Modify a project home

This case study shows how cost effective changes to a standard project home were negotiated with the builder to improve comfort and lifestyle and reduce environmental impact. The result was an actual annual net saving for the owners.

If every project home was adapted in this way, a staggering reduction in environmental impact would be achieved at no cost and the owners would enjoy Increased comfort and better living.

The house was re-oriented on the site to achieve true passive solar orientation.

The plan was mirror reversed to achieve:
> North facing living areas and windows.
> Exposure to cooling breezes and views.
> Reduction of west facing window areas.

The garage was re-located under the house to:
> Improve solar access and better fit site slope.
> Reduce excavation and brickwork.
> Save money and embodied energy.

The floor level was raised to maximise exposure to cooling breezes and views.

Allowance for cost of turf was traded for low water, native landscape design and mulch.

Existing native trees were retained.

Gas storage HWS replaced off peak electric.

AAA rated shower heads were fitted.

R1.5 wall insulation was added.

Roof insulation increased from R2.0 to R3.0.

Total additional cost	**$6,791.00**
Additional annual mortgage repayment:	$440.00
Saving (approx.) annual energy bill:	$400.00
Saving (approx.) annual water bill:	$600.00
Net annual saving	**$560.00**

BUILDING TYPE: New home, brick veneer construction		
CLIMATE: Cool / Cold temperate - New South Wales Southern Tablelands		
Topics Covered		**Success Level**
Passive solar heating		Very Good
Reducing water use		Excellent
Rainwater harvesting		Excellent
Greenhouse gas reductions		Very Good
Reducing transport impacts		Very Good
NatHERS Rating	Before ★	After ★★★★

PROJECT BACKGROUND

The owners were tired of the rent cycle and houses that were hot in summer, cold in winter and could never be heated sufficiently – no matter how much they paid in heating bills. A new "house and land package" offered by a local project-home builder was very attractive to them.

The plan included all the rooms they needed. The builder had a good reputation and the land was in a convenient area, close to shops and friends. They were able to visit other houses built by the builder, speak to the owners and see for themselves that the quality met their needs.

Mortgage repayments were kept equivalent to rental on a similar sized home allowing them to own their home without restricting their lifestyle. This was important as the owners like to travel frequently, eat out regularly and pursue their hobbies free of an onerous mortgage.

A designer experienced in sustainable design and familiar with the climate was engaged by the owners to investigate options for improving the performance of the house at least cost.

The owners had a secondary but very important ambition to reduce the environmental impact of their new home.

The builder agreed to discuss the changes and was pleased with those eventually negotiated. Being a good businessman, his initial estimate for the changes were a "little high" in the designers opinion but some quick negotiations arrived at "a deal" that all parties were happy with.

After a site analysis, evaluation of the proposed floor plan and discussion of costs and benefits of various options with his clients, the designer negotiated with the builder on their behalf to "tweak" the design to improve its comfort, operating economy and lifestyle requirements.

THE SITE

The sub-division is a small cul-de-sac, greenfields development over which the developer and builder had control of 80 percent of lots (some were sold to individual owners).

The block is located on a moderate to steep north-east sloping hill with excellent views north and east from the higher portion.

The hill provides protection from prevailing cold SW and hot NW winds. It has potential high level exposure to cooling summer breezes.

The diagonal slope presented significant challenges for locating a single level home without substantial cut and fill.

Climate – Cool/cold temperate. Low rainfall (600mm pa) High day/night (diurnal) temperature range winter and summer. Cold, damp winters (minus 5ºC is common at night); severe frosts; short, hot to very hot summers (mid 30ºC common with occasional heatwaves to mid 40ºC.

Former land use – Used for grazing purposes and contained significant mature individual eucalypts. Soil had-been "pasture improved" with exotic grasses and addition of superphosphate over the preceding century. Overgrazing had turned the soil acidic (pH 4.3).

Planning controls – A brick and tile covenant over the entire subdivision. Minimum one metre setback required from all boundaries. No easements or tree preservation orders.

Orientation – The block had a long N/S axis and was battle axe shaped. It was in an elevated position in the cul-de-sac, facing NNE.

Neighbouring houses – These were of similar style and construction, varying street setbacks and alignments. Due to poor subdivision design all houses are built one metre from either boundary.

Existing flora and fauna – The block and its trees formed part of an identified wildlife corridor that the Council is working to restore. It linked remnant bushland habitat with a nearby river.

THE ORIGINAL PROPOSAL

The battle axe shaped block limited siting options for the rectangular plan. The builder's proposal was that the home be aligned to the west boundary with longest axis running N/S.

