Energised Homes P/L
Peter & Nicole Reefman
8 Aquarius Crt, Portland Vic 3305
Phone: 03 5523 2811
Email: peter@energised.com.au

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Energised House. Portland, Vic, Australia.

Scope of project

Between 2007 and 2009 Energised Homes P/L designed and built an 8-Star rated house located at 8 Aquarius Crt, Portland Vic. The purpose of the project was to demonstrate right now what is achievable in terms of energy ratings and sustainable housing on coastal Victoria, and to then inspire consumers and the residential building industry to achieve much higher energy ratings.

The original design and energy rated specs of the house rated 7.1-Stars, and during construction new materials and techniques were sought out and meant the house was able to continually lift its rating to a completed level of 8.1 Stars.

The house is also fitted with energy and water producing equipment which has made it a net energy exporter (carbon negative) and water independent. It has also virtually eliminated formaldehyde, VOCs, and other toxins.

A house such as the 8 Aquarius Crt residence as it currently stands WITHOUT any extra energy efficiency measures would cost approximately $280,000 to $420,000. This is a 23 square (213m2) double storey house with a double garage. The large variation on price is due to the scale of the builder and quality of fittings used. Because of this very large variation, we have attempted to identify the ADDITIONAL cost for the consumer to increase the house's energy rating, independent of the base costs of the house itself.

It must also be noted that although the focus of the house is on its ability to achieve the highest levels of energy efficiency possible, the house still needed to be functional and desirable. It needed to be a home that enhances its occupants' lives, as well as being as economical as possible.

House construction

Construction site and waste management

The construction of houses requires material, energy and water inputs, and does create waste in the form of material offcuts, site runoff, and cleaning chemical wastes.

These issues were factored into the construction of this house, with the following:

Materials

To minimise the embodied energy of materials used in the house, those which were lightweight, renewable, durable, and local were chosen where possible. This meant locally grown plantation radiata pine was used extensively, along with recycled bricks for the garage, recycled feature timberwork in the kitchen and staircase, and LOSP pine window frames were used.

Concrete which has relatively high embodied energy was used for the floors, but the combination of concrete's durability together with its key role in passively heating and cooling, meant it was a good choice over the life of the house.

The house was kept to a modest size to also minimise the use of materials.

Energy

Energy during construction includes electrical energy used for tools, and transport of materials and labour. At the start of the project, 100% green energy supplied by the local Codrington wind farm was applied for through Origin Energy, however at the time Origin had a maximum of 20% for businesses. However this policy changed in the course of construction, and the majority of the house was officially built using wind energy.

Transport of labour and materials within Portland is minimal due to the city's small size, however this is offset by large distances required to supply many building materials. Because of this most of the materials were sourced as local as possible, and anything transported from a great distance had an emphasis on lightweight, such as the Unitex polystyrene external cladding.

Water

Water was taken during construction from the Wannon Water Portland supply, which has never required water restrictions due to a replenishing aquifer and small population base. Rainwater tanks were fitted and filled on completion of the construction. The role of the rainwater system fitted to the house is primarily for demonstration.

Material offcut waste

All offcuts were sorted in real time during construction and placed in segregated areas. This meant that virtually all offcuts could be sent to recycling rather than general landfill. In fact there was so little actual landfill that it could be transported in a small trailer rather than more usual regular skip pickups.

Site runoff

The combination of a very level building site, and efficient material & waste management meant there was no sediment runoff whatsoever, which was a very pleasing result.

Cleaning chemicals

Because the house used very little toxic and/or oil-based products, very few solvent-based cleaners were needed at all. Almost all cleaning was able to be performed with tap water.

Site

The single most important decision before designing an energy efficient house is site selection.

Traditionally, site selection considered a large range of factors, such as

- Cost, size and value of site
- Adjacent properties
- Location in relation to workplaces; schools; recreation; shops; family; services.
- Views, trees, and topography
- And perhaps to a small extent, solar access.

Because good access to sunlight is such a hugely important part of passive solar design, solar access has a MUCH higher importance. That's not to say that the other factors are no longer important – they are, just as they've always been. But very good solar access is also essential.

The good news for anyone wanting to build an efficient house is that (currently) sites with the required solar access are valued at no more than a site with terrible solar access. This is because many (most) developers; real-estate agents; and builders have little idea exactly what makes good solar access. This will no doubt change over time, as it should.

The bad news is that because of this, sites with good solar access are created almost entirely randomly, and as such less than 50% of a typical estate's sites have this very important attribute.

So what actually makes very good solar access for a site?

