THE FOUR PILLARS OF SUSTAINABLE DESIGN: EARTH, AIR, FIRE AND WATER

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What is sustainable design?

Sustainable design has become a popular idea in the last ten years with many architects and clients seeking building designs that better reflect our concerns for the environment, energy and healthy living. Sometimes called "Ecologically" or "Environmentally Sustainable Design" (ESD) or "Green Design", it is a development of our earlier concerns for energy efficiency, passive solar design and environmental responsibility that have been growing for the last 30 years. Essentially it is concerned with making designs that have better performance with less impact on the environment, with the ultimate aim of having a built environment that can continue indefinitely.

Why has sustainability become important?

Sustainability is the catch phrase to describe concerns with the degradation of the environment generally, and the concerns about resource depletion and greenhouse gases in particular. Since the early 1970s there have been concerns that coal and oil dependent energy have a limited lifetime and that alternative methods of energy production should be developed. This expanded into concerns about environmental degradation caused by obtaining and developing building materials, including the depletion of rainforests for timber and the despoliation of the land in mining, together with the depletion of resources for their operation such as water. This expanded further into concerns about environmental pollution and health issues in the manufacture of materials generally and building materials in particular, including concerns about the use of heavy metals and toxic chemicals in the production of materials such as PVC. Further concerns about environmental health then centred on the building itself and the developing awareness of internal air quality (IAQ) issues where materials used in the fit out in particular (paints, glues, plastics) would emit volatile organic compounds (VOC's) that would lead to poor human health. The link between energy efficiency and greenhouse gases which is now known as E2G2, is a relatively recent development in the environmental debate and sustainability issues. The link between the outgassing of CFCs that caused ozone depletion and CO2 that caused greenhouse gas increases and climate change, have added to the overall concerns that the holistic nature of the design of our cities has not been addressed.

The urgent need for sustainable housing: the 2 x 2 x 2 x 2 x 2 syndrome

The critical need for sustainable design can be seen in our current approach to housing, which we may call the 2 x 2 x 2 x 2 x 2 problem. By comparing housing now to 40 years ago, we can see several alarming trends:

- The average size of the block of land for traditional subdivision has been halved from 800-900 sqm to 450 sqm
- At the same time the house built on that land has doubled in size from about 120 sqm to 257 sqm.
- This larger house on a smaller block, often means that it is changed from single storey to double storey with all the downstream consequences: a loss of privacy and a dramatic increase in overshadowing.

But the changes go further.

- The houses now incorporate garaging for two cars rather than one, two refrigerators rather than one, and so on;

but ultimately the greatest is that:

- The house occupancy has almost halved in that time - a shift from the average 4.3 persons to the current 2.2.

What are the sustainable issues in building design?

Whist sustainable design in buildings is complex and interwoven, it can be broadly summarised along the lines of the four Aristotelian elements of fire, water, earth and air. These represent the four major concerns of energy, water, resources for building materials and environmental health. The approach in each of these areas can be broadly summarised as follows:

Energy: Minimising the energy required for space heating, cooling, hot water, lighting and general power and optimising the energy costs for construction materials. This reduces the greenhouse gas output in the construction and operation of the building.

Water: Optimising the water supply and purification, water usage in the building and the recycling and/or disposal of the wastewater. This reduces the requirements for this precious and environmentally costly resource in the operation of the building.

Resources: Using materials and processes which have less impact on the environment, emphasising materials that require less resources, take less energy and cause less environmental damage in manufacture that cause a minimum of construction waste.

Environmental Health: Optimising the internal environment to minimise the harm to occupants from chemicals or outgassing. This ensures a healthier internal environment in the building.

In each of these areas there have been a number of approaches taken in order to promote better design. The main two of these can be characterised as “carrots” and “sticks”.

Encouraging sustainability: the “carrot” approach

Under the “carrot” approach people are encouraged to adopt sustainable design because of its improvements to the environment. Similar to the program to encourage recycling in materials, there has been an exhortation to the public generally to reduce energy and water use and to better consider the use of materials for their resource and environmental health issues by encouragement rather than by legislation. Unfortunately this approach, which appeals to the good nature of the populous to believe in and support environmental issues, is largely let down by the NIMBY syndrome (Not In My Backyard) which may be characterised as: “Of course I support the environment, however I need my lifestyle, and it is my neighbour's responsibility to adopt these sustainable issues”. An example of the failure of this approach in building design include the lack of insulation being included in buildings, despite its well known performance characteristics, until legislation required its inclusion. As it could not be seen in the building, it was not perceived to add to its value and builders and developers were reluctant to adopt anything that might cause a minor increase in costs without it being obvious to the purchaser. Another example is the adoption of air conditioning despite encouragement by the State Government to reduce energy use, in particular the demand on the electricity system at peak times. Or the profligate use of water (e.g. washing down driveways), despite government programs to save water.

Regulating sustainability: the “sticks” approach

Given the many failures in the use of “carrots, various governments have legislated to introduce sustainable requirements. Following the examples above, legislative initiatives include the introduction of mandatory insulation levels, the requirement for buildings, to meet certain minimum thermal standards to lower air conditioning requirements, or the introduction of water restrictions to reduce water usage.

Supply side vs demand side sustainability issues

The “carrots” and “stick” approaches have both concentrated on what has been called “demand side management”. These approaches try to encourage or regulate for behavioural change or better building performance, rather than by changing the supply or costing of the resources (such as energy, water and materials). They are hoping that the issues of energy and water will be addressed by the owners or occupiers of the buildings, rather than by the suppliers of the resources. Many critics in the sustainability movement believe that this puts the onus on the area where it is least effective, the most difficulty to introduce, and the hardest to measure.