This orientation meant that the house spanned the greatest range of slope requiring extensive cut and fill and an estimated 5,000 extra bricks to build up the front.

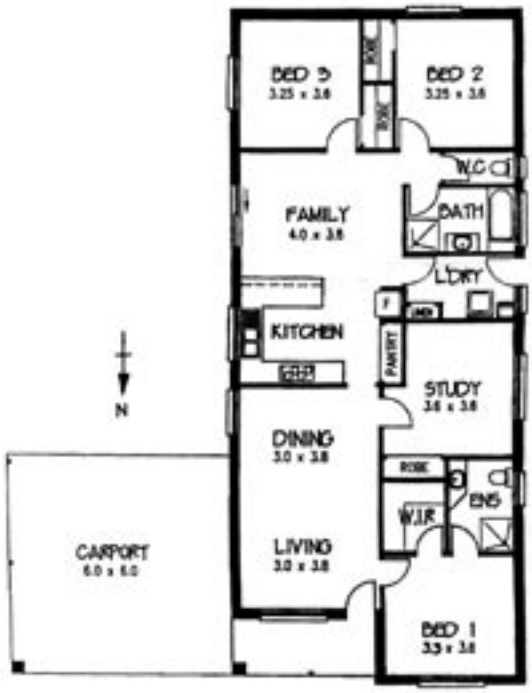
Living areas and kitchen faced east and opened into a garden with north sun blocked by the carport. This would have allowed winter frosts to remain well past mid morning.

Only the carport took full advantage of panoramic NE views in the proposed orientation.

Only one window had exposure to northerly sun (the main bedroom). The single north facing living room window would have been permanently shaded by a verandah.

Siting towards the front of the block also reduced elevation and exposure to views and cooling breezes which are generally easterly or south easterly in the region.

Much of the back garden would have been lost to excavation and steep embankments.



Original proposal

Final plan as built

The laundry opened out onto a one metre wide path to the west running the full length of the house and the study, bedroom 2 and the bathrooms looked out onto the neighbour's fence.

WHAT WAS ACHIEVED

The designer explained the concepts of passive solar design and their importance for comfort and lifestyle in the climate. The standard plan was ideal for passive design principles – but only if orientated north. The first priority was therefore to find a way to orient the longest axis and the living areas to north without making expensive changes to the floor plan.

This was easily achieved by turning it through 90 degrees and mirror reversing it. The builder agreed that there was little additional cost in turning the small entry porch into additional living area as the wall and roof and floor areas remained the same.

North facing glass areas were enlarged and one west window deleted. [See: Orientation; Passive Solar Heating]

Standard eave overhangs (450mm) were inadequate to provide summer shading to full length glass. The builder agreed to increase the eave overhang to 600mm to exclude all sun from late October to late February. Cost $500. Unfortunately, only 500mm (including the gutter) was achieved. [See: Passive Solar Heating; Shading]

Fitting the plan on the narrow block in this configuration meant moving it well towards the back of the block making a smaller back garden and a larger front garden.

Site plan

Initially, the owners were not keen on having their living areas opening toward the street. However, after roughly pegging the house out on the block and visualising it by running some twine around the pegs it became clear that:

> By retaining existing eucalypts and planting a dense privacy screen of shrubs, the area outside their living rooms would be the most private as the neighbour's garage faced that boundary and had no windows.

> The views were much better from the higher rear portion of the block and, if the floor level was set at the highest point, panoramic views to the north and east over the neighbour's roof were achievable.

> Exposure to the views meant exposure to cooling breezes in summer.

> When the eucalypts matured, their height would provide summer shade to much of the house and allow lower angled winter sun to penetrate under the canopy for passive heating.

It was quickly decided that this orientation offered the best results and maximised site usage but the entry was well above ground level and the carport blocked north sun.

The owners wanted a lock up garage instead of a carport. Some quick calculations by the builder revealed that locating the garage under the house as part of the conversion saved around 5,000 bricks. This saved embodied energy and reduced excavation. [See: Embodied Energy]

Moving the garage forward created an entry verandah, reduced the number of steps required to the front door and further reduced excavation. [See: Sediment Control]

The second priority was to maximise the passive design benefits by providing thermal mass to store heat in winter (and cooling from summer breezes).

Thermal mass – The builder estimated that replacing the timber floor with a suspended concrete slab would add around $4,000 to the price. After lengthy consideration, the owners decided against this option which would have increased the NatHERS rating to 5 stars. [See: Thermal Mass]

A recently released lightweight concrete floor system could have provided the required thermal mass at similar cost to the timber flooring. It was unfortunately not available at the time of construction.