A brand new building estate on a sunny day will see new roads in all directions, and sites of all orientations, shapes and sizes - All with full sun covering them. How is one better than another? How does one have the capacity for an 8+ star house, while a nearby site would only ever be able to achieve 6 stars (at a stretch)?

In a nutshell, we need to see beyond what the sites look like empty, and understand how they will perform once they (and their neighbours) have completed houses built on them. Sites with bad solar access will force their occupying houses to waste sunlight on things like garages, entries, laundries, bedrooms, etc – and sites with good solar access will do the reverse. They will encourage basic passive solar design by allowing the living areas to face north and into the sunlight.

To achieve this project goal, site selection and design was paramount. The site selected was a flat 800m2 block on the north side of the end of a court. It had a narrow frontage and tapered side boundaries that opened up to a larger north-facing backyard. This is as close to perfect as a residential housing estate can produce.

Design

The house is designed to be orientated and zoned as perfectly as possible for this site. Design is still the most important and cheapest component and what allowed the house to achieve such a high energy rating.

The key message is that with good design, a high level of efficiency is economical.

Details of the design are included in the room by room descriptions below. But in general terms the house is designed to be a double storey and single width so that as many habitable rooms as possible can have both a northerly aspect for winter heating and light, and a southerly aspect for cross ventilation, particularly for summer cooling.

The design is also geared to face the living areas into the sunny back yard to help integrate indoor and outdoor living, but also has a cool southern courtyard and "half-hidden" front yard to balance openness with privacy.

Renewable energy & carbon emissions

The goal of this house is total self-reliance in both water and energy. Of these two key goals, energy self-reliance is where this house really stands out. In fact the house has potential to help pay a reasonable portion of itself off over its lifetime. Along with financial savings are CO2 savings. The house has an operational zero carbon footprint so saves approximately 9 tons of CO2 per year compared to an average house.

To achieve this, the house has first been made as energy efficient as possible, and as such is one of Australia's first and only 8+ Star rated homes. This combined with very low energy consumption fittings and appliances means the house needs only around 2,000kw/h of electricity each year. This around a third of the electricity that most houses use, and this figure even includes all of the house's heating, hot water and cooking needs.

So why is there is no gas used in the house? Simply because even though natural gas can be used very efficiently, to be measurably self-reliant the house uses only electrical energy which can be created by solar photovoltaic panels.

The house's 1.4kw of solar PV panels generate around 2,000kw/h per annum, which literally means zero energy bills (compared to $1,600 per year for electricity & gas for an average house). On top of this is an ability to generate an annual cash payout of around $800 through the Victorian Feed-in Tariff, which will pay home owners approximately three times as much for electricity they export, as energy they import. The net benefit is around $2,400 over an average house.

In future the solar PV system's capacity will be doubled to 2.8kw which will see a large surplus and much larger FiT payout of around $2,500 per year. This is on top of the $1,600 saving will give the house a net benefit of over $4,000 compared to an average house.

Flooring

The house has three forms of flooring, an insulated concrete slab on the ground floor, an insulated timber floor upstairs, and an uninsulated concrete slab for the garage.

Concrete is an ideal material to use on ground for its excellent thermal properties and it plays a major part in passive heating and cooling. That is, with correct orientation and window/eave configurations, the slab will store winter sunshine and effectively become the house's heater, while in summer the shaded slab will absorb unwanted heat. Some heat transfer can occur from the slab into the ground in colder conditions, and huge amounts of unwanted heat from direct sunshine can be absorbed by the slab edge in summer, so the slab has R1.5 polystyrene insulation around its perimeter to minimize both of these occurring.

While concrete consumes a lot of energy in its production, this is offset in the benefits of its correct use and very long lifespan.

There are no actual floor coverings on the slab, as even carpet inhibits its thermal potential. Instead, the slab is polished and sealed with a non-toxic water based varnish. Scattered rugs can provide a soft surface if required.

The timber floor upstairs has no actual thermal properties, but is heavily insulated with R5.0 bulk insulation to minimize heat transfer from the downstairs living zones into the upstairs sleeping zones. This is very important because unlike many double storey houses where heat targeted for the downstairs living area ends up overheating upstairs bedrooms, any downstairs passive and artificial heat stays where it's needed. The insulation also greatly reduces noise transfer in both directions.

Floor coverings upstairs are wall to wall 100% woollen carpet in all Bedrooms, and rubber tiles in the Bathrooms. The actual timber used is 19mm pine tongue and groove, which ensures that no glue (formaldehyde) is needed – unlike chipboard or ply flooring.

