SWC – RETROFITTING FOR SUSTAINABILITY – DOES IT WORK?

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1. Introduction

To develop a truly sustainable built environment, there are two issues to take into account. In Australia, new buildings, which are now regulated in terms of their anticipated carbon footprint, do not account for existing building stock, and are a relatively small proportion, about 20% in 2003/04. (R. Horne, H. Stanley, N. Willand and C Maller, 2008). So there has been no control over the majority of the existing residential building stock, and most of it has been constructed without and certainly prior to any energy efficiency requirements or regulations.

And, even if the existing building stock is upgraded and adapted to address these issues, the theory cannot account for behaviour. That is, the assumptions about the houses' energy and thermal performance are based on the physical reality only and not how the inhabitants will use that physical structure and infrastructure.

Much of Australia's existing building stock is old and inefficient, the total building sector accounting for approximately 19% of Australia's total energy consumption and 23% of total greenhouse gas emissions (GGE) (ASBEC 2008). So there is plenty of incentive to do *something* - and as tempting as demolition may be, there is plenty of scope to retrofit much of the existing building stock and therefore justify to *not* simply demolish and replace the existing buildings. And many of these homes are not even that old, much built within the last few decades. With so many options of what can be done to help reduce a building's Greenhouse Gas Emissions, most buildings have some merit and potential.

So usually we can fix and improve these buildings, even retaining their character and charm, but how do we know that we have got it right? We can run ratings software to convince ourselves that both the new and the improved existing buildings will perform better than they have historically, but is the theory a true reflection of reality? Anomalies in climate and weather patterns, such as severe weather events, heat waves, cold snaps - can affect real results that the theory has not predicted. But given that it is not just the structure and fitout, but also the how the building's occupants use the building to achieve their desired level of comfort and lifestyle that can influence a building's sustainability, can we separate theory from behaviour?

2. Case Study

This paper looks at a case study of an existing house and its initial rating, and then what was done to improve the rating. The house was rated initially (*Tab.1: Predicted and Actual energy usage and Star ratings*) and then 4 years later after significant changes had been made. This shows changes from a 0 star rated house to a 3 to 5 star rated house (NatHERS V2.32, 2011). So what were the changes made, and is the theory correct? Monitored results show not only whether the rating's predictions are correct, but also how behaviour can have an impact on the results. And the bottom line?– that there are a myriad of things you can do to reduce a building's carbon footprint, to make it more comfortable, but that nothing is in isolation.

Tab. 1: Predicted and Actual energy usage (kWh/m^2.annum) and Star ratings

Year	Star Rating	Rated Values			Actual Values
		Heating	Cooling	Heating & Cooling	All energy usage
2007	0	189.0	8.2	197.2	61.0
2008					49,0
2009					43.0
2010	3	95.7	3.0	98.6	37.0
Improvement				x 0.5	x 0.6

This house is located in Armidale, north inland NSW, at approx 1000 m above sea level. So longitude provides a climate with reasonably warm summers (high 20s to low 30s, occasionally higher) but pleasant nights (rarely over 20), mild to low humidity, but altitude also brings cold winters, (minimums below zero and occasionally as low as -11, occasional snow and plenty of frosts).

But what really makes this a challenging climate is the diurnal range, especially in spring and autumn – of 20-25 degrees Celsius. So design needs to account for both cooling and warming – and sometimes in the same day.

The existing house was built in the 1920s – uninsulated cavity brick, solid brick internally, timber framed floor, some uncarpeted, minimal ceiling insulation, single glazing, very little north sun, and so on. Added to that it was ‘modernised’ in the last 10 years with 23 downlights, a 420 litre electric hot water system located externally and as far as possible from the plumbing it fed, a large electric oven, a gas central heating system. Fortunately the improvements also included a skylight and two solar tubes, and reasonable blinds and curtains to some, though not all, of the windows.

3. Improving the Existing Building

Over several years, a series of improvements and changes have been made, thus bringing up the star rating for its predicted thermal performance. Firstly, electric hot water system was removed and replaced with an evacuated tube system. The immediate benefit was a reduction of, on average, 7-10 kWh a day. But then after 12 months, we experimented with leaving the booster off and managing it manually – and found we would run for 7-8 months at a time without using the booster at all (partly the upside of drought) - so the total offset from the previous hot water system was now even better. The tank was also relocated internally in a small room adjacent to the bathroom, doubling as an airing and drying cupboard, and saving on pipe runs (and therefore wasted hot water), and of course ensuring all pipes were insulated.