A more positive outcome might be to amend the supply side of the equation. That is, to raise the costing of energy and water, to better reflect the environmental cost, so that the behaviour of occupants and the design of buildings will respond more directly to the cost impetus. However this approach has the difficulty of requiring considerable political will which has not been evident of late.

Unfortunately the recent history of the sustainability movement is littered with failures in both carrots and sticks as we shall see in a detailed look at each of the “pillars”:

FIRE = ENERGY

The use of energy in housing can be broadly divided into four areas: for thermal comfort (heating and cooling), for water heating, for lighting and for general appliances. In larger buildings (both residential and commercial) we can add mechanical requirements such as lifts, car park and other ventilation requirements to this list. Looking at each of these areas in turn, we can see how the desire to reduce energy use, particularly electricity which has the greatest green house gas outputs, has often been thwarted by difficulties in either promoting or regulating energy conservation.

1. Energy for thermal comfort

The difficulty of introducing regulations to control buildings for thermal design is highlighted by the problems associated with computer simulation of thermal performance. The best known of these programs for housing has been NatHERS, although this has largely been superseded by a more technically proficient program called AccuRate. The first major problem with NatHERS, which stands for National Housing Energy Rating Scheme (or Software), was that it was nothing of the sort. Whilst it described itself as an energy rating tool, it only looked at thermal performance which for most of Australia accounts for 25% or less of energy consumption in houses.

Secondly, the NatHERS program did not adequately deal with problems of simulation, particularly for conditions of Summer and the benefits of cross ventilation and increased thermal mass.

Thirdly, NatHERS averaged the energy use over area of the house rather than looking at the total. In this way preference was given to larger houses as it became easier to amortise the energy over a larger area and therefore the appearance is that a larger house has a higher star rating, implying that it would use less energy. Of course in the real world the larger house will most likely consume more energy. The regulations are seemingly counter productive: promoting or reinforcing the idea of very large houses being better, rather than promoting the more environmentally sound “small is good” or “less is more” approach.

These problems have largely been overcome with the introduction of AccuRate, a more sophisticated program, however, there is still a lingering bad taste in the architectural community because of the problems with NatHERS. A list of some further technical issues with NatHERS is listed in Appendix 1.

The major limitation with <u>all</u> the simulation tools for thermal performance (AccuRate, NatHERS, First Rate in Victoria and BERS in Queensland), is that they encourage what we might call the “esky” approach to house design. By placing the emphasis on energy, rather than thermal comfort, that encourage the design of highly insulated boxes that reduce the amount of energy required for the air conditioner or heater. Although the programs, particularly AccuRate, provide detailed simulation of thermal comfort, the regulators have chosen the output to be listed as energy used to achieve a thermal comfort level. This enables an easy codification for rating, including the use of stars but does not necessarily encourage the analysis of how better thermal comfort may be achieved by “passive” means.

With the emphasis is placed on energy through star ratings (the more stars the better), the easiest way to achieve a higher rating is to shut the building off from the outside climate and rely entirely on inputted energy. Since windows are the greatest source of heat loss and heat gain the logical extension is to remove or reduce window areas. Project builders were quick to realise that they could achieve high star levels in houses, and reduce their costs, by reducing the glazed areas. This reduces the liveability of the house, and may also have contributed to the rise of the late 90s house style of the “Fediterranean McMansion”: a large brick box with limited windows and just four doors: front and back, garage and patio.

The opposite of an esky may be said to be a tent. That is a large roof that provides shade to the occupants and allows interaction with the surrounds. In Sydney many architects have developed an architecture that is based on this approach, such as Glen Murcutt, Ric LePlastrier and Peter Stutchbury. Whilst this might be an architecture that suits some clients (with outdoor oriented lifestyles) and some locations (such as the shores of Pittwater), and despite claims to the contrary, it is not a house type that will bring about reductions in energy use for thermal comfort for the general public. What we may be searching for here is a compromise, a “tentsky”. In this design there are high levels of thermal mass and insulation to certain parts of the houses whilst other areas of the house would be open to the outside to allow interaction with landscape and often benign climate. This gives an indoor-outdoor relationship, which is one of the hallmarks of an often desired lifestyle, centred on the BBQ, the terrace and maybe a pool.

However, an emphasis on star ratings runs counter to this desirable outcome. Any increase in the number of stars can only further drive housing design towards the esky model. Whilst it may be appropriate for energy reduction, it is not appropriate for liveability and in the long term may be counter productive as it reduces the possibilities for the house to be operated passively by its occupants should energy prices rise to the point where and air conditioner, no matter how efficient, cannot be afforded or run at the times when needed.

Aside # 1: heritage conflicts

The current understanding of contemporary passive design, which we have called “tentskies”, is at odds with the built forms of the past. This can be seen in the desire for such shapes as skillion roofs that face the sun, small counter veiling structures that hold solar water heaters and photovoltaic cells, the lightweight nature of a layered external skin that includes glass doors, louvres and other screens whilst retaining a heavy weight interior for thermal mass. Thus the leading contemporary sustainable buildings are often at odds with the heritage overlays in inner urban areas of the city and many towns.

Contemporary design is not a style, as it is the inheritor of the modernist tradition that building forms be shaped by their function so contemporary building design may throw up forms, shapes and “styles” that have not been seen in the past.