Insulation – The standard package allowed no wall insulation and only R2.0 insulation in the ceiling. This was considered inadequate. The builders quote for R2.0 wall insulation and to increase the roof insulation level to R3.5 was accepted. [See: Insulation Overview]

Cross ventilation was improved by adding a second window to the main bedroom to draw cooling breezes across the bed. The two room depth plan otherwise provided good cross ventilation to the living areas. [See: Passive Cooling]

Adjustable shading was recommended for the three east and west facing windows. Canvas awnings could have been installed during construction for around $700 per window. The owners are planning to have them added in the near future. [See: Shading]

A natural gas Hot Water Service was used in place of the off peak electric one at no additional cost. This reduced greenhouse gas emissions by almost two thirds. [See: Hot Water Service]

AAA showerheads were fitted at no additional cost. This reduced both water and energy consumption.

Landscaping was important to the owners. They often work weekends and felt that mowing lawns was a chore. The builder's allowance for turf lawns was traded for a low water native garden including plants and mulch. The smaller back yard was planted to lawn as a dog compound and clothes drying area.

COSTS

Features negotiated with the builder:

Additions:

Double garage + bonus storage area under house.
Larger living area (additional 10 sq.m.).
Extra cost of altering roof (tiles, timber, etc.).
Extra insulation.
Extra concreting for balcony.
Patterned concrete driveway finish.

Total additions **$15,951**

Deletions:

Carport.
Turf allowance (instant roll lawn).
Excavation costs.

Total deletions **$9,160**

Builder's original contract price offer.	$144,500
Final price (after modifications).	$151,291

Total additional cost **$6,791**

Additional mortgage repayments of $440 per year are more than offset by energy and water bill reductions.

After construction a registered valuation was prepared and the home was valued at $25,000 more than the purchase cost, in a regional city where house prices were falling.

The valuer attributed this to improved views, higher daylight levels and in-built passive solar features.

EVALUATION

In the new home the entire house is comfortably heated for-the same cost as just two rooms in the previous rental-house.

Winter heating bills have only slightly reduced compared to the old home but the entire house is now comfortably warm, something that was impossible in the previous home.

"It is considerably easier to keep warm in winter and although the new home is double the size of the old one it feels twice as warm."

No daytime heating is required on sunny winter days to keep the house at a comfortable temperature – even when the outside temperature is only 5ºC.

The additional insulation reduces heat loss at night but the low thermal mass does not retain heat and supplementary heating is required to maintain overnight temperatures.

Part of the home is used as a natural therapies clinic. For the benefit of clients, gas or wood heating is used to keep temperatures higher than normal on clinic days.

The owners are extremely happy with their home and feel good about the contribution they have made to reducing its environmental impact. Occupants, visitors and clients all comment on the abundant light and "feeling of space" in the average sized home. No artificial lighting is required during daylight hours.

"The home is so easy to live in and my emotions and sense of well being have improved since moving in. I feel happier in this light, bright space – even our house plants grow better."

Natural cross ventilation throughout the house and bedrooms makes summer sleeping very comfortable.

The owners wished that they retained the designer to monitor construction. This would have avoided the problem with eaves not sized as planned. The designer would have noticed this and had it corrected before completion. As a result, sun penetration occurs two to three weeks earlier in summer causing minor discomfort.

A west facing window intended to be deleted was installed by mistake. Planned adjustable awnings will rectify this and still allow winter heating.

Given the choice again, they would definitely spend the extra to install a concrete floor for thermal mass.

"I didn't understand the value of thermal mass but regret not having the suspended concrete floor as we were advised. We would certainly make it a priority if we ever built again."

What the owners would do differently next time:

> Add the extra $4,000 to the mortgage for a concrete floor with high thermal mass.

> Include E/W sun control during construction.

> Include a larger, shaded East facing window in the lounge for views and cooling breezes.

> Choose a non reflective surface for the verandah.

> Extend the eaves to 600mm as specified.

> Install ducted heating.

"We would like to add a solar hot water system in future and add PV panels to generate electricity on site in the long term." [See: Renewable Electricity Overview]

ADDITIONS MADE AFTER MOVING IN

An efficient wood heater was installed for ambience and space heating – cost $1500. Wood is a renewable energy source but the owners go to great lengths to ensure the wood they buy comes from a sustainable source. Wood is kept dry and the heater burns cleanly because they only turn it down after it has burnt hot for at least an hour. Tell tale creosote stains on the chimney appear when the heater is not burning efficiently. [See: Heating & Cooling]

A rainwater tank for drinking water and gravity fed garden watering – cost $900 including the first flush divertor and installation. Water is carried inside by bottle. [See: Rainwater]

COMMENTS FROM THE BUILDING DESIGNER

I would argue more strongly for the concrete slab floor and possibly an internal brick wall to increase the thermal mass. The climate has very high diurnal ranges and the design would really benefit from accessible thermal mass in summer and winter. Gas heating would not be required if the thermal mass was included.