We also replaced all incandescent bulbs with compact fluorescent lamps (CFLs), as well as most of the downlights. Ten were removed totally using one of the holes for a smoke detector.

The others were replaced with various CFLs – this was in the early days on the market so experimenting with colours, brands etc. Average wattage of the new lamps is 11W compared to the previous 50W bulbs which also required a 10-12W transformer. Splitting the banking has also allowed for less lights on per switch. In the kitchen, for example, where previously there were 6 x 60W lights on one switch, these have been now split into two banks of 2 and 4 lights, each light at 11W. However, we have found we usually only use the two with a wall-mounted 8W CFL lamp – so total 30 watts where previously it was in excess of 360W.

But there are other issues – holes in the ceiling as a result of downlights generate massive heat at the point of the light, but also loose heat around it due to the lack of insulation, and of course potential fire risks within the ceiling space.

Next some structural changes were made, opening up the rear of the house, which fortunately faces almost north (as appropriate to the southern hemisphere).

Originally a brick veranda – this was a great suntrap but the sun did not penetrate any further into the house from there. Demolishing the room onto the veranda meant letting in lots of northern sun for winter, with sufficient eaves to shade for summer. The external line of the building was replaced with a full wall of double glazing. This now makes it a sun trap in winter, keeping the heat in at night, and opened up for fresh air in summer. While the double glazing does reduce some solar gain on winter days, this is more than offset by preventing heat loss during winter nights. That is, while inside might not warm up as much, nor does it cool down as much either. The area is now a better use of the space that was previously closed in with little daylight, and the laundry has been placed inside a cupboard.

Then some more specific changes were made to the western side of the building, as the western sunroom was to be converted to an office. The long western wall, and short northern and southern walls were uninsulated cavity brick to 1200 high, then single glazed windows the full length of the room, as well as north and south.

First the western wall was lined internally with 20mm Styrofoam sheeting, then covered with fibro and painted – lightening up the dark brick walls as well as now insulating the wall significantly. About 1/3 of the windows were covered with insulating noticeboards, with R2.0 bulk insulation packed in behind. Insulating blinds were installed over the remaining windows.

The southern wall previously flush to the end of the building, was moved inwards 1.8 m, creating a veranda and covered entry, allowing us to insulate the new wall structure supporting the reused windows and door, and providing an external window to the middle room (previously this window opened onto the enclosed veranda only).

The lighting in this room was also replaced – 2 x 3 bulb wall lamps (180 W each) were replaced with strip fluorescent lighting, and a 3-spot light (300W) replaced with 4 CFL spots (40W). While we have since investigated replacing the strip lighting with more efficient T3s, it cannot really be justified yet. There is so much daylight in the room, the lights are more often off than on, and after nearly 5 years, no tubes have yet been replaced. After this length of time, they would otherwise have clocked up some 10,000 hours of burn time, but in reality, due to ample natural lighting, it has been far less.

And finally 3/4 of the bare timber was carpeted to insulate the floor.

In regards to insulation – very old dusty Rockwool in the ceiling was ineffective, so R3.5 bulk insulation was installed. At the time this was being done, it was the middle of winter. The difference was apparent immediately (refer later graphs) – the week prior to installing it, the indoor temperature during the day, unheated, was more or less equal to the external maximum, 13, 14, 15 ^{0}C, but the week after, which coincided with a run of single figures, the temperature remained above the previous internal maximums – that is, 8, 9, 10 ^{0}C outside, but rarely less than 14-15 ^{0}C inside during the day. So effectively a 4-5 degree difference, which in turn meant not having to heat from as low a base come the evenings.

Similarly, the house does not heat up as much midsummer when it needs to be kept cool, though this was never a major problem due to the extensive thermal mass of the solid brick building. So insulation makes a significant difference - it works.

We have also subsequently insulated under the floor for part of the northern area – using two layers of second hand carpet tiles, made of rubber and pigs' hair. Whilst not as good as 20 mm Styrofoam, it nonetheless definitely makes a difference, notable on the bare timber during winter. Also it provided an opportunity to reuse an existing product, free of charge and defer sending it to landfill.