The original tenets of modernism were that a building should reflect its workings and not be designed according to some external style. In this way it was often said that modernist buildings were designed inside out and had new forms that had not been seen before as a result of this process. The same things can also be said of contemporary passive design where new forms relating to the sun, wind, shade, rain and water may give rise to conflicts with an ideal of a traditional style.

Given the inherent conservatism of the Australian population in regard to housing style, this would seem to be yet another stumbling block in the introduction of sustainability. Where suburbs are threatened with substantial change, an appeal to heritage values is often the first or main argument that is raised for its retention. And yet a consideration of the sustainable aspects for a building may lead to radical, often uncomfortable, designs being proposed which are being rejected on the grounds of "style" which forms little to no part of the sustainable argument.

Aside # 2: do passive design houses reduce energy use?

Counter intuitively NO. Like much of the work in sustainable building design there is very little real world evidence to support much of the argument. Where POE (Post Occupancy Evaluation) studies have been done, such as by Solarch UNSW and at Davis in California, the rather surprising results were that the passively designed houses used as much, or more, energy than comparable non passive (or totally externally energy derived) houses. The reason is that the level of thermal comfort is adjusted upwards (better thermostat settings for longer) as the costs of energy in both cases were so low as to have no bearing on its use. This would seem to be the clearest indication of the failure of demand side initiatives to deliver the desired E2G2 savings. The best positive spin is that the passive houses will be better placed when energy costs or supply become an issue.

2. Energy for water heating

The second area of energy use in buildings is for domestic hot water. This area is important and indeed in the benign climates of northern NSW, it may represent a greater energy demand than that for thermal comfort of heating and cooling. It is also an area in which the efforts of both carrots and sticks have had their failures.

The ability to switch from electrical heating of water to gas has had significant benefits in terms of reducing greenhouse gas emissions, however it has been evident in Australia for a long time that the most efficient water heating in our sunny climates is to use solar. Despite it being an obvious energy saver, and the proficiency of Australian designers and manufacturers in developing solar panels, its uptake has been lamentably low. The failure in this area is usually cited as the additional cost between a conventional hot water system (around $1,500), to the cost of a solar water heating system (greater than $6,000-$7,000). Solar water heating has been heavily promoted, but it is only where their use has been mandated (e.g. Leichhardt Council for the last 10 years) that its introduction has been more assured

One issue has been problems with its integration into the building design. On this point we can observe that the design of these panels has become highly efficient and requires the correct orientation and placement . This is often at odds with the roof slopes of existing houses in a tight urban areas, leading to conflicts between sustainability and good urban and building design. The solution would seem to be in a change to the design of the panel to allow for greater inefficiencies of orientation, with perhaps larger areas of panels. To this end recent developments of a panel which is far cheaper to construct, allowing larger areas to be installed which would compensate for the lack of exact orientation and inclination may be a way in which solar water heating can be successfully integrated to house designs that do not have the necessary steeply sloping, north facing roof.

This is also important because there is a potential conflict between roof pitch for good passive solar design (skillion roofs pitched to the north) and roofs designed for good solar active uses such as photovoltaics and water panels which imply a roof pitched towards the south allowing for good north orientation. This conflict is particularly evident on smaller sites where architects would prefer to stress the passive relationship of the house to the environment rather than the allowance for active solar uses. However, for the vast bulk of the existing housing stock in Sydney in particular, almost every house has some part of the roof which would allow 10-20 sqm of active solar for water heating or photovoltaics.

3. Energy for lighting

There has long been a resistance to switch from incandescent to fluorescent lights even though there is much lower energy demand and far greater lamp life with fluorescents. The resistance centres on not only the additional costs, (12V lighting has avery low cost, although high heat outputs and low performance), but also a perceived problem with aesthetics. The bulk of our current light fittings can adapt to fluorescent lamps that mimic the shapes for incandescent bulbs, although there is still a resistance to its colour rendering and difficulties with flicker on its initial start up. Given that lighting plays such an important part of energy use in all buildings, it is appropriate that some form of regulation for the promotion of fluorescent lights be introduced given the lack of success with the carrots approach. To this end BASIX includes consideration of fluorescent lighting on its energy page, which is a very effective method for improving the use of fluorescent lighting. As we shall see later, there may be a better way of achieving its low energy lighting by promoting its better design outcomes.

4. Energy for appliances

One of the early difficulties in establishing a regime for energy use in the BASIX research was a lack of real data on energy use in housing. Most studies were assumptions, or repeats of estimates made without there being recourse to real world evidence . Often the information was not collected or where it was available was treated as commercial in confidence and was not readily available to the public. When the initial studies for BASIX were done, they showed that some areas had higher energy uses than had originally been anticipated, notably appliances, and refrigerators in particular. In turns out that not only do Australians have large refrigerators, but often they have more than one refrigerator as we have seen in the 2 x 2 x 2 x 2 analysis of housing.

The large refrigerator, with its ice maker and water dispenser, can be seen as a hallmark of a certain attitude by the public towards energy consumption. To this end a star rating system was introduced for a number of household appliances including refrigerators, washing machines and dryers. Again there is an irony in the star system that makes it easier to obtain a higher number of stars on a larger refrigerator or washing machine. With larger machines the energy use is amortised over a greater volume and therefore appears to be a lower, with more stars. Similar to the house stars system the opposite outcome may result : the larger appliance with a higher number of stars will ultimately consume more energy.