Framing

All framing materials in the house are sourced from radiata pine plantations. This includes solid timber, and engineered products such as posi-struts and laminated/ply timber for selected structural uses.

Also, plantation timber used for construction is an effective way to draw CO_2 from the atmosphere and lock it up safely for a long time.

Wall Cladding

The external walls of the house are 100mm Unitex polystyrene panels, which is an excellent product for thermal insulation. Because they are extremely light the panels also require less energy to transport and install than conventional clay bricks or other dense/heavy products, while providing far more insulation.

Unitex was also chosen because it is screwed directly onto the pine framing. This is important for two reasons.

First, most external wall systems require a cavity for waterproofing, which also allows air to freely move around the back of outside skin, greatly reducing its thermal effectiveness. Claddings such as Unitex which have no cavity eliminates this airflow, and is therefore much more efficient.

Secondly, a goal of this house is to show a model that could be easily built at a large scale, and even though alternative materials such as straw bales; mud brick; rammed earth; etc are excellent if used correctly and certainly have their place, we felt that keeping the house as conventionally built as possible would give it the best chance of influencing a large number of other houses/builders.

Insulation

The house is very heavily insulated, with the majority of insulation being bulk glass wool fibre batts. Insulation is extremely important to the efficiency of the house. We set out to create a thermally impenetrable skin with as little heat loss and gain as possible, and then insert holes (windows & doors) to allow strategic sunlight and airflow to serve the house's heating; cooling; and lighting needs.

From the bottom up, the house has

- A concrete slab floor with R1.5 polystyrene insulation around its perimeter and 450mm into the ground. For a house that is using its concrete slab to heat and cool itself, perimeter insulation is a very good idea, as very cold soil in the winter can and will cool the concrete. And the same is true in summer, where very hot sunlight baking the outside of the slab will heat it up and this heat will transfer directly and quickly inside the house.
- The walls have 100mm Unitex panels (rated as R2.8) fixed to timber frames with sisilation and R2.5 wall batts for a total of R5.3.
- The upstairs floor and all roofs both have R5.0 bulk insulation, and the roof also has Air-Cell sisilation for a total roof insulation of R6.9.
- Windows are double glazed and insulated as described in the Window information below.

- All internal walls separating habitable room also have R2.5 wall insulation, which further enhances the house's ability to be thermally (and acoustically) zoned.
- All internal doors separating habitable rooms are also fully insulated and weather-stripped.

Windows

Windows are an important part of any house, and are even more so in a passive solar heated and cooled house, which this house certainly is.

As described room by room, the house has large northerly windows which are shaded by wider than normal eaves and minimal windows in the South, East, and West sides of the house. These South, East, and West windows are used for cross ventilation and natural light, and in many cases are in non-habitable rooms such as the Hall.

- All windows used feature best practices for window materials, construction and insulation.
- All have renewably sourced finger-jointed LOSP treated pine frames. Timber is naturally insulating which reduces heat exchange between the inside and outside of the house.
- All have double glazing of 4mm glass, 10mm argon gas and 4mm glass. The glass also has low-E film fitted to further limit heat transfer. This is a substantial improvement over standard double glazing of 3mm glass, 6mm air, and 3mm glass.
- All have optimal eaves for their individual shading requirements, so that practically all warm winter sun can enter the house and practically no hot summer can even come into contact with any glass.
- All windows are at least partly open-able to allow maximum cross ventilation during summer.
- All large windows in habitable rooms have heavy drapes with integrated pelmets.

Plumbing

The plumbing incorporates all features of the toilets, bathrooms, kitchen and laundry. Refer to those rooms for more information.

Hot water is produced with a solar hot water unit positioned on the roof of the house.

All water used for the house is from harvested rainwater. The house has two 2,700 litre underground tanks with one 4,500 litre above ground tank to accommodate this.

Electrical

The house uses lowest possible consumption electrical fittings and appliances. From LED & CFL light bulbs to a cool-air ducted fridge.

These fittings and appliances include:

- LED lighting that produce light with even less energy than CFL bulbs are used as often as possible, and none of the problems of CFL like slow start-up and mercury in their manufacture.
- Energy efficient heater; fridge; washing machine; and dishwasher.
- Next generation convection microwave for most cooking, as well as induction cook top.
- Fully sealed and ducted fridge system that draws cool air from the south side of the house via a below-ground duct under the concrete slab.
- Elimination of high energy electrical appliances such as clothes dryer and second fridge/freezer.
- Very low energy consumer goods such as mid sized televisions; a 'Green' switch for easily turning off all phantom loads; total shutdown power boards; and laptop computers.