Better curtains and insulating blinds have also been added throughout the house, though some windows still only have blinds where better quality ones are really needed.

Next we tackled the windows. While some external shading helped offset some of the summer heat gain, winter heat loss through most of the existing windows was a major concern. Single glazed windows provide the path of least resistance for heat loss and heat gain, equivalent to about R 0.17. Adding good curtains and blinds can bring it up to R 0.3-0.5, still under or on par with the uninsulated cavity brickwork.

So we investigated double glazing. While we can easily double glaze new windows, tackling existing windows can be done as well. After a severe hail storm in late 2006 damaged every pane on the 80 year old stained-glass windows, the windows were taken away for repairs, and while gone replaced with plain glass. But when the repaired windows were returned, the clear glass was retained as an outer sheet – the restorer's suggestion to protect the stained-glass windows. But in fact it also created a double-glazed panel, the lead allowing enough air leakage to prevent condensation between the panes, but the benefits immediately apparent. A simple hand on the glass indicated that the double glazed panes were not as cold as the adjoining single glazed panes on the same facade. And while double glazing is nominally also only R 0.3, it is not dependant on curtains being closed. And then adding curtains and/or blinds to the double glazing of course improves its performance even more. The matching bay window on the other side of the house has also since been upgraded, and the glass front door will eventually be done as well.

Elsewhere, a window was replaced with the old back door, with a double glazed panel, and with 'Comfort Plus' louvres above (equivalent to double glazing) filling in the hole above from the higher head on the original window. The louvres also allow for cross breezes in summer.

And then we added the solar array. Our priority was to upgrade the house first - there is little value in placing a 1 kW system on the roof of a house that is poorly designed and a complete energy guzzler – it would be more effective, and money better spent, to retrofit the house first to improve its efficiency and lower its energy demands. Which is of course what has been done. First a 1.5 kW system was installed, then the following year another 2 bringing it up to 3.5 kW - so that we now export over 2 to 3 times what we import – and this includes running an office (though with some anomalies are explained later). Though this does not actually reduce the total amount of electricity the house and office use, it does reduce the carbon footprint significantly.

The indoor-outdoor relationship of the house within the context of the site has also been part of the changes - the deck with shading and growing trees, ponds with cooling breezes across in summer (and plenty of frogs). The new side deck gives better access to the garden. Both decks are also built of Modwood, flooring made of 50% sawdust and 50 % recycled PET bottles. It is made of waste materials, requires no staining or maintenance, does not splinter and is highly durable. A win-win all round.

Rainwater collection has also been considered, especially given the size of the block (4,004 sq.m.) and therefore the garden. The one acre site includes an extensive garden, though much of it for growing vegetables and fruit trees, but is largely supported by 8,315 litres, plus we have another 5,000 litre tank waiting to be plumbed in. A small wall tank is plumbed directly to the kitchen sink, the overflow then running into the garden tank below. All the tanks rely on gravity feed.

4. Monitored Results

4.1 Rating and Monitoring

So to the ratings – and do they measure up? We have now collected 4 years of records – daily readings of the internal thermostat, centrally located, the externally located min-max thermometer, the rain gauge, and reading of inverter for the solar array, coupled with electricity and gas accounts over the same periods; there has been some interpolation when readings were missed, and notes made to one-off events (storms, visitors, builders on site, a large bath and so).

And though there are some anomalies – most of them explainable – there are also some encouraging trends. Initially the building was rated at 0 stars, then improved to at least 3 stars.

Given some of the assumptions for the ratings process, it is probably more like 4 or even 5 stars. The ratings are calculated on a standard set of occupant behaviours for anticipated heating and cooling loads. So straight away there are some issues – what is standard behaviour, numbers of occupants, acceptable heating and cooling levels, and of course this house also incorporates a full-time office which would certainly be outside standard behaviour patterns and usage.

Add to that the limitations of the software (NatHERS V2.32 in this instance) which limits the number of window/glazing/covering combinations; only allows for one roof space type; and assumes gas solar hot water is better than electric while in fact in this case electric is better because we generate excess power whereas the local gas is trucked in from Victoria, thousands of kms away.