There would seem to be a need for two major changes: firstly it should be possible to get a high star rating for a smaller and therefore less energy consumptive appliance rather than amortising it over size. Secondly, one would have to question why 2, 3 or 4 star appliances should be sold at all, given that there is nothing that a consumer can do to regulate its use - once a 2 star fridge is installed, its poor performance runs for its life. Were there to be a stronger commitment to environmental sustainability all appliances that fail to meet certain standards would be banned. An analogy would be the ban on leaded petrol which, whilst available and required for certain cars, had grave environmental issues, leading to its withdrawal from the marketplace.

5. Lifts and Mechanical Ventilation

Whilst much emphasis has been placed on energy use in housing, particularly for thermal performance, it is larger buildings that provide greater data on actual energy consumption. This indicates that some aspects such as lifts, fans and mechanical ventilation account for a far higher proportion of energy use in these buildings. As the recent regulations introduced for class 5-9 buildings in the BCA take hold, it will promote the increased use of computer simulation to analyse the energy paths in these buildings. This is an area that is already well established technically with a number of computer simulation programs available that will provide a sophisticated analysis for such a building. They are as inappropriate for houses are they are expensive to model, but are entirely appropriate where much larger and more expensive buildings are involved.

Aside # 3: supply side management and energy costs

One way to curb energy use would be to raise its price. One of the criticisms for this approach is that it would be extremely punitive on the lower economic groupings and that it would be highly inflationary. However, some commentators, myself included, have proposed a system whereby energy and water are made cheaper for all houses up to a certain limit and then a stepped increase in costing is introduced that becomes highly punitive for energy and water usage well beyond the average or an agreed amount. In this way it may be seen to be socially progressive in that low income households who are conservative with energy and water could effectively pay less for their services, however, the profligate use of these resources by either poor design or excessive consumption would be penalised by higher costs that would either kerb the behaviour or help to pay for the added load on the infrastructure.

Another supply side management may be to control the energy supply at certain times of peak load. In this case air conditioners or other heavy demand equipment may be linked to certain circuits that can be switched off by the supplier when peak demand across the entire grid requires load shedding. In this case air conditioners to houses would shut down at the peak operational time. Some have suggested that it may be more beneficial to allow air conditioning to only run at off peak times such as in the evenings. This would have the benefit of evening out the supply side demand for energy, where coal fired power stations now produce an excess of energy in the middle of the night which could be used to cool and heat houses at that time. This would have an immediate impact on the design of buildings in that it would require much higher levels of thermal mass within the building to accommodate the energy input for heating or cooling being added outside the hours when it is most expected by the occupants.

WATER

All buildings interact with a water cycle in a number of ways: there is the rainwater that falls on the building and its surrounds that becomes stormwater, mains water is supplied to the house when used becomes either grey water (from sinks, baths and basins) or black water (WCs).

Most suburban sites on the eastern seaboard of NSW receive sufficient or greater rain on the site than is required for use by the house. If the mains supply is added to this, each suburban house becomes a net exporter of water from the site. This water becomes a problem in two forms: the rainwater becomes stormwater and has to be carried away to the nearest watercourse and the grey and black water have to be carried to the nearest sewer.

Given that there is a shortage of water for mains supply in many places, it would seem obvious to turn to the water cycle and see if the excess water on the site couldn't be better used. This usually entails the collection of rainwater (roof water) or stormwater from the ground being stored on site. This water can then be used for a variety of purposes depending upon the degree of filtering that is used. Water filtered for sand, etc can be safely used for outdoor purposes, garden taps, car washing, landscaping as well as for WCs and the laundry for the washing machine. With further filtration and sterilisation the water can safely be used for all domestic uses. The process of sterilisation is usually achieved by one of two means with either UV filters or by reverse osmosis (RO).

There is a relationship between the area of the roof and the size of the tanks that can be designed to allow for a small amount of water to be used just for external purposes or for a larger body of water to be collected and stored which may provide for all uses in the house. Where large roofs are available and large tanks can be installed, the eastern seaboard sites have sufficient water to meet all needs. Where the sites may have less water (further west), or where the sites are small and the roof areas are small, the capacity for water collection may be diminished below the levels of use. In these cases the use of grey water as a substitute, either in its raw state in the landscape or again filtered for use within the house, will increase the water availability.

Black water is usually dealt with by being disposed of to the sewer. To safely deal with it on individual sites is usually expensive and complex and is better handled to a number of dwellings for instance in a suburban subdivision or in a large apartment tower. The alternative is to dispense with the water in the WCs altogether and to use a composting toilet on an individual house or individual toilet basis. This too has difficulties in that it requires some space within the house and some maintenance on the equipment and entails additional work by the owner. The incongruity of the water cycle is, however, related to the fact that most suburban sites connected to towns water are exporters of water, creating problems of excess stormwater overflow, which effects the aquatic quality of the rivers, bays and harbours, and the amount of water required to shift the grey and black water to the nearest sewerage system, where the volume of water exacerbates the ability to be able to clean and return the water to the cycle.

Technically it would seem very simple to close the loop by using the water that falls on the site to provide the start up water and to recycle the grey water at least once through the site before disposing of it to the sewer. In this way the total amount of town water required is dramatically reduced, the amount of water going to the stormwater drains is reduced and the total volume of water entering the sewer system is also reduced. This would seem to be a win win win situation.

However, there have been impediments on many levels: the collection of rainwater and its storage has been viewed as a potential health risk, whilst there has been little evidence to support the idea that the levels of contamination pose a risk to human health if the bare minimum of filtration and sterilisation is applied. There has been a sea change in regard to the collection of rainwater as water and health authorities have realised that the practice long held in country areas is equally applicable in the city.