Even during construction electricity consumption was taken seriously, with 100% green power from the Codrington wind farm used to build the house.

Waste

Very little waste leaves the house. Grey water is recycled to be fed onto the house's garden during summer. Stormwater is caught and used for the house's fresh water needs. Food wastes are composted and fed to the garden. Household goods which have minimal packaging and/or are easily recyclable are taken in preference to 'dead-end' packaged products.

Even during the construction of the house waste is managed carefully, and was separated to be recycled accordingly which meant that only a tiny fraction of the construction waste had to go to landfill.

Heating/Cooling

The house achieved 8.1 House Energy Rating (HER) Stars. Very little artificial heating and cooling is needed for the house, as the advanced passive solar design with careful cross ventilation provides virtually all its needs from the coldest winter nights to the hottest summer heat waves.

The main and really only regular heating/cooling assistance is a next-generation reverse-cycle air-conditioner. This will only be needed for heating in winter, and only then on only the coldest, cloudiest days. Estimates based on usage patterns so far indicate that heating and cooling will cost around $10-$20 per year, and this cost will be more than offset by the income produced by the solar PV system.

More about star ratings

Australia's HER star rating system is a system to define how thermally efficient a house is. The scale is 0 to 10 stars, with 0 needing all of its heating and cooling from artificial means, and 10 needing absolutely no artificial heating or cooling.

The system is also national, and is divided into climactic regions. This is because us humans can acclimatise and live with heat easier than cold. The table below shows various regions. Notice that 10 stars in Darwin is far higher (easier to achieve) than in Hobart, which clearly illustrates this hot/cold acclimatisation.

Australia's existing stock of housing has an average rating of approximately 2 Stars.

Table 1. Examples of energy consumption in Mega joule hours per square metre per year.

Region	Location	1 Star	2 Stars	3 Stars	4 Stars	5 Stars	6 Stars	7 Stars	8 Stars	9 Stars	10 Stars
1	Darwin	773	648	555	480	413	349	285	222	164	119
26	Hobart	723	498	354	262	202	155	113	71	31	0
63	Warrnambool	716	493	349	258	197	151	110	70	32	2

Being rated 8 Star in region 63 (Warrnambool), the Aquarius Crt house should use 70MJ/h per m2 per year to keep a comfortable temperate range. This then requires another table to compare what this means over a whole year, and the actual dollar differences. There are three assumptions in the table below which are made to simplify the explanation. That the house is only being heated (as opposed to heated and cooled); that natural gas is used; and that the gas cost is 1.2 cents per mega joule.

Also included in table 2 is CO_2 emissions. This is important not only from an environmental perspective, but also because a future with a price on CO_2 emissions will certainly increase costs. This is calculated by using EPA figures of 0.06kg of CO_2 per MJ/h of natural gas burned. Carbon costs are likely to be in the range of $20 - $60 per 1,000kg.

Table 2. Energy consumption (MJ/h), costs, and CO_2 per year for a 213m2 house in region 63

	2 Stars	5 Stars	6 Stars	7 Stars	8 Stars	9 Stars	10 Stars
Megajoule hours	105,009	41,961	32,163	23,430	14,910	6,816	426
Costs per year	$1,260	$504	$385	$281	$179	$82	$5
CO_2 emissions (kg)	6,354	2,517	1,930	1,406	895	409	26

As stated above, current estimates of $15 per year based on real world performance indicate that while the house is formally rated at 8.1 Stars (or $179 per year), it is in fact performing far closer to 10 stars.

It's also important to note that energy costs across all sectors are expected to rise dramatically in the future, with at least 40% expected and possibly 100% over the next five years.

Rooms

Entry

Entries are very important to energy efficient homes. With a sealed door into the main living area, this entry not only provides an airlock to the outside world, but is also perfect for housing the staircase rather than having an open stair void in the living area. These two elements greatly improve zoning and thermal performance to the rooms that really count.

This house's entry also serves another purpose. It is a thermal cooling tower. It's the highest point of the house, with operable windows around the entire top perimeter. As heat rises on hot days any unwanted heat can easily be pulled out. This is further enhanced by the fact that all internal doors for habitable rooms are 2.3m high, which allows the entire house to be cooled from the entry tower. In winter, with insulation in all internal walls and (closed) doors, as well as the double glazed tower windows closed, there is virtually no heat loss.

The entry is on the south side of the house, and allows people to move as efficiently as possible into the northerly living area. Windows are restricted to a single westerly operable sidelight beside the front door which is fully shaded from the west sun by the portico roof, and the tower windows as discussed above. The Western window in the Cooling Tower also has additional tinting to reduce any hot sunshine entering during summer.