The broader results indicate a definite improvement – the ratings imply total rated energy requirements reduced from 197.2 kWh/m^2.annum to 98.6 kWh/m^2.annum. The actual energy loads based on collected results have dropped from 61 kWh/m^2.annum to 37 kWh/m^2.annum, so a similar ratio in reduction, though the total amounts are also approximately only a third of the predictions anyhow.

So if we could include those finer details, this implies that the building would in fact rate significantly higher – and when we compare actual energy usage – as this also includes all the energy not just the heating and cooling loads, and includes use as an office.

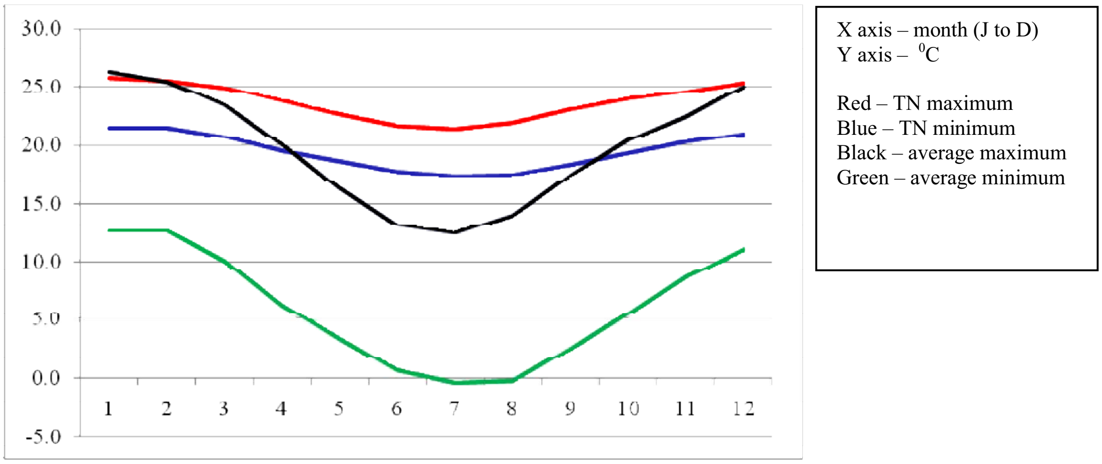
So putting aside the actual figures, the relationship of the figures is what counts here – ie not whether it's 50% vs 60.5%, but that simply put energy consumption has reduced by half.

4.2 Temperature Comfort

The other interesting issue here is the ratings (*Tab.1: Predicted and Actual energy usage and Star ratings*) emphasise a heavy heating load which is justified, but also imply there is still a cooling load, namely 8.2 kWh/m^2.annum down to 3.0 kWh/m^2.annum – when in fact cooling was and still is more or less zero.

But that is also because the software assumes what is a bearable temperature – what is an acceptable winter temperature? Summer temperature? What temp do you heat and cool to? We heat to 17-18 ^{0}C in the body of the house, never higher. And apart from the heatwave of November 2009, we have also rarely needed to use the fan. But while some might react that that seems too cool, in fact it is not. At least not for the given location and climate, and the internal temperature's relationship to the external temperature. And that is also where behaviour comes in again – dressing appropriately to the season, such as jumpers in winter, and lightweight clothes in summer. Not only does everyone have a different thermostat, an individual's own temperature perception will vary depending on mood, health, stress etc.

Fig. 1: Thermal Neutrality plotted to Armidale Monthly Average temperatures (LTA, BOM, Updated 2008)

