'Passive' Building Design and Active Inhabitants: The potential of frugal hedonism?

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ABSTRACT: Drawing on experience in Australia, Nepal and Italy, this paper examines factors influencing user attitudes and behaviour to impede good climatic design, construction and management of buildings. The term 'passive' design is unfortunate: for effective outcomes both building and inhabitants must be active. Combining low environmental impact and (non-renewable) energy consumption with high levels of comfort and pleasure requires buildings of climatically responsive design and thermally effective construction, inhabited by committed and knowledgeable people.

The science and the technology required are available, and the technical knowledge required of the user is not abstruse. Yet it is surprisingly difficult to persuade people that environmentally sustainable design (ESD) of buildings not only can provide pleasurable living/working spaces, but is the sensible economic choice. Many consider environmental consequences irrelevant; energy prices have been too low to dent the assumption that ESD represents an unnecessary extra cost, rather than a wise investment. Lack of basic knowledge often combines with the seduction of automation, pre-fabrication and electronics to distance people from direct engagement with the physical world. Perhaps in the future the realities of pollution, climate change, peak oil and economic recession will bring frugal hedonism into its own.

Keywords: energy, houses, comfort, pleasure, users, regulations, frugal hedonism

PREFACE

Architecture is not a merely scientific or technical matter. If it were, there would be little need for architects. Thousands of years of human culture would have resulted in a database of appropriate solutions for the multiple combinations of functions, programmes, budgets, materials, technologies, micro-climates and topographies. Only a few architects would be needed to find solutions to new programmes, or apply innovative technologies for construction and services. Designs and technical documentation for buildings with 'normal' programmes, using conventional construction materials and technologies, could be 'googled' and downloaded, perhaps personalised with some aesthetic addition or amendment. An absurd proposition, of course.

In traditional pre-industrial economies that are more or less how building operates: building typologies and construction methods, evolved over centuries, are continually replicated. Traditional buildings in a specific cultural context and a specific locality often work well climatically in terms of their users' expectations. In conventional segments of technologised economies a similar process pertains: traditional building forms are replicated, at times combining new materials and technologies with overt reference to a nostalgic past, but often lacking those aspects of the traditional originally developed in response to the interaction of climate, people and thermal comfort requirements.

The human factor in building design, production and functioning is not confined to the cultural, the aesthetic or the idiosyncratic: it extends to complex aspects of use, behaviour, knowledge, expectations, assumptions and even prejudices. (Not by chance the acronym PLEA stands for 'passive and low energy *architecture*', not 'passive and low energy building'; of course PLEB would have had an unfortunate ring.) The term 'passive' design appears to emphasise the building itself: but those engaged in it are well aware of the crucial role of a building's inhabitants. In fact 'passive (solar) design' is an unfortunate term: to work well together both building and inhabitants must be *active*: switching on the airconditioning is the *passive* option.

So this is a discursive, speculative paper, dealing with the potential for 'passive'/low energy architecture, drawing on experiences as user, practitioner, researcher and teacher in three different countries. It is not a scientific or technical paper; it describes no socio-logical research. It reports no new 'results'.

THE CHALLENGE

In earlier PLEA papers [1, 2, 3] and elsewhere [4, 5] I have discussed the energy / environmental implic-ations of the design and construction of domestic scale buildings in Australia, Nepal and Italy. This paper examines further some of the factors which affect the environmental impact of buildings by influencing and/or constraining user expectations, decisions and behaviour. It is neither a lack of scientific, technical and practical knowledge, nor the unavailability of appropriate materials and systems which impedes effective thermal performance of buildings in use. It is not that 'passive design' imposes unacceptable aesthetic or practical restrictions on a building's form or function. It is not that a good 'passive-design' building is not demonstrably economic in terms of life-cycle costs. But the market continues to provide, and people continue to build, commission, buy and live in climatically inappropriate buildings. And the users of these buildings, good or bad, seldom operate them in the most appropriate way for thermal effectiveness. To change this unfortunate state of affairs, given that adequate knowledge, materials and techniques are already available (capable of course of improvement and elaboration), we need expert and experienced designers and other technicians, appropriate building evaluation techniques and regulations which encourage appropriate buildings - and an informed public.

AUSTRALIA

Williamson [6] has related the early history (1942-1972) of research by the CSIRO (Commonwealth Scientific and Industrial Research Organisation) and other Australian government organisations into the thermal performance of buildings. The earliest work, both experimental and theoretical, focussed on design and construction solutions to the problem of providing reasonable thermal comfort in the extreme heat of summer, to which 'Europeans' were not accustomed, but was then extended to cover the entire country. By contrast with Europe, in much of Australia the climatic design of buildings has to contend with both hot and cold conditions. For instance, Adelaide experiences summer maxima up to 44°, but its winter minimum can reach 0°: design solutions providing winter comfort at the expenses of summer discomfort are unacceptable. So to provide realistic results, simulations of building behaviour must extend beyond steady-state calculations based on U-values and air temperatures.

Analogue and later digital simulations were evolved to model internal temperatures in buildings subject to fluctuating external conditions. While computers were still huge machines housed in entire buildings, data were input with punch cards, and output was produced on endless lengths of folded paper, at the University of Melbourne Allan and Elizabeth Coldicutt produced the Tempal program [7], which estimated heating / cooling loads and simulated internal temperatures (with *and without* heating/cooling) over specific periods. Tempal used CSIRO solar tables and decades of hourly climatic data (wet and dry bulb temperatures, direct and diffuse solar radiation, wind speed and cloud cover) in graphic form, allowing the selection of representative periods to be carried out 'manually' — that is, by eye.

Tempal identified user behaviour as an important factor in the thermal behaviour of buildings. Variables included assumptions as to the clothing of the inhabitants (clo), and the effects of manipulation of adjustable shading devices, curtains and openable windows, and the regime of openings between zones. [8] Strategic user behaviour is more important in providing low-energy solutions to the provision of comfort conditions in hot climates [9] than it is in cold climates, where the last resort is more insulation – of the building, or of the inhabitants (heavier clothing and more quilts). And it is particularly important in the effective operation of 'passive' solar buildings.

Since World War II a number of Australian architects had been producing buildings whose orientation, fenestration, shading and insulation, intuitively and sensibly disposed, produced thermal (and aesthetic) results significantly better than the 'normal' house, in which convention required kitchen and laundry to face the 'back yard', and 'main' rooms (main bedroom and living room) to face the 'front garden' and the street, regardless of the requirements of privacy or orientation.

The 1973 'energy crisis' aroused environmental awareness in Australia. Following an Australian 'do-ityourself' (DIY) tradition, many 'green' buildings had owner-builders. [10] Publications, organisations, and entire 'green' communities flourished, sharing experience and knowledge for example about 'passive' solar design, