Introduction to EcoSolar house design principles (V2)

Derek F. Wrigley, OAM

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EcoSolar is a *system* of residential construction designed to provide human comfort in a climate of cool to cold winters and warm to hot summers found in most of the southern states of Australia. These temperature extremes create difficulties in designing residential buildings and in the 20thC the colder months have required artificial heating for reasonable comfort and, in recent decades, artificial cooling by way of air conditioning. These two extremes require balances and some compromises in construction.

Both heating and cooling have created increasingly unacceptable surges in energy consumption when using fossil fuels, resulting in excessive atmospheric pollution and rises in domestic running costs. Science now clearly tells us that global warming is occurring partially as a result of these activities and that we can expect climatic changes which will increase domestic discomforts.

Australian housing contributes approximately 20% of our total atmospheric pollution, but we have not yet learned to design our houses to take advantage in any scientific way of the abundant natural - and free - resources available to most areas in Australia.

Our resources of fossil fuels are finite and will become more and more expensive in the future and if we are wise, we must learn to design our houses more effectively.

CSIRO predicted in 2002 that we can expect less rainfall in the coming decades, so why are we not modifying our housing designs to make better us of diminishing resources?

We have a much better knowledge of the thermal behaviour of residential buildings than was evident in the 20thC, science has given us more predictive tools with which to overcome these problems and many individuals and industries have risen to the challenge.

The EcoSolar system is an *integrated* response to many of our current problems based on fundamental science. It is not a *specific house design as such*, rather it is a group of science based systems complementing an essential structural core to achieve reasonable human comfort at low running costs and which can apply to a variety of house designs. These systems have been designed with two aims - to provide better *new* housing and to make them individually suitable for *existing* houses - by far the biggest return on investment for the environment.

Lastly, in considering the cost of housing we will soon *have no choice* but to adopt a *'whole of life'* approach, not only from the 'cradle to the grave' but from the 'cradle to the cradle' - 100% re-use and re-cycling - *real sustainability*. It *must* be seen from an ecological or a bio-sensitive perspective in terms of its consumption of resources and energy over a much longer lifetime.

There are some provisos however :

1 We cannot continue in our current *unscientific* design mode if we are to achieve our aim. If we are to effectively use science to our advantage then we have to discipline our selves to accept the uncompromising geometry of the sun's daily and seasonal

movements relative to our house location. The sun is our only source of continuing energy.

2 Subdivision planners can no longer be allowed to divide up parcels of land in smaller and smaller plots which pay no regard to solar orientation, sizes and proportions with little or no regard for how effective solar house designs can be placed on them. Cost-benefit analyses must balance the economic savings *now* with the long term energy and human consequences of short term, so called economic thinking.

3 Urban designers, house designers and the regulatory authorities must work more closely together and agree on what constitutes an effective house to match the coming changes in our climate. Ignorance by all relevant parties in the supply of housing can not be accepted any longer.

4 We can no longer rely on cheap energy to *correct* basic design mistakes. The problems have to be designed-out at the early stages of the design process by designers who are competent to achieve what must become standard practice.

This is not a complete guide to low-energy house design - it is simply one person's design suggestion toward a better answer than what has gone before. It is a series of integrated sub-systems based on good building science to suit the circumstances which now face us all.

An effective EcoSolar house must conform to the following principles, based on the technologies we have in the early 21st century :

Planning

1 The house must be relatively small, preferably rectangular, with its longest elevation facing within 15° toward the equator. This aspect has a critical bearing on the energy effectiveness of the house and the comfort of its occupants.

2 The roof is the most valuable solar receptive area of the house envelope and should be a strong determinant of the overall energy design of the house in terms of area, orientation, pitch and available energy collecting technologies.

3 To maximise planning densities with economic and human relationships the east and west walls should preferably have no windows or doors.

4 The elevation facing away from the equator should be regarded as an effective solar collector rather than unthinkingly abandoned as a lower value area for occupant use.

The EcoSolar structure

1 A suitable external wall construction system would have the mass on the inside and protected insulation on the outside with high mass internal walls throughout to balance the solar heat gain from southern as well as northern windows. This house concept has been designed to suit precast, prefabricated, insulated panel construction which can be erected very quickly on site, especially in housing estates. This technique can significantly lower the overall cost of construction and reduce bad weather delays.

However, it does not exclude the effective use of more traditional unitary construction methods which are more generally understood by the housing trades, but much slower and more inconvenient to build.