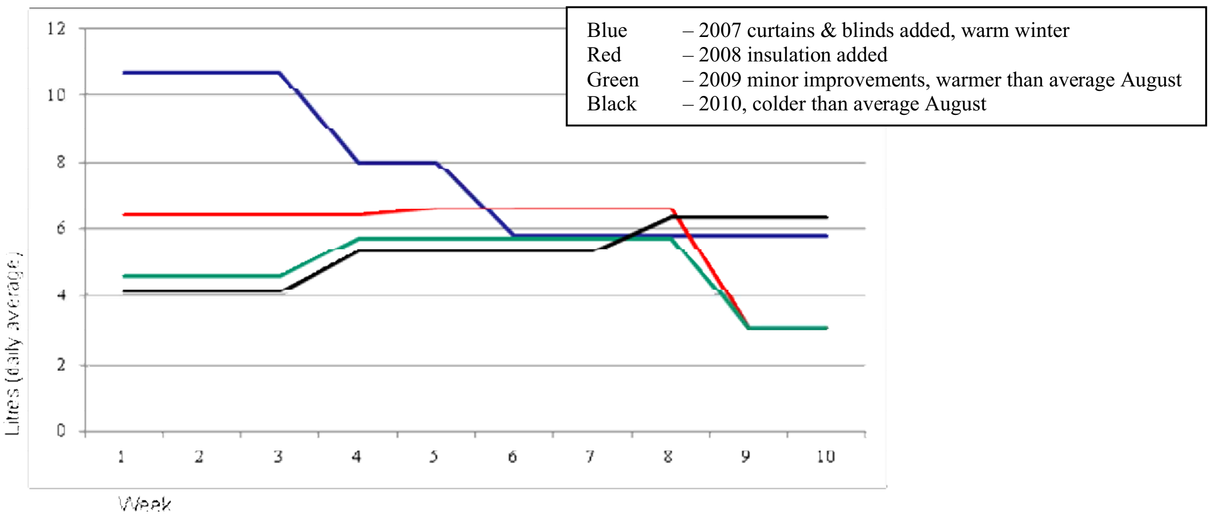


Using the formula for thermal neutrality – 0.31 x average monthly outdoor temperature + 17.6, we can determine what is a comfortable temperature, with a bandwidth either way for an acceptable comfort level. Mapping Armidale's average monthly minimum and maximum temperatures against this formula (*Fig.1: Thermal Neutrality plotted to Armidale Monthly Average Temperatures*), the house's internal temperatures are on par with the acceptable comfort levels. The figures indicate a minimum figure of 17.5^{0}C and more for winter, and a maximum figure of 25.8^{0}C and lower for summer. Given that we only heat to a max of 18^{0}C in winter, and the house rarely reaches 26^{0}C in summer, it would appear that we are living fairly comfortably.

4.3 Heating

A central gas heating system feeds most of the house, but does not extend out to the office, where an electric heater is used. The house is rarely heated during the day, and runs at night only long enough to raise the internal temperature to 17 or 18 ^{0}C, then switched off. There is a free-standing gas-log heater in the family room, used intermittently, and a built-in gas log in the lounge room – used more often, though only for a few hours, and only turned on after the central system is turned off.

Fig. 2: Gas Usage - mid May to mid August

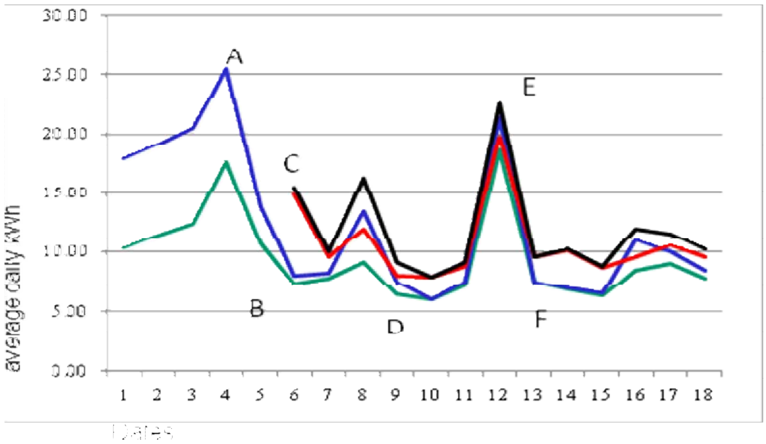


The ratings imply basically a halving of heating needs – 0 stars at 189 kWh/m^2.annum dropping to 95.7 kWh/m^2.annum with 3 stars (NatHERS V2.32 rating assessment, May 2011). The actual litres (1 litre = 7.08 kWh) have more than halved (*Fig.2: Actual Gas Usage*), though there are weather variances contributing to this as well, and some gas is used for cooking. Again, use is affected by behaviour. But the reality indicates yes, the improvements to the building have contributed to reducing the heating demand.

4.4 Electricity

The office, unlike the house, is heated during the day in the cooler months, though not all day or even every day due to the room receiving good sun in winter. The heater is electric, and during an increased work period in 2009, two electric heaters in two rooms were running for a short time (the spike in the graph, *Fig. 3.Electricy Usage – August 2006 to August 2010*). The internal door from the office leads to a hall, which in turn has a door to the rest of the house, so allowing the office to be isolated from the rest of the house and other conditioned and unconditioned zones.