The issue of water storage can become increasingly difficult on smaller sites. However, design solutions on underground tanks and integrated pump systems have largely overcome those difficulties. The requirement for detention tanks for stormwater has also had poor design outcomes where above ground detention basins lock up large areas of landscaping in areas with very poor visual and physical amenity.

Whilst there are valid health concerns about the use of grey water, again technology offers us a solution with micro filtration systems being developed that allow for grey water to be safely used.

All of these considerations are magnified in larger scale developments, such as multi residential and commercial buildings. Here the potential for rainwater gathering may be reduced and therefore the value of grey water recycling is increased. The greater value, however, in larger scale buildings and developments is that water resources are far more efficient on a mini development scale such as 20-100 houses or a 30 storey building than they are at the micro level of a single house. In this regard the operation of a single grey water system that feeds a number of houses is far more efficient both in terms of health and safety as well as energy required.

EARTH = RESOURCES

There is an irony that materials are the lifeblood of any architectural design and construction, and yet until recently have received scant attention in concerns of sustainability. There would appear to be two reasons for this: firstly the urgency of addressing energy and water issues have often been seen to have primacy, and the sheer complexity of establishing a set of guidelines for the sustainable characteristics of building materials has been a vexed question. Early studies in the 1970s concentrated on the embodied energy in building materials, a reflection of the primary concerns with energy. More recently a more holistic concern of cradle to grave, or as the US architect William McDonnough would have it, cradle to cradle, has focused attention on the life cycle aspects of material use.

In this regard, materials are considered from the inception of mining or obtaining the raw materials through the energy used for initial transport, manufacture and waste, transport to site, installation and waste and finally the possible reuse, recycling or disposal of the material. Even having established a set of parameters for examining the sustainable aspects of building materials, it does not necessarily make its quantification any easier. Whilst energy may be quantified, this is not always possible in a commercial world where that information is often held privately. The more troublesome aspects relate to the wider ecological implications at both the sourcing and recycling disposal ends of the spectrum. To date there are few parameters that establish what the requirements for those fields are. The use of timber is a salient example. It is commonly held that plantation timber is better than natural forest, particularly old growth or rainforest timbers. However, plantation timber is often a foreign species that causes significant degradation of the soil, water and particularly the fauna and local flora conditions where they are planted. Recent research by Victorian Forests in conjunction with the CSIRO has demonstrated that the most sustainable form of timber available in Australia at present is the selectedly harvest timber from managed forests which may include old growth as well as regrowth timbers. This would seem to fly in the face of conventional wisdom yet is evidence of the change in thinking when a more holistic approach to ecological sustainability is engaged.

Another consideration in the search for sustainable building materials is the large amount of waste that is generated with current construction methods. One has only to see the amount of waste on a typical building site to realise the extraordinary inefficiencies in transporting materials to site only to cut them up whether they be timber or brick and then dispose of the off cuts as landfill. The various NSW Waste Boards have been at pains to try to minimise the amount of waste by encouraging two considerations: 1) a more accurate assessment of the materials that are required on site so that less waste is generated, and 2) that the waste that is made is sorted in such a way that it can be recycled or reused. This program has led to significant gains in the recycling of all metals, particularly steel and all clay products, particularly clay tiles, all concrete materials which are often crushed as road base, and the recycling of plasterboard offcuts.

One further solution may be to adopt a different form of construction process, emphasising off site prefabrication, sometimes called factory building. Where buildings are manufactured in a factory (either in whole or part), the waste can be limited to the same area where it can be reused, avoiding transport and handling costs, as well as improving OH&S conditions. The design considerations and accuracy that can be engendered in factory design, can also limit the amount of waste material that is generated in the first place and ensure that it is safely reused in the second. This inevitable leads to modular design choosing same sized repetitive elements that can be used in the fabrication of a building, which is ideologically totally at odds with the

Australian notion of an individual house styled in particular for its owner. There is not only the resistance of an extremely organised craft-based industry of building, but also the buyer resistance to the idea of a mass manufactured or factory built house. Whilst we accept improvements in almost all other aspects of our life: cars, appliances, computers being mass manufactured in factories, we have so far resisted the gains that can be made in flexibility and in particular in environmental performance from factory based building manufacture, particularly in regard to our largest building stock, the individual house.

AIR = ENVIRONMENTAL HEALTH

The last of our four pillars of sustainable building design has to do with environmental health, particularly expressed as indoor air quality (IAQ). This broad area covers all of the conditions that are often expressed as “sick building syndrome”. These are buildings where the outgassing from materials or furnishings renders the space an unhealthy environment, or its operation by use of air conditioning equipment, water and other activities renders the space inside uncomfortable or untenable leading to a loss of productivity in commercial buildings and a feeling of unwellness in housing. This last aspect of sustainability is the most recent to gain acceptance and a sense of notoriety in the United States at least. It was only following the oil crisis of 1973 when the US undertook a radical rethink of its building stock that tests were done on indoor air quality. Initially the research centred on air infiltration, looking at ways to reduce heat loss and heat gain into the building, together with levels of external pollution. Early tests, however, quickly showed that the indoor air quality could be substantially worse than the outside due to the build up of outgassing, particularly from volatile organic compounds (VOC's). These are chemicals that are used in the manufacture of building materials that give off a gas during manufacture and during their lifetime. Whilst OH&S considerations can bear upon concerns at the factory, the outgassing in buildings goes largely unregulated.

To date this concern has been more focused on commercial and public buildings than individual houses, although the rise of allergies and the awareness of sick building syndrome has meant that it is an increasingly important consideration for some home purchasers.