Kitchen

Like many modern houses this kitchen is incorporated into the main living area. It extends out into the northerly orientation with eave-shaded windows on the north and northeast walls, which provide maximum natural light and passive heating/cooling.

All water for the sink and dishwasher come from the house's rainwater storage tanks.
The dishwasher is rated five stars for water efficiency and three stars for energy consumption, and uses less water than conventional hand washing. Cooking is with a combination convection/grill/microwave oven and induction hotplate. The kitchen also has a common multifunction oven to when extra baking is required.

All kitchen cupboard materials are taken from renewable resources and are formaldehyde free, while the benchtop is a combination of recycled Messmate timber and Eco-Top, a product made from recycled paper and bamboo which is bound by a non-toxic water based resin.

This fridge is the most efficient on the market, and costs less than many popular models. A typical old fridge uses between 2.5 and 3.5 kw/h per day. The fridge used uses less than 1kw/h per day.

Plus there is a duct running under the concrete slab which feeds cold outdoor air to the fridge, and another overhead duct that pushes this air back outside. This makes the fridge run even more efficiently, and allows it to operate on around 0.7kw/h per day.

The bottom line is that this fridge system is about $180 per year cheaper to run than many old fridges – and saves lots of carbon as well.

Dining

The Dining room is the hub of the main living area, which sits between the Kitchen and Lounge room, and is on the north side of the house for maximum natural light and passive heating/cooling.

Large eave-shaded glass sliding doors extend into the warm backyard to the north, while a sliding door opens to a cool breezeway courtyard to the south. This substantial double opening provides a huge amount of cross-ventilation to help cool the entire living area on hot days, while also allowing immediate access to the outdoor living areas. It also gives the room a much more dynamic natural light than windows on only one side of the room.

Lounge

As with all living areas, the Lounge is located on the north side of the house, and has large eave-shaded operable windows on its north face for maximum natural light and passive heating/cooling.

There are also operable strip windows on the Southeast wall to allow cross ventilation and dynamic natural light. The low window is particularly important, as on hot days this is a perfect source of cool air to compliment the hot air leaving the house from the cooling tower. This incoming air is even further cooled by passing over the polished concrete slab on its way in.

Games

The Games room is thermally separate from the main living area with fully insulated walls and door. It is located on the north side of the house and like the Dining room has a large eave-shaded sliding door that provides not only immediate access to the backyard, but also maximum natural light and passive heating/cooling.

Heating for this room is passive solar, with artificial heating needed on only the coldest winter nights. Cooling is also entirely passive, with cross ventilation for this room from the external sliding doors into the main living area and up to the Cooling Tower.

Study

The Study is a room to the south of the house off the Lounge. The windows in the Study are to the south and west, with the bigger westerly window positioned under the Southern Courtyard roof, which totally eliminates hot westerly sun penetration. As with all other rooms the windows are operable and on two sides to allow cross ventilation and dynamic natural lighting.

The study also serves as an important element to the house's outside living environment, by defining the Eastern side of the Southern Courtyard.

Double sliding cavity doors are used for access to the Study from the Lounge room, which give the ability to easily shut the room up or open it up to be fully included with the main living area.

Laundry

The Laundry is located on the South side of the house. This room is unheated and has R2.5 insulation in the walls and doors between it and adjacent rooms. It is also used as an access room from the Garage to rest of the house.

As with the Bathrooms, all wastewater from the Laundry goes to a grey water filtering unit, which allows the water to be reused for watering perennial food (fruit and nut) trees and non-edible plants. This compliments the house's water efficient appliances and rainwater harvesting to allow total water self-reliance.

The front load washing machine is rated 4.5 stars for water efficiency, 4 stars for energy efficiency, and there is no electric clothes dryer. Wet weather drying occurs with internal mobile racks in the Games room.

All Laundry cupboards and linen shelves are formaldehyde free.

Toilets

There are two toilets in the house. One is located downstairs which services the main living area and one in the bathroom/ensuite zone upstairs to service all bedrooms.
Both toilets are 4 Star water efficient dual flush systems. They use only 3 litres for a half flush, and 4.5 litres for full. Plus even better, they are flushed with collected rainwater.

Also note that there is no toilet in the Ensuite. This is because there is already a downstairs toilet, and a further two upstairs was seen as unnecessary. Instead, a single toilet was positioned halfway between all bedrooms to allow easy 3am access for everyone. It also frees up space in the bathrooms, separates the very different hygiene needs of toilets and bathrooms, means one less toilet to keep clean, and reduces construction costs.