Fig. 3: Electricity Usage – August 2006 to August 2010



Green – Import – house only
Blue – Import – House + Off-peak supply
Red – Total – House + PV
Black – Total – House +Off-peak supply + PV

1. Aug06 to Nov06	5. Aug07 to Nov 07	9. Aug08 to Nov08	13. Aug09 to Nov09	17. Aug10 to Nov10
2. Nov06 to Feb07	6. Nov07 to Feb08	10. Nov08 to Feb09	14. Nov09 to Feb10	18. Nov10 to Feb11
3. Feb07 to May07	7. Feb08 to May08	11. Feb09 to May09	15. Feb10 to May10	
4. May07 to Aug07	8. May08 to Aug08	12. May09 to Aug09	16. May10 to Aug10	

A. Builders on site	B. Solar Hot water (SHW) added	C. 1.5kW added; Builders on site
D. Insulation added; SHW Water booster off	E. Increased office staff	F. 2.0 kW added

The house has the usual electricity demand - TV, stereo, kitchen appliances, washing machine, fridge, freezer etc. Most appliances are turned off to avoid standby load – typically 10% for the average household. But the office obviously adds higher demands to normal household load.

Yet, putting the spike aside, the total office and house combined are well down below the average, implying then that the house itself is indeed a very low electricity consumer. Taking the spike out, the downwards trend is quite apparent, and is likely to now level out rather than continue to drop much further. Though the reduced carbon footprint will be maintained due to the excess generation of the PV array.

So what caused the spike? – the office temporarily expanded into the adjoining room, increasing from 1½ people and 1-2 computers, to 4 full-time staff and 4 computers (and all the added extras - more coffee breaks, two heaters, small fridge, etc). This then dropped again very quickly with a change in weather (our hottest August on record) but also a change in behaviour when the newcomers were instructed on better use of the heater. The office is now back to 1-2 people, but 2 computers used significantly more often than before the spike. Again, equipment was and is not left on standby when not in use, and practices such as batch printing employed.

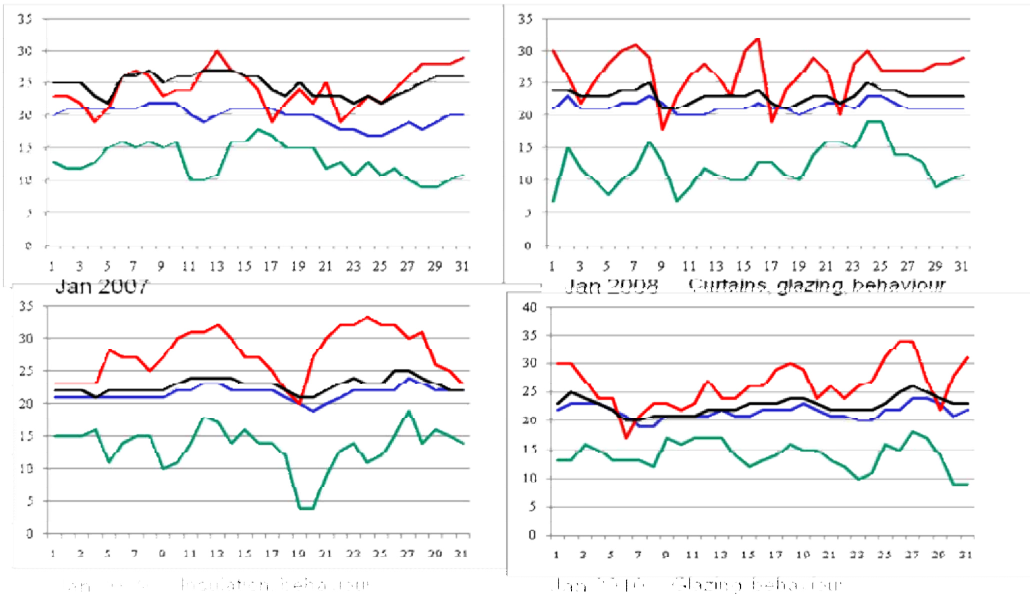
So increases were also caused by builders on site, but then reductions when the solar hot water was added and then manual management of the booster. The addition of the PV systems, while not reducing actual energy use, has reduced electricity import, and therefore CO^2 emissions, as the office draws directly from the system during the day.