Whilst outgassing may appear to be be less of an issue as the building ages, it is important to realise the degree to which churn occurs in many buildings, particularly commercial buildings. By this we mean the removal of substantial parts of the building and its updating such as the refitting of kitchens and bathrooms or the replacement of fit out to commercial floors in a building.

To this area we may apply the one third rule, that is broadly that a building's cost may be divided into three equal parts: the cost of its structure and envelope, the cost of its services within the building and the cost of its fit out. Whilst this rule is distorted from building to building, it nevertheless remains true, particularly as buildings get larger. The one third rule plays and important part in the consideration of sustainable design, in that it suggests that buildings are neither sustained nor demolished, but are rather regenerated at different times over their life span. In a house this may be seen in the retention of the basic structure of walls and roof, whilst the floor or floor coverings are replaced the kitchens are removed and updated and the bathroom are pulled out and replaced. Further improvements may involve increasing the wiring in the house for electrical and communications and the replacement of the hot water service and improvement in the hydraulics.

Thus the first third of the structure may be retained for some houses, now in excess of 150 years, however, in that time the services may have been updated two or three times while the bathrooms and kitchen may have been replaced four of five times in that life span. Thus we may say that the building is sustainable whilst there is an internal churn which suggests that considerably more materials are used in the maintenance of that house than is at first apparent, and that the potential for improvements in environmental health in the increased quality of fittings and services can be counter balanced by the increased environmental health risks of the materials that are used.

For commercial buildings the churn is even more apparent where the average life for an internal fit out to offices is about eight years. Add to this the need to replace lifts and mechanical services every 20-25 years, we can see that the structure, being only one third of the building, may appear to have longevity whilst the amount of construction waste and the indoor air quality may be greatly affected by the churn in frequent fit outs.

Neither Sticks nor Carrots: A Third Way

As we have seen the area of sustainability is both complex and vexatious. Whilst everybody may agree that sustainable design as a response to environmental degradation or climate change is everyone's concern, not all will subscribe to take action. On the other hand, the establishment of regulations to enforce environmental savings has been fraught with counter productive efforts and contra indicative outcomes. It is in the light of these complexities that I would suggest that a third way may be possible: that we return to an emphasis on good design in achieving good outcomes.

There is possibly an alternative route to promoting sustainable design which appeals not to the demand side of “carrot” and “sticks”, nor to the politically difficult supply side of resource economics, but deals directly with the traditional ideas of what a building provides by way of comfort and lifestyle. In this approach the sustainability is promoted for improvements in the quality of lifestyle, rather than the negativity that is often perceived in the demand side promotions to date. In this case we would return to the traditional areas of building design and note that there is a confluence of improved performance together with improved sustainability. It is important to show a link between improved design and improved performance that will see that sustainability issues are taken up to make better buildings , rather than as a result of legislation that deals with narrow issues only. In each of the areas of fire, water, earth and air it can be demonstrated that good environmental design leads to far better outcomes which will give benefits to the owners and occupiers far in excess of the quantified savings for energy and water or the measurable improvements in environmental performance. In each area it is a qualitative improvement that can lead to its adoption rather than a quantitative enforcement.

One example is the nature of thermal comfort. Recent research shows that our bodies are far more receptive to radiant heating and cooling than convective heating and cooling. In other words, a person sitting in a room has a greater sense of thermal comfort as a result of the temperature of the surrounding walls rather than the temperature of the enclosing air. This aspect was known for hundreds of years where buildings were designed with large areas of thermal mass and radiant heaters in order to maintain thermal comfort. It is only since the 1930s that the mechanical engineering profession has emphasised the possibilities of air conditioning, whereas what we prefer is building conditioning.

Thus it turns out that the passive solar house with substantial thermal mass in the walls and floors has a better quality of thermal comfort as well as lowering the energy demand for heating and cooling. In other words, the thermal mass storing warmth in winter in coolth in summer, is capable of providing radiant heat and coolth to provide a better level of comfort, rather than trying to condition the air. On this basis the occupant is likely to allow the doors and windows to remain open for a longer period of time, engaging an indoor - outdoor relationship, than the tight requirements that are necessary when energy is used for heating and cooling by air conditioning.

Sadly this aspect of the benefits of sustainable thermal comfort design are not well understood and well promoted, but they can lead to more interesting architectural solutions and a much better quality of life which is after all the reason for the use of energy.

In the area of water there are many who would argue that having unfluoridated water for most of your life may be a benefit. This has an attraction to many people who regard the chlorinated and fluorinated water available through the town supply to be of an inferior quality to that that can be collected as rainwater. The plentiful availability of water may also have qualitative implications for the design of landscaping around homes. Where water is plentiful a greater diversity of plant material, including growing vegetables and fruit, is possible. For a long time the emphasis in Australian landscape has been on the use of indigenous species and a drought oriented landscape around housing. The celebrated ecologist Tim Flannery has criticised the use of non native plants in suburbia and has suggested that we should return to the ecology of the landscape prior to the introduction of the houses. This, however, is a false reading of the actual ecology that surrounds these houses. Whilst forest trees have once stood in that area, they are highly inappropriate around houses where their susceptibility to dropping branches and whole trees, particularly where forest species are used sporadically, means that there are safety issues beyond the considerations of sustainability. These species may also be completely out of scale with the nature of one and two storey houses towering above them and being indiscriminate in the shade that they cast sites and indeed blocks away from where they are planted. Where rainwater is captured and stored on site it may lead to species which may have a higher degree of photosynthesis that increases the water output giving cooler conditions in summer, and providing more controllable and substantial shade. It is notable that there are very few native deciduous trees and that many of the species which are ideal for providing good thermal control, that is shade in summer and openness in winter, are exotics that require larger quantities of water.