2 High mass ceiling and floor are also appropriate to the panel construction system.

3 The roof space is traditionally triangular for many reasons, enabling a number of solar collection techniques to be integrated on suitable surfaces outside as well as making possible effective systems such as the NatVent, WaterShield, InterSun, GreyPura, GreenVent as well as photovoltaic and solar water heating (described below).

Supporting sub-systems

a Bushfire protection (EcoSolar basic construction, WaterShield, CoolBank)

1 The roof space is usually the first area in the house to catch fire in a bush fire event, and history has shown that once this area catches fire the house is quickly destroyed.

Consequently, *there is no flammable material above the ceiling line* of an EcoSolar house. Combined with a concrete plank ceiling the habitable areas of the house below provide a reasonably secure haven for both occupants and possessions. In a life/death situation there is the fallback position of CoolBank (**e 5** below).

2 Although the house structure is as economically fire resistant as is economically practicable, a further safeguard is WaterShield, two rooftop, intermittent radial sprinklers, separately activated from the laundry supplied from the water storage. The circular coverage would keep the roof area wet with most water returning to the storage bladders.

3 The above provisions should have the potential to reduce fire insurance premiums, but this has not been tested.

b The natural ventilation sub-system (NatVent)

1 A concrete ceiling throughout, insulated on top, enables three sub-systems to work together in appropriate seasons.

The major NatVent sub-system works in summer to keep the internal house structure cool, with large, easily adjustable vents in the concrete ceiling to promote naturally buoyant vertical ventilation from windows and doors (usually after 6pm) in all habitable spaces to the variable remotely closable vents in the clerestory window. This buoyant upward air flow continues throughout the night to enable any residual stored heat in the house structure to escape upwards to the night air and creates no noise or uses any energy. This ensures that the house interior remains as cool as possible to avoid the usual cumulative heat gain experienced in traditional brick houses. These air currents are controlled manually by the ceiling vents in the kitchen area and the clerestory vents by remote control. The NatVent system can be supplemented in very hot conditions (a few days in Jan/Feb in Canberra) by forced air through floor openings from the sub-floor space which is cooled by the large water storage bladders.

2 The internal solar reflector sub-system (InterSun) makes a secondary use of the NatVent space by directing solar heat and visible sunlight down through the translucent ceiling vents into the darker central area of the house, creating good natural lighting as well as visually cheerful sunny area. This enables about 90% of the floor area of the house to receive sunlight in the colder months, having a very significant effect on the psychological wellbeing of the occupants.

d Reducing radiant heat gain through the roof

1 Summer heat gain through the northern roof induces a separate upward air flow through lower, permanently open slot vents above the northern windows. This flow is controlled by the open clerestory vents *(closed in cool weather of course)*.

e The underfloor water storage area (CoolBank) serves a number of functions :

1 It stores rainwater to meet all domestic consumption needs.

2 The space maintains a large volume of cool air which can provide cooled air in a very hot period, using the large mass of stored coolth in the storage bladders.

3 Manually closable supply and return vents in the floor of all habitable spaces will distribute the cooled air to ensure cross-ventilation. The slab should be insulated underneath to reduce winter heat loss.

4 The NatVent and CoolBank systems make an air conditioner unnecessary, especially if the CoolShade or GreenVent systems are constructed *(see **GreenVent** below)*.

5 In a really serious bushfire emergency the cool, ventilated underfloor space would be accessible to the occupants through a trap door in the laundry. Even if unventilated there would be more than sufficient air for survival.

f Making southern rooms more useful in winter (WinterSun)

1 Unused sunlight passing over the roof is reflected into southern windows to heat the rooms (8 to 12° above normal have been recorded with similar systems in Canberra)

2 The cheerful sunlight makes the rooms warmer and more attractive to use, having the effect of enlarging the usefulness of the house, especially with children needing to use their bedrooms for study purposes.

3 The WinterSun panels also shield the southern windows from the hot western sun in late afternoon, thus reducing the heat gain in the southern rooms. The supporting structure further enables retrofitted sunshades to be erected should the late afternoon summer sun prove troublesome particularly if the house is oriented significantly away from due north.

g Sun control over northern windows (CoolShade)

1 Extendable sunblinds, remotely controlled, are integrated with a pergola structure to shade the windows in summer and enables full penetration of winter sun into the house. White Coolaroo shadecloth ensures that daylight levels are maintained internally (even enhanced).

2 The pergola extension enables deciduous vines to grow beyond the blind area helping to create a volume of cool air outside the windows, reducing ambient heat gain in hot weather and serving as a further bank of buoyant cool air when the house is opened up around 6pm.