An airlock for the entry would have reduced heating costs and eliminated cold air blasts every time someone enters or leaves during winter. The climate really warrants it but it was difficult to achieve within the standard plan. "I really think project home designers should consider airlocks in their designs for cool and cold climates."

Enlarging the east facing window in the living room would have allowed too much heat loss in winter. "The view is great – but in this climate, I'd rather move my chair a little to take it in. I am pleased that it was not made bigger."

The designer is urging the owners to:

Insulate under their floor. The sub-floor is well ventilated and much of their winter heat loss is through the floor. "I estimate they can do it for about $1,000 with a few friends on the weekend."

Fit adjustable external blinds to the east and west facing windows to reduce summer heating and allow full sun in winter. "I nearly had a heart attack when they told me they were considering an air conditioner for the clinic to keep patients comfortable in summer."

An adjustable awning blind to keep the sun off the glass combined with cross ventilation will be just as effective and less expensive (to buy and operate). It will also allow fresh air in.

Install snug fitting pelmet boxes to all windows. The single glazed aluminium windows are WERS 0 star rated for heating climates. Double glazing was too expensive but well fitted pelmets with heavy drapes would achieve the same insulation value (around R0.5) for less than double glazing. *"In an ideal world, we would have both."*

NatHERS ASSESSMENTS

The house was modeled in five configurations.

1) Originally proposed floorplan and orientation with no insulation in ceiling or walls.

NatHERS Rating: Zero Stars **0**
Energy consumption: 916.9 Megajoules per square metre per annum (MJ/m²/a).

2) As originally proposed by the builder. As above with reflective insulation under the tiles and R2.0 bulk ceiling.

NatHERS Rating: 1 Star ★
Energy consumption: 534. MJ/m²/a.
A 42 percent reduction on 1).

3) As built: longest side (living areas) oriented to magnetic north; sarking under tiles; R3.5 bulk insulation in ceilings; R2.0 insulation in walls.

NatHERS Rating: 4 Star ★★★★
Energy consumption: 274.5 MJ/m²/a.

A 48 percent reduction on 2 and 70 percent on 1.

Note: This option was also modeled with R1.0 insulation under the floor but no change was recorded because NatHERS assumes that no heat is lost through a timber floor with an enclosed sub floor. Local experience does not support this. Significant benefits are experienced.

4) As for 3 but with adjustable, vented, canvas awnings to east and west facing windows.

NatHERS Rating: 4.5 Star ★★★★★
Energy consumption: 272.3 MJ/m²/a

5) As for 4 but with 125mm suspended concrete slab floor in lieu of timber.

NatHERS Rating: 5 Stars ★★★★★
Energy consumption: 244.1 MJ/m²/a

Note: Whilst option 4) scored an additional 0.5 stars compared to option 3), its energy consumption is only improved by 2.2 MJ/m²/a This is because option 3) is just outside the 4.5 star band and option 4 is just within it.

Option 3) was also modeled in various cities to demonstrate why houses must be purpose designed for their climate.

Hobart	191.3 MJ/m²/a	★★★★★
Melbourne	188.0 MJ/m²/a	★★★★½
Sydney	153.7 MJ/m²/a	★★★★
Brisbane		
(old band)	165.6 MJ/m²/a	★★★
(new band)		★½
Cairns		
(old band)	290.6 MJ/m²/a	½
(new band)		★★

Note: In Sydney, Melbourne and Brisbane, a concrete slab floor would add 0.5 stars or better.

The ratings also show how NatHERS adjusts sensible energy consumption relative to climate.

Various “climate bands” recognise that each climate has different heating and cooling needs. The bands are adjusted so that, in any climate, a 3.5 star house will be comfortable but require heating and/or cooling. A 5 star house will be the most comfortable in a given climate and save more on energy bills. Many “best practice” homes achieve well in excess of 5 star ratings.

Updated bands have been introduced for Queensland which de-rate the house in Brisbane and increase its rating in Cairns. They do not affect the energy used – simply the expectation of what will be a comfortable house. For details about NatHERS
[See: Rating Tools]

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