In this way it may be seen that to collect and store water on site not only has the quantitative benefits in reducing stormwater and sewer demands, but also has the qualitative aspects of providing us with better gardens and possibly a localised food source. In consideration of the qualitative aspects of materials it is also apparent that sustainability may mean better quality rather than quantity. It is particularly relevant that we seek to reduce the amount of churn, and maintenance that is dependent upon exotic materials such as paints and oils, in order to be able to reduce the footprint that a building takes. In his regard the poor quality of much of the housing that was built in the 20th Century is now being replaced because it is worn out, however, the brick veneer and lightweight construction that replaces it often has a very short life span. There has now been a reconsideration of the qualitative aspects in construction where more solid is construction is viewed more favourably. This suggests that longevity and lower maintenance have a higher priority than the speed of its construction.

Finally, the area of environmental health is one that shows where particular aspects of quality over quantity has shown substantial reasons to move to sustainable design. One positive aspect of the consideration for indoor air quality and other sustainable initiatives in commercial buildings has been a dramatic rise in productivity. Recent studies in the US show that the savings from the increases in worker output can far out weigh the savings that are predicted on the basis of energy and water savings. Whilst the early appeals for sustainable design rested on an internal rate of return (IRR) on the expenditure to improve energy and water, it appears that the improvements in quality, for instance the improved thermal comfort within the building, the improved indoor air quality and the improved lighting levels and quality, may lead to far greater savings through energy and water that may have been calculated through the programs to predict building performance.

CONCLUSION

Sustainable design in buildings covers a wide area of considerations which are often inter linked in non linear and complex ways. Our earlier attempts at both encouraging sustainable design through promoting its benefits, or attempting to regulate for it would seem to have been failures because of the rather simplistic approach that is taken. In this regard it is noteworthy that the best of the regulatory tools, BASIX, is an interactive tool based on the web that allows for some of these complexities to be explored in the design process leading to better sustainable outcomes.

Nevertheless, it would seem that an emphasis on quality in our built environment may return greater dividends in sustainable design. First and foremost of these must be a return to the idea that small is beautiful, or less is more. The idea of a sustainable McMansion is an oxymoron. Building design should emphasise the efficiencies that are inherent in modern materials and techniques and the improvements in spatial design that allow more to be done with less space, and much more to be done with modern materials.

The third way forward in the sustainable debate would seem to be an emphasis on the qualitative aspects of our built environment, rather than attempt to make a quantitative assessment and enforcement for change.

APPENDIX 1

An Outline of Some Problems with NatHERS and other Thermal Design Software

Scope

NatHERS is not a HOUSE ENERGY RATING SCHEME, but rather a thermal design simulation tool. It is too limited in its scope as it deals with only one aspect of building ESD (energy/CO2 for thermal comfort). A "whole of building" approach is required that looks at other energy uses (particularly water heating) and environmental concerns (water consumption and recycling, embedded energy in building materials, LCA, etc).

Coverage

NatHERS, or preferably a whole of building approach, should be applied to <u>all</u> housing planning applications, particularly alterations and additions as these form far more of the change to the built environment than new houses. The value of alts and adds in the economy is now almost equal to new housing and is twice that of engineering infrastructure. Also if we were to assume that all houses were 5 star as of today, it would take until 2030 for at least half the houses to be more ESD efficient.

Application

The 5 star rating system currently used is based on energy use per <u>square metre</u>. This disadvantages small houses and advantages big houses, the exact opposite of what an environmental audit should do. The rating system should be based on energy use per <u>dwelling</u> (or per person based on some measure of number of bedrooms).

Also the application of NatHERS rating does not discriminate between energy sources, treating electricity use and gas use as the same in regard to greenhouse gas production, which they are clearly not (measured as final energy used in houses).

Program Choice

NatHERS is not a good predictor of energy use (see paper by Terry Williamson and others to ANZAScA Conference, 2003), nor is it the best program to use (see section 1.10 of Your Home Technical Manual).

Program Shortcomings

NatHERS appears to have a number of shortcomings in its modelling approach. It is limited in scope of designs, in its modelling of complex spaces, measurement of summer comfort from natural ventilation, use of innovative materials and other areas. All of these shortcomings impact severely on architect designed houses. NatHERS should be withdrawn until it addresses these issues, or alternative methods of compliance acceptance.

Individual Design

Many architects have found that they have clients who have requirements that lie outside the NatHERS parameters (e.g. thermal comfort levels), which render the results problematic. Some architects have also developed innovative designs that are very ESD based (e.g. using stack ventilation, mechanical diurnal cooling) which are not modelled by NatHERS. For these reasons there need to be alternative "pathways to compliance" that should be issued as a matter of urgency if NatHERS is to be retained.

APPENDIX 2

ENERGY SIMULATION SOFTWARE AND RATING TOOLS

NatHERS, AccuRate, SEDA, DIPNR, HMB, ABSA and BASIX!

The mandatory modelling of the thermal performance of houses has been one of the most contentious issues in residential architecture recently. Since 1998 it has been a mandatory for all new houses in NSW to have a certificate of thermal performance submitted with the development application, usually from a program called NATHERS which was developed by the CSIRO and gives a star rating to one to five. NATHERS stands for national house energy rating *something*. It is the confusion over this last initial in the acronym that has caused so much trouble, because it stands for 2 quite different things: the software and the scheme.