Hall

The upstairs hallway extends along the south side of the house, and exists to allow all of the bedrooms clear and efficient access to the north side of the house. Windows are kept minimal to limit the amount of heat loss, but do exist to allow natural light and cross ventilation to the habitable rooms that the hall serves.

All doors from the hall into bedrooms extend to the ceiling to allow surplus summer heat to flow unrestricted into the cooling tower.

Cooling Tower

At the top of the entry/cooling tower is a mezzanine platform which performs several tasks. Firstly it provides easy access to open and close the ventilation windows, which are on all four sides of the tower. With windows open, convection is created which sucks up and expels any heat from the living rooms of the house. Also, the mezzanine can be used as a cosy retreat.

The Western window in the Cooling Tower also has additional tinting to reduce any hot sunshine entering during summer.

Bedroom 1

Bedroom 1 is located on the far eastern end of the house. It has operable windows on all available walls, which are north, south, and east. Having windows on three sides provides excellent natural light and cross ventilation.

The east and south windows are kept small to limit heat loss, while the northerly window is large and eave-shaded to maximize passive heating/cooling.

The main bedroom is thermally zoned from the rest of the house with R2.5 wall insulation, R5.0 floor insulation, a fully insulated door, as well as the house’s external wall & roof insulation.

The wardrobe shelves are formaldehyde free, and the carpet is 100% pure wool on recycled underlay.

Bedroom 2

This bedroom is located in the middle of the north side of the house, and as such does not have opposite external walls for cross ventilation. To compensate this, the Bedroom door into the hall is located exactly opposite one of the Hall’s external windows, and coupled with the full-height door, provides adequate cross ventilation.
The room has a small alcove – play area in the north side and as such has two separate northern walls. Each has a moderate sized eave-shaded window to allow good natural light and passive heating/cooling.

Bedroom 2 is thermally zoned from the rest of the house with R2.5 wall insulation, R5.0 floor insulation, a fully insulated door, as well as the house’s external wall & roof insulation.

The wardrobe shelves are formaldehyde free, and the carpet is 100% pure wool on recycled underlay.

Also, the bed mattress is Latex which is far less toxic and discourages dust mites.

Bedroom 3

Bedroom 3 is located on the far western end of the house. It has operable windows on the north and south walls. The south window is kept small to limit heat loss, while the northerly window is moderately sized and eave-shaded to optimize passive heating/cooling.
There is no western window in this Bedroom, despite an available western external wall. This is because unwanted summer afternoon heat gain outweighs any benefit in natural light and cross ventilation that a window on this wall would provide.

Bedroom 3 is thermally zoned from the rest of the house with R2.5 wall insulation, R5.0 floor insulation, a fully insulated door, as well as the house's external wall & roof insulation.

The wardrobe shelves are formaldehyde free, and the carpet is 100% pure wool on recycled underlay.

Also, the bed mattress is Latex which is far less toxic and discourages dust mites.

Bathroom/Ensuite

The Bathroom and En-suite is located on the north side of the house with moderate sized eave-shaded windows to allow good natural light and passive heating/cooling.

All water for the bath, vanities, and showers come from the house's rainwater storage tanks.

As with the Laundry, all wastewater from the bathrooms goes to a grey water filtering unit, which allows the water to be reused for watering perennial food (fruit and nut) trees and non-edible plants. This compliments the house's water efficient appliances and rainwater harvesting to allow total water self-reliance.

100% rubber flooring has been used, which is a sustainable option compared to floor tiles and is far warmer and softer.

The vanity cupboard shelves and doors are formaldehyde free, while the bench tops are Eco-Top which is a product made from a recycled paper and bamboo composite and bound by a non toxic water based resin.

Garage

The Garage is on the extreme southwest corner of the house, and helps shield it from the prevailing southwest winds of the Portland area. Its construction is second hand single skin masonry. The internal walls between it and the main house are fully insulated with R2.5 wall batts.

The garage is sized at 7m x 7m for car parking, and a rear extension for storage and a work area. This extra storage helps free up extra storage space in the house, and eliminates the need for an external backyard storage shed.

The solar photovoltaic system's inverter is located in the garage.

Garden / landscaping

The house has a productive Permaculture garden which is currently under construction. A major goal of the landscaping is to have no lawns at all.

It will be food producing and have zones of the original local indigenous plants that this site would have had before it was cleared for farming.

The front (South) yard garden is small and ornamental habitat, with no lawn and drought resistant native grasses, shrubs and trees selected. The front yard is broken in half by a recycled timer screen fence, which in effect makes the front yard 'half hidden', giving it a balance between being open from the street and a private area for the decked and shaded (summer) cool southern courtyard.