The solar array initially at 1.5 kW was averaging about 85% of total electricity demand, and exporting about 80% of its generation into the grid. The improvements to the house increased that to 100% plus on occasions. Then with the increase in the system size, the house now exports, on average 2-3 times the amount it imports. Again, climate affects this and with the ending of the drought and a very wet and overcast spring and summer (2010-2011), generation has dropped significantly, though it still manages to be a significant net exporter. And while the PV's do not actually reduce energy usage, they do reduce GGE.

4.5 Internal Temperature Stability

Over four years, the internal temperatures are also evening out and less vulnerable to external changes. The graphs comparing January temps over four years (*Fig. 4: January Temperatures – 2007-2010*) show that while initially the internal fluctuation partially imitated outside fluctuations, the internal temperatures are much more stable and flattening out. This in turn of course reduces the need to heat (and cool) but also improves overall thermal comfort within the building.

Fig. 4: January Temperatures ^{0}C – 2007 to 2010



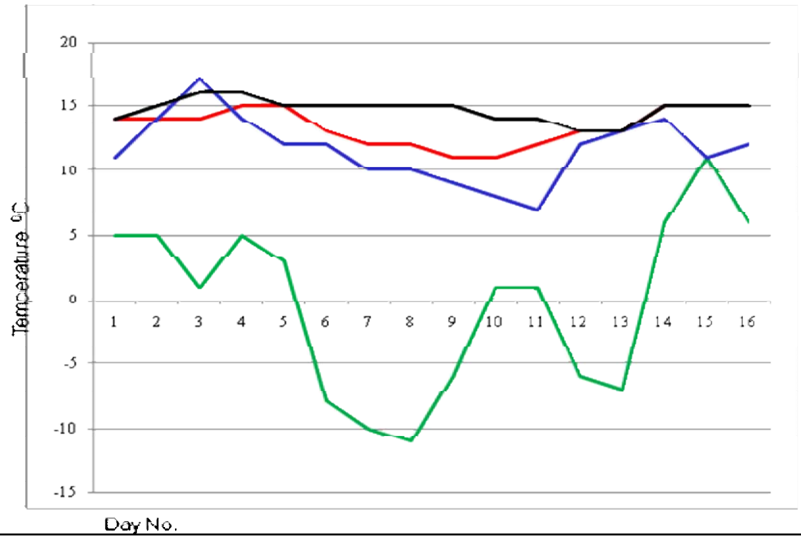
Green – external minimum; Blue – internal minimum; Red – external maximum; Black – internal maximum;

The most immediate improvement was the addition of the ceiling insulation (with similar results for winter temperatures). So with all the improvements, the internal temperature is now very stable and far less reactive to the external weather changes.

However, behaviour does have an impact – the 24^{0}C maximum internal reaching 26^{0}C on the day the house was not closed up early enough and it reached 35^{0}C outside. And after a week of very warm weather, the night purge becomes less successful as the thermal mass can only absorb so much. But once again, it appears that things have much improved in 4 years.

And likewise for winter (*Fig.5: Temperatures ^{0}C - 23 June to 8 July, 2010*), with the minimum internal temperature for an unheated house during the day, never dropping below 14^{0}C, more often at least 15^{0}C, unless uninhabited. The one exception was a fall to 11^{0}C and 12^{0}C degrees in June 2010 after overnight temperatures dropped to minus 10^{0}C and minus 11^{0}C. Taking the 2 week period around this event, the house was unoccupied on the second day, with no evening heating on the second, third and eighth days – and yet despite the extreme minimums, managed to hold its temperatures better than two years previously in warmer weather.

Fig. 5: Temperatures ^{0}C – 23 June to 8 July, 2010



Green – external minimum; Blue – internal minimum; Red – external maximum; Black – internal maximum;

4.6 *Behaviour*

So a closer look at some of the other variations - especially with the temperature – aside from unseasonal weather events, is due to behaviour. The most obvious one is when no one was home to open/close curtains and blinds, open and shut windows and doors – let in the winter sun, block out the summer heat, or keep in the evening warmth. In midsummer, the internal temperature is rarely above 24^{0}C, usually no higher than 23^{0}C – but the days the house was not shut up early in the morning, or not purged at night, the temperature went higher.