*OR alternatively to **g** above :*

h Northern conservatory (GreenVent)

1 Glazed conservatory outside the *northern* living areas can be useful all year round :

In *winter* it will naturally facilitate natural warm air circulation *in the house* without the use of any energy.

In *summer*, with the extendable blinds and deciduous vines (as **g**1 and 2 above), and specifically located vents in both glazed walls the GreenVent conservatory will become part of the NatVent sub-system by venting hot air to the roof space.

2 The enclosed space can be used as a vegetable growing space having an extended growing season (compared to outside).

3 The indoor plants oxygenate the air and remove the carbon dioxide from the circulated air to the house interior.

4 The plants also increase the volume of negative ions in the air which are known to be beneficial to humans.

5 The conservatory is very useful as extended living space and can be very pleasant to look at.

6 The conservatory can be added as a retrofit later on, using the pergola system already in use for the northern sunshading system.

i Greywater purification system (GreyPura) This system can significantly reduce the consumption of potable water by storing selected greywater from showers, washbasins, and clothes washing machines, partially purifying it by natural solar means (rather than by chemicals and energy) and re-using it in the toilet cisterns and washing machine. (this sub-system is still in the developmental phase and not yet commercially available)

Other considerations

Bio-sensitivity

It has been assumed that solar hot water and photovoltaic systems will be provided as logical inclusions for an EcoSolar house and the roof has been designed to facilitate their installation of any reasonable size without aesthetic disruption.

It should be noted that all of these systems are designed to use *natural* resources with manual operation selected in preference to being electrically assisted. If no photovoltaic panels are supplying electricity to the house then an EcoSolar house still makes a good contribution to reducing atmospheric pollution, but, if photovoltaic panels of appropriate size are installed electricity is still naturally generated ensuring virtually free power and a financial return from the Feed in Tariff .

The roof area of an EcoSolar house is such that a photovoltaic array can be enlarged to cater for the charging demands made by electric cars in the near future.

Consequently, significant reductions in running costs are possible, partly dependent upon the lifestyle of the occupants *(up to $4000 annual saving has been calculated in comparison to the typical bio-insensitive types of houses so commonly constructed.*

(See pages 30-32 in "Low energy affordable housing" book available through Derek Wrigley or EcoSolar Housing $20 +pp. This annual saving does not include the significant reduction in transport costs if electric cars are charged at home overnight when a photovoltaic array is in use).

Aesthetics

The EcoSolar house has not aimed to use avant-garde aesthetic techniques to provide novelty and 'look-at-me-ism'. Its form has arisen logically from a scientific rationale to provide good living conditions and past experience has shown that by a judicious use of colours, textures and a good auditory environment then its simplicity will prove acceptable. eg. great care has been exercised to reduce the reverberant effect so commonly the result of hard surfaces, such as experienced in restaurants.

Simplicity has been a significant criterion in the design of these systems as general experience indicates that *"if anything can go wrong, it will"* Electrical operation has

only been adopted where it is inconvenient for manual activity - and hence is often neglected by most occupants, eg. closing or opening of the clerestory vents.

The deniers of global warming will no doubt say that reliance on natural resources is unsound because of natural variability. It is unfortunate that such views are often coloured by our past experiences rather than our knowledge of building science. Most of our views have arisen from traditional, unscientifically constructed houses having comfort conditions which quickly fluctuate according to the weather outside. Science clearly shows us however, that externally insulated, high interior mass houses respond much more slowly and to a lesser extent in response to the weather.

Life is not perfect and the EcoSolar system has been designed to *reduce and smooth out the extreme discomforts at reasonable cost. This is achievable by letting the house structure automatically control the internal climate without any need for airconditioning - and only minimal back-up heating*. Rolls Royce comfort is possible - but rarely enjoyed on a Ford income. The EcoSolar house is the result of a balancedß scientific and aesthetic approach.

The future

Will the EcoSolar system work in the hot, humid climates further north?

We have not attempted to design a universally appropriate solution, because there is really no single, simple answer to suit all climates - effective design must arise from the climatic situation, but given the challenge we will.

It should not be that difficult if science is correctly integrated with art and bio-sensitivity .

Derek F. Wrigley, OAM

ARIBA FRAIA LFDIA DA(Manchester)

Originator of the EcoSolar housing system

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2/72 Shackleton Circuit,

Mawson.

ACT 2607

Tel: 02 6286 6134 Email : <dwrigley@cyberone.com.au>