The back (North) yard is the main outdoor area of the property and is yet to be constructed. A large area of decking and paving co-exists with and orchard of deciduous fruit trees which share space with a fully caged 4 yard rotational chicken run, and an intensive six bed rotational vegetable garden. The Northeast corner of the yard has more original local indigenous trees, shrubs, and grasses which balance production, habitat, and recreation.

Evaluation

Cost effectiveness

The completed house cost of $405,000 includes approximately $40,000 of equipment which allow it to operate with zero carbon emissions, water independence, as well as costing approximately $2,400 per year less to occupy than an average Australian house of the same size.

This extra cost also allowed the house to have extremely low toxins for a far healthier long term environment fir its occupants.

The payback period based on those figures is approximately 16-17 years on today's energy prices. Even though this is a reasonable timeframe in our opinion as the house has been constructed to last far far longer than that, we recognise that many people will see this as a barrier. But the overall cost effectiveness has more factors than simple dollar/year paybacks.

- Energy prices are based on today's costs, which is expected to at least double in the next five years, even without a price on carbon. This house is fully insulated fro both of those increases.
- With the recent announcement of mandatory energy efficiency ratings of all houses for sale and rent effective mid 2011, extremely efficient houses will have a huge resale price advantage over inefficient existing stock. So a large part of the extra expense of this house will be available to the owner even if the house sells before the payback period is complete.
- Extra money on water harvesting/recycling can be difficult to recoup, due to the very low price of water. However, in many regions with heavy water restrictions, the benefit is that if being able to maintain an attractive and productive garden.
- There is no tangible price that is able to be put on occupant health, especially long term health. However, it is clear that living in a built environment which had far less toxins and carcinogens is extremely preferable and one which nonetheless has an important value.

Star rating costs and variations

We can now see exactly what it took for the house to rate as it has, and what other options would have achieved in terms of the energy rating and costs. At the most simple form, if the house was built with minimal insulation and clear single-glazed aluminium-framed windows it would already achieve the current 5-Star minimum standard.

5 to 6 Star

To go from 5-Star to 6-Star at this point is extremely easy and affordable. All that is needed is an increase in insulation and other cheap measures such as improved draft sealing. All windows at this stage (6-Star) can still be cheap single glazed aluminium.

The cost of bringing this house from 5-Star to 6-Star is approximately $1,300. This would cause a 24% improvement, which would result in an approximate saving of $120 and 0.6 tonnes of CO_2 per year.

Payback in dollar terms on today's energy prices and NO price on carbon would be 10.8 years.
That payback would shift to 6.7 years if energy prices rise the expected 40% and carbon costs of $40 per tonne are taken into account.

In the longer term, this would be a net benefit of at least $10,700 and 60 tonnes of CO_2 over 100 years.

5 to 7 Star

The next level (7-Star) is also quite easy and affordable to reach. At this point all insulation and draft-related measures are at maximum levels, and all living area windows and doors are upgraded to double glazed aluminium. Going from single to double glazing increases window costs by approximately 50%, which in dollar terms for this house's living areas is approximately $4,000.

The cost of bringing this house from 5-Star to 7-Star is approximately $4,300. This would cause a 44% improvement, which would result in an approximate saving of $220 and 1.1 tonnes of CO_2 per year.

Payback in dollar terms on today's energy prices and NO price on carbon would be 19.5 years.
That payback would shift to 12.2 years if energy prices rise the expected 40% and carbon costs of $40 per tonne are taken into account.

In the longer term, this would be a net benefit of at least $17,700 and 110 tonnes of CO_2 over 100 years.

5 to 8 Star

To go past 7-Star into 8-Star requires all windows and external glass doors to be significantly upgraded. There cannot be any single glazing, and aluminium frames are not adequate. What is needed is for all windows and external glass doors to be not only double glazed, but to also use timber frames and have low-E film fitted. The cost of upgrading to this is a further $11,000.

The cost of bringing this house from 5-Star to 8-Star is approximately $15,300. This would cause a 64% improvement, which would result in an approximate saving of $325 and 1.6 tonnes of CO_2 per year.

Payback in dollar terms on today's energy prices and NO price on carbon would be 47 years.
That payback would shift to 29.5 years if energy prices rise the expected 40% and carbon costs of $40 per tonne are taken into account.

In the longer term, this would be a net benefit of at least $17,200 and 160 tonnes of CO_2 over 100 years.

Above 8 Star

Going above 8 Star proved to be all but impossible, and clearly unpractical.