Likewise overnights rarely below 15-16^{0}C but lower when curtains were not closed in time, or with several days unoccupied and no one to open up and let the sun in during the day, and sometimes also if there was no evening heating to maintain the temperature (as noted above).

So it is obvious that regardless of the structural improvements, behaviour can also be an influencing factor.

And then there are obvious behavioural impacts on energy use, though not necessarily in this particular house, such as standby power, which can easily add 10% to energy usage. How appliances are used is important - CFLS will not save energy if they are left on all the time.

So behaviour has a big impact – but even with poor behaviour, the house's carbon footprint has been lowered. And due to the net export of the PV system, this is reduced even more.

5. Conclusion

5.1 Future Improvements

There are still things that need and/or might be done to further improve the building –

- Double glaze the rest of the southern windows, and the front door and surrounds;
- Install better blinds to the kitchen windows;
- Finish insulating under the floor;

While we have opted not to even attempt to insulate the double brick cavity walls, the many other things we have done and will do will offset this loss. As they will also offset the behavioural issues we cannot avoid.

We are also considering options to replace the gas heating – which after all is still a fossil fuel, as without insulating the walls the house will still need midwinter heating, but in the meantime we will keep reducing the heating load required.

5.2 Lessons Learnt

Returning to the original issue of retrofitting existing buildings – yes, the ratings do add up via a myriad of things you can do to reduce a building's carbon footprint, but nothing is in isolation. Different changes will have different impacts, but all combined can still be manipulated, reduced, or enhanced by how you use the house.

So lessons learnt and conclusions drawn –

- It is about finding a balance – getting the building structure right, the fitout and appliances right, but behaving appropriately to the building.
- It is understanding that no matter how good the infrastructure, your actions need to be part of the story to enhance the benefits.
- It is about using the building appropriately and taking advantage of free heat and daylight for an acceptable level of comfort.

For our buildings, new and renovated, we need to understand the relationship of structure to nature, working with it rather than against it. But also design for appropriate use rather than just for fashion.

So Australia has this existing building stock. And most of it is anything but sustainable. But nor is demolishing buildings that would otherwise still stand for many years to come, and, in terms of their function of providing shelter essentially successfully, a sustainable thing to do. So we need to upgrade, retrofit, improve what we have already.

We have access to technology, systems, materials, energy sources far superior to those that were around when these buildings were built. But we need to employ them in the right way. A good retrofit will first reduce the demand, then make the demand more efficient and only then is it appropriate to consider sourcing that demand renewably.

In order of importance – and of cost and effectiveness – the simplest, easiest and least costly actions are also often the most effective. And while we can use the ratings process to assist and predict, we still need to use these buildings correctly. "There is no good or bad technology to carry out a task – only appropriate or inappropriate. Big, modern, expensive is not necessarily best, it all depends on the circumstances." (Schumacher, E.F., 1973. Small is Beautiful: Economics as if People Mattered). And it is those circumstances that we should be addressing.

In this case, the circumstances of a significant amount of ineffective building stock. New work might be fine, but the existing stock must be addressed.

And we need to embrace an holistic approach – the physical, large and small, and the behavioural.

But it is time to wake up - we need to educate behaviour, choice, expectations. We do not need to compromise on lifestyle – we can still be warm in winter and cool in summer, and our existing houses can be quite easily retrofitted to achieve this in a myriad of different ways.

We need to include our behaviour and our expectations into the equation, we need to experience these things as part of a different lifestyle. Of a sustainable lifestyle. What we need is "not an old vision with a new program, but a new vision with no program." (Quinn, D., 1992. Ishmael – An Adventure of the Mind and Spirit).

We can still create beautiful buildings, we can still live in our 100 year old houses, we can even still have our precious detached house on the quarter acre block - but we must do so sustainably. And it is possible. It is doable. But it is also essential.

If you have the opportunity to upgrade your own house, or renovate someone else's, if you can influence choices with the ratings and modelling tools, if you have the power to legislate for retrofitting, or if you sell products that can improve existing buildings, take that responsibility and run with it. And believe that each of us individually and collectively will make that difference, and be inspired to do so.

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Note: Energy data obtained from records collected on site and converted to Excel spreadsheet and graphs.