be supported in place with wire mesh.

## Air Leakage

An air-tight building envelope is integral to achieving maximum insulation performance as well as a healthy indoor environment. Uncontrolled air leakage (draughts) is responsible for at least a 15% increase in winter heat loss and summer heat gain. Also unwanted dust, pollen and other outdoor pollutants can enter to increase indoor air pollution.

Great care will be taken to ensure that the building envelope is properly sealed in order for it to be effective. All electrical and plumbing penetrations through external walls, ceilings and floor will be sealed off using purpose-made materials such as a low-expansion foam and electrical powerpoint 'shrouds'.

The natural leakage rate for an average home in Victoria is 1.49 air changes per hour natural (achnat) (SEAV 1992). To be considered energy efficient, a building should have a natural leakage rate of 1.0 achnat or less. The natural air leakage of the existing building was determined using a "Blower Door" depressurisation test. The result was natural leakage rate of 1.32 achnat. It is expected that the 2004 Healthy House achieve a natural leakage rate of between 0.4 and 0.5 achnat using the same testing procedure.

## Windows

Windows are thermally and, often acoustically, the weakest point in the building envelope. The increasing amount of glazing and poor positioning in new housing creates a significant reduction in comfort and energy efficiency. This in turn increases the need for heating and cooling.

The total glazed area of the 2004 Healthy Home will be less than 30% of the total floor area, which is within the recommended energy efficiency ratio of glass to floor area.

High quality, uPVC low-conductivity framed, double-glazed windows will be incorporated throughout the house. These windows will also incorporate weather seals to reduce air leakage. The thermal efficiency and outside noise reduction provided by these windows will increase comfort, energy savings and use of space which will easily offset their initial higher cost.

Following installation, all window frames will be sealed around their perimeters to minimise air and heat transfer. Sealing methods include the use of an expandable foam material inserted between window frames and exterior wall framing, caulking compounds and sponge rubber seals.

**Shading of windows** will be provided by verandahs shading of all the ground floor windows as well as external vertical blinds for east and west facing windows. The 1.8 metre wide verandah covering on the north-side will be made up of properly sized clear polycarbonate sheeting over all north windows to allow in adequate winter sun.

East and west-facing windows will also be shaded with adjustable external blinds and verandah coverings over south-facing windows will be composed of clear polycarbonate sheeting to maximise light to adjacent rooms. External blinds will also be utilised to protect all the north and east facing windows on the first floor.

## External Doors

All external doors will be fully weather sealed and draught proofed to minimise air infiltration and exfiltration (draughts).

The main front door will be isolated from the main living area and the main rear entrance will be via the laundry, which will create an air lock between this rear entrance and the main living area.

## Ventilation

### Natural Ventilation

The positioning of doors and windows for effective and efficient **natural cross-flow ventilation** is incorporated into the building design. The style of windows used (double-hung and slider type) will also add to the natural air flow to cool and/or refresh the home when outdoor conditions are suitable.

The stairwell to the first floor master bedroom will also allow for the use of controlled '**stack effect**' ventilation - warm air rises naturally up the stairwell and exits via windows and doors.

### Mechanical Ventilation

Mechanical ventilation in Australian homes is, typically, limited to exhaust-only systems (kitchen range hood, bathroom and laundry exhaust fans). This form of mechanical ventilation has its place but does impact negatively on energy efficiency, comfort and air quality if used frequently.

A relatively new mechanical ventilation technology now available in Australia will be employed in this project. A form of balanced mechanical ventilation known as **Energy Recovery Ventilation (ERV)** will be incorporated into the building along with standard kitchen range hood and bathroom exhausts (with backflow dampers). The ERV system will continuously exhaust the stale, polluted air from kitchen and bathrooms while bringing in 'fresh', filtered air into living and sleeping areas. While ventilation is taking place the system is able to recover up to 80% of the heat from the exhausted air in winter and a similar amount of cool in summer through the use of **state-of-the-art energy transfer technology**. All the air in the building is turned over every three hours (0.35 ach). This rate of air exchange is sufficient to maintain healthy indoor air quality while enhancing the energy efficiency of the building. The use of this type of system reduces the need to open windows when either weather conditions, outdoor noise and air pollution or security make it problematic or impractical.

Buildings will often experience negative pressure episodes where the air pressure within the building falls below the outdoor air pressure. This can occur during windy periods, when there is a temperature difference between indoors and outdoors and when exhaust fans are in use. During these periods the building's envelope is stressed and outdoor air forces its way into the building (draughts) which impacts on energy efficiency, air quality and comfort. Balanced mechanical Ventilation overcomes this problem by maintaining either a neutral or positive pressure plane within the building.