NATHERS software

NATHERS is essentially a software modelling tool based on a well tried 'engine' called Cheenath (don't ask about that acronym) developed by the CSIRO where the configuration of the house is entered as data and a simulation of it's thermal performance is run using real weather data for each location throughout Australia. The output of this software can be a myriad of information: the temperature profile outside and inside any room, the solar heat gain or heat loss at any point and a simulation of the amount of energy that would be required to deep the house at a nominated comfortable temperature. The software has a number of well recognised limitations, particularly in modelling difficult spaces and adequately modelling summer natural ventilation. However this is not the area that is of most concern to architects over the last few years.

NATHERS and SEDA

Rather it has been the implementation of the software in what has become known as the 'scheme' . This is the adoption of NATHERS by the sustainable energy development authority (SEDA), an independent authority now within the department of planning (DIPNR). In order to rate the houses a 5 star rating system was adopted based on the amount of energy that could be expected to be used to achieve a nominated thermal comfort level. This was used as a basis for comparing houses but does not provide a detailed picture of the real energy use that the house might consume when constructed. Rather it is a simplified ranking system in order to ensure that the houses achieve a level of reasonable thermal performance. In developing the scheme the levels for cut off for each star rating are arbitrary, and represent a best guess for a reasonable thermal performance level.

Architects had significant difficulty with both the software and the scheme. The software does not adequately model the often unusual spaces that architects design, particularly spaces like atriums, voids, vertical spatial connections, and the use of unusual materials. More over the clients for many architects may wish to use the house or to expect thermal comfort levels different to those set in the scheme. For instance a summer time holiday house may assume to be naturally ventilated and expect higher day time temperatures since that would be acceptable in holiday use mode. Although the software can be easily programmed to accommodate these changes for the sake of consistency the scheme required a common base for all measurements which was ensured by having all assessors accredited by a governing body called the HMB (House Energy Management Board). Given some of the difficulties that architects experienced with the software and the scheme an expert panel was formed within the HMB to deal with unusual or difficult cases. So far only a few architects and designers have taken advantage of this expert panel. And just to make things more complicated, in response to these and other changes, the HMB will be reconstituted as ABSA (Association of Building Sustainability Assessors) from 1 July 2004.

AccuRate

Now two initiatives are aimed at improving both the software and the scheme. Firstly the software is being upgraded by the CSIRO under a grant from the Australian greenhouse office. For this update NATHERS will be renamed AccuRate and will contain a number of significant improvements. The modelling will allow for a greater number of zones within the house, will allow for atrium and void spaces to be better modelled, will better model cross ventilation and natural ventilation in summer and will have a greater range of material chooses for the simulation of the construction of the house. All of these initiatives will ensure that AccuRate is a better programme for use by architects. Currently the BETA version of AccuRate is available to specialists assessors for evaluation, but as with most software the bugs will take some time to be resolved and it is not expected that AccuRate will replace NATHERS until much later in 2004.

BASIX

The major innovation however is likely to come with what we may call a change in the scheme. Currently in order to achieve compliance in a DA the NATHERS programme must demonstrate that the house only uses only uses a certain limited amount of energy for the heating and the cooling on a yearly cycle. This is a limited view of the potential energy use of a house for it does not take account of energy required for water heating, lighting, general power including refrigeration and so on. DIPNR are currently developing a planning tool that supplant the NATHERS scheme in requiring a much more thorough audit of the potential energy and water use for a new house or substantial alteration and addition. The new scheme will BASIX. This is a web based interactive tool that will require the designer to in put information about the house in order to demonstrate that sufficient energy and water savings can be achieved against current practice. The implementation of basics is discussed by Rod Simpson in an adjacent article. What is of concern is how the information from the thermal modelling programme, now Nathers but soon be AccuRate, will be used in BASIX.

The most important change is that the projected energy use for both summer cooling and winter heating will be separated out and an additional requirement to indicate the peak heating and in particular peak cooling loads will be required to be entered in the BASIX data base. This will have significant ramifications for all house designs since anecdotal evidence suggests that most houses particularly project type houses, achieve a satisfactory Nathers rating currently by reducing down the heating requirement dramatically but still leaving a high cooling load. By combining the two the NATHERS - SEDA scheme has masked the design decisions to highly insulate the building but not deal with the requirements for adequate shading and higher levels of thermal mass for most of the NSW climate zones. By separating out the two measures of both heating and cooling designers will be required to meet mandatory limits for both seasons and thus house designs will have to address the thermal design requirements for both summer and winter.

The combining of both heating and cooling is a part explanation for how the NATHERS program has provided houses with seemingly little thermal design character to them to be provided with a five star rating. This has been achieved by reducing down glazing areas and increasing insulation values in the walls and roof of the building. Thus the building may have improved it's thermal performance modelling, particularly in winter, however the house is counter intuitive to interaction with the climate and a better use of the benign climate. This is because the house has less window and particularly door areas that lead from inside to outside that would promote an outdoor lifestyle 'that we know leads to a lessening of a reliance on thermal energy consuming equipment' (heating and particularly air conditioning) that is the main source of green house gases in energy use.

The more stringent requirement to address summer design requirements will see a return of bigger eave overhangs and better shading to glazing, a consideration of the better thermal performance of glazing that is installed, and a return to the use of higher levels of thermal mass to store not only warmth in winter but coolth in summer in the temperate regions of NSW. In this regard the development of a more accurate tool, and in particular a better targeted scheme, BASIX, will ensure that house design moves towards real improvements to thermal performance.

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