Possible improvements to achieve this included triple glazing for an additional $68,000; Suspended concrete slab for the upstairs level which would mean significant upgrades and expenses to the lower storey structure; Even higher levels of insulation which would also require structural changes (such as using 190mm thick external wall studs to accommodate thicker insulation); etc.

The expenses required for any extra official stars far outweigh their real world benefit, especially when the house's operational thermal performance of $10-$20 per year is considered.

Benefits to the environment

The environmental benefits of this house are immense.

- A house that is zero carbon means that there are literally no climate change contributions from this residence, and because houses such as this can be replicated easily, there is huge potential for all new houses to be climate neutral as well
- Further to that, this house actually produces MORE energy than it consumes, meaning that it is in fact a small clean energy provider and if large number of houses were able to achieve the same they could actually help mitigate climate change by powering other energy users as well.
- The house and its landscaping is reintroducing the original local indigenous trees, shrubs, and grasses that were removed when the site was cleared for farming
- Far lower levels of toxins and less waste means less toxins also entering the environment through landfill leeching and air pollution.
- Onsite food production also helps the greater environment by requiring less industrially produced food to be grown and transported.

Benefits to occupiers

Benefits to the house's occupiers are many, and centre on financial, health, and satisfaction.

- As set out in Cost Effectiveness, the financial outlay is more than compensated financially through savings payback and resale increases.
- Health benefits are from spending indoor time in a far less toxic and carcinogenic environment, and also fro the ability to eat the fresh organically grown produce from the house's garden.
- The satisfaction from living in a house like this cannot be overstated, especially for an occupier that is genuinely concerned about the environment and where we as a society of heading in our future. In short, there is an immense level of satisfaction fro being part of the solution rather than contributing to the problem.

Replicability

This house is unashamedly built using materials and techniques as established and common as possible. The reason this has been done is to demonstrate that we can build a far greater level of energy efficiency and sustainability using tried and tested building systems.

We have nothing against alternative building techniques such as straw bale, mud brick, etc. However, our goal has always been to help the majority of builders, working for the majority of home owners.

To use Melbourne's five growth areas as an example, where and expected 284,000 new houses will be required to be built by 2026, we feel the sheer number of construction that will take place will exclude alternative techniques simply because the builders that will build those houses do not have the trades, materials, or systems in place, and are likely to prefer to use their existing systems. Our goal is not to replace those existing systems, but to show that they can be greatly improved instead.

As well as this goal, we feel that there is a very real probability that the overall cost of $405,000 of this particular can be reduced substantially by the existing large-scale building industry to be approximately $25,000 above their regular prices, which in the case of many 212m2 volume built houses, would see the cost of carbon zero and sustainable housing become a reality for less than $250,000.

Reduced heating system costs

Another dynamic to keep in mind is that the more efficient a house is, the less heating – and therefore less heating equipment - is needed. This can offset the cost of better insulation/windows. In the case of this house $3,000 for heating had been allowed for 5-Star, $2,000 for 6-Star, and $1,000 for both 7-Star and 8-Star (even 8-Star still needs basic heating equipment along Coastal Victoria).

Lessons learned

We feel that building this house has very clearly taught us some important things.

First, with the right site and design the costs involved in upgrading from 5-Star to 7-Star are minimal. We strongly feel this extra cost would pay itself off quickly and greatly reduce the house's long-term environmental impacts, while increasing the comfort and value of the property.

The second thing we've learned however is that while 8-Star is achievable and still affordable for this particular site, the site itself was carefully chosen from over 100 available blocks. Of those, only a minority were seen to be capable of 8-Star at all. Most of the other sites we looked at would perhaps even struggle to achieve 6-Stars. This of course demonstrates that the quality of residential estates also needs to be improved significantly. It's simply not good enough that only a minority of sites 'happen' to be good enough to accommodate highly efficient buildings. It must also be noted that even with good estate planning, many areas will have steeply-sloping sites that further reduce potentially high levels of efficiency.

And finally, it has taught us that despite being able to reach 8-Star for this site, we feel that it is not practical to lift the minimum efficiency standards to 8-Star for all sites across Victoria. We're very passionate and committed to doing all we can to vastly improve the housing being produced, but feel that across ALL sites, 7-Stars with efficient appliances, renewable energy, etc. is a more realistic and achievable way to the same end goal of zero-impact housing.

In closing we are excited to have completed this project, and look forward to being able to demonstrate it not only to people looking to build or retrofit, but also to demonstrate to the building industry just what is achievable and what we need to do to get there.

Yours Sincerely,

Peter Reefman
Director – Energised Homes