## Heating and Cooling

**Heating and cooling accounts for at least 50% of the energy use within a typical home in Victoria.**

### Space Heating

The heating requirements of the Woodend Healthy House will be very low and are estimated to be no more than 40 watts per square metre (a detailed heating and cooling load analysis to be conducted). This is at least 60% lower than an average home in Victoria. An existing high efficiency, slow combustion heater located centrally within the building will be maintained to provide comfortable temperatures throughout during cooler periods. As well as providing continuous ventilation, the ERV system can be used to move temperature around the building while filtering the air.

### Space Cooling

Due to poor building design and growing consumer demand, active cooling of homes has increased dramatically in Australia over the last few years. This phenomenon has led to the largest use of energy in Victoria in a single day occurring during a very hot day (41 degrees Celsius - Melbourne) in December 2003.

**No active cooling of the 2004 Healthy House** is planned due to:

- The high thermal resistance (insulation) of the building's envelope (windows, walls, ceiling and floor);
- Thermal Mass capacity to assist in heat regulation within the building;
- Adequate sealing of the building envelope to reduce draughts;
- Zoning of areas which significantly reduces the movement of warm air into the building and between zones;
- Access to good cross-ventilation and stack-effect ventilation to quickly cool the building late in the day or following a cool change.

## Hot Water

**The production and delivery of hot water accounts for at least 25% of the energy used in a typical home in Victoria.**

The Healthy House will utilise **the latest Solar Hot Water technology** which will reduce hot water energy use by at least 60% over the year.

The building design and the 'clustering' of wet areas (kitchen, bathrooms, laundry) as well as proper insulation of all hot water piping will further ensure a significant energy saving for hot water.

## Other Appliances

All white goods selected for the project will be at least 5 Star-Rated for energy efficiency (eg. Refrigerator, freezer, dishwasher, washing machine and clothes dryer).

## Lighting

The house design and window size and placement will minimise the need for high levels of active lighting and make full use of natural daylight.

A mix of various forms of energy efficient lighting will also be incorporated into the design to minimise lighting costs and energy use.

High efficiency fluorescent lighting will be used in living areas since it consumes only one fifth of the energy of equivalent incandescent lighting and lasts 8 to 10 times as long. All lighting fixtures will be surface mounted to maintain the thermal efficiency of ceiling insulation. Recessed lighting fixtures will be avoided as they decrease ceiling thermal efficiency and increase air leakage.

## **Health Measures**

### **Indoor Air Quality**

**“Indoor air pollution is seen as one of the 5 top environmental issues in the world today. Indoor Air can be 5 to 40 times more polluted than the outdoor air” (US EPA).**

**We spend more than 90% of our time indoors (CSIRO ), therefore the quality of the air we breathe, indoors, should be of utmost importance. As a building is made more energy efficient, indoor air quality suffers.**

A multi-level approach will be utilised to maximise the quality of the indoor air and occupant health. This approach includes:

- Reducing sources of indoor pollution through use of non-toxic paints and finishes, low and non-toxic floor coverings and reduce use of particleboard and MDF (Medium Density Fibreboard) where practical; and
- Reducing indoor air pollution and potential for toxic poisoning through the use of non-toxic cleaning and washing products and cleaning technologies; and
- Complimenting natural ventilation (windows and doors) through the use of a whole house, balanced mechanical ventilation (Energy Recovery Ventilation) system (further details under ventilation).
- Low-Allergy garden design.

### **Reduce Sources of Indoor Pollution**

#### **Interior Design/Cabinets**

An effort will be made to minimise horizontal surfaces will be minimised throughout the house where dust can accumulate. This will be done through the design of all cabinetry and choice of internal window coverings. The use of double-glazing will provide more choice in window coverings as the windows already provide excellent thermal insulation.

All cabinetry will be made of solid wood to eliminate the use of particle board products as much as possible. Particleboard is made using glues which contain formaldehyde.

**Formaldehyde** will ‘off gas’ from these products and can cause upper respiratory irritation as well as more serious long-term problems for the occupants. Any particleboard which is used within the building will be sealed to eliminate ‘offgasing’ into the indoor airstream.

#### **Flooring**

Flooring used throughout the house will be a combination of wood ‘strip-flooring’ (floor boards) protected with a non-toxic floor oil, clay tiles and modern linoleum (non-toxic) floor coverings. This will allow for ease of cleaning and accumulation points for dust and other allergy-causing materials.

Other soft floor coverings will include natural fibre (hemp, sisal) rugs in living and bedroom areas.

#### **Interior & Exterior Paints and Finishes**

Paints, sealants and other coatings used in homes can contain significant quantities of **Volatile Organic Compounds (VOC's)**. These chemicals are released into the airstream as gases (offgasing) after application. Offgasing can continue for many years, in some cases, (eg. particle board) or may last only a few weeks or months. This chemical offgasing can cause or aggravate minor health problems such as respiratory irritation and nausea to more serious conditions such as asthma, eczema, sleep apnoea, chronic fatigue, and cancer.

The paints and finishes used in the ‘2004 Healthy House’ will be non-toxic, VOC-free to reduce the negative impact on indoor air quality and health of the occupants.

## Cleaning and Maintenance

**A large part of ongoing indoor air pollution comes from the products we bring into the home for cleaning and maintenance.**

All cleaning products used within the healthy house will be of a non-toxic nature. The latest textile technologies allow cleaning of surfaces to be done using electrostatic attraction and water as the cleaning solution.

Sealing of the building envelope and the use of **continuous mechanical ventilation with air filtration** will create a low-dust environment within the '2004 Healthy House'. However, a **whole-house central vacuum system** will also be installed. This form of vacuuming extracts dust and dirt to a container located outside the building preventing the reintroduction of fine dust which standard portable vacuum cleaners do not filter adequately.

## Enhance Natural Ventilation

**A proper ventilation regime is needed within a building to remove and dilute air pollutants and control moisture levels.**

**Moisture is the key ingredient in indoor air pollution. Consistently high relative humidity within a building leads to increases in dust mite, moulds and 'offgasing' from building products.**

### Natural Ventilation

Contrary to popular belief, fixed or 'natural' ventilation does not guarantee a good supply of fresh air to a home. On still days little ventilation occurs within the building and when it does 'short-circuiting' can occur. 'Short-circuiting' occurs where fresh incoming air fails to mix with the stale indoor air before it is drawn out of the house through windows and doors or cracks and gaps in the building envelope.

***"The Challenge is to achieve good indoor air quality while maintaining energy efficiency" (Choice Magazine Sept. 2003)***

**Balanced Mechanical ventilation** overcomes this problem by providing fresh, filtered air to all areas and constantly diluting and removing air pollutants. A mechanical ventilation system such as the Energy Recovery Ventilator ensures one full air change every three hours thereby expelling any pollutants in the indoor air. Fresh incoming air is distributed through a tightly sealed duct system and the desiccant wheel within the ventilator provides the homeowner with control of indoor humidity levels while recovering around 70% of the heat or cool from the exhausted air. Setting the unit's humidistat between **30% and 55% relative humidity** prevents the growth of moulds and mildews in the house and controls dust mite and the associated problems for asthma and allergy sufferers.

## Low-Allergy Garden Design

A low-allergy garden design will be implemented over time. This will assist in reducing the potential allergic reactions (eg. Hayfever) some people may develop through local exposure to certain plants and grasses.

## **Sustainability Measures**

### **Use of Sustainable Energy**

**Electricity generation from non-renewable fossil fuels is a major contributor of Greenhouse Gases.**

The use of renewable energy will be incorporated into the project in the following manner:

- Interactive Photo-Voltaic (PV) power system to provide a proportion of the electric power needed to operate the home. As the 2004 Healthy House will also be connected to the electricity grid, any excess power generated will be sold to the local power supplier and any extra power requirements will be supplied from the grid; and
- Solar Hot Water System (see details under Hot Water).

### **Water Conservation**

**We live in the driest continent on Earth therefore water conservation should be a major criteria of any built environment.**

The Healthy House will incorporate the following technologies and techniques to provide for maximum water conservation. These include:

- The latest '**water-saving**' technologies including low-flow shower roses, AAA rated taps and fixtures, pressure reduction valves, etc..
- **Low-water use garden design.** Use of composting and drought-tolerant plants.
- **Rainwater collection and storage system** for property watering needs.
- '**Grey water**' diversion for flushing of all toilets.

### **Soil Conservation**

**Arable soils in Australia have always been at a premium but increasing losses (erosion, salinisation, pollution) due to human mismanagement and neglect have reached epidemic proportions and require significant effort at all levels to redress this situation.**

A **permaculture-based approach** will be taken to manage the soil and vegetation on the property.

### **Sewerage System**

Traditional septic tank sewerage systems are problematic as tank leakage and poor sewerage processing can cause soil and ground water pollution as well as human health problems. The existing septic system on the property will be replaced with an **environmentally friendly aerobic sewerage system** to treat and manage the 'blackwater' waste.

### **Recycling of Construction Waste**

Recycling will occur in the following areas:

- Where possible the soil and other materials from excavation will be used on-site as part of the landscaping plan.
- Timber removed from the existing structure, as part of the renovation, will either be reused (eg. old floorboards to be re-laid in part of the new extension), where possible, or be stored for firewood.
- Old single-glazed windows and external doors, which are being replaced, will be sold to second-hand dealer.
- Existing recycling of food waste (composting) as well as paper, plastics, metal and glass will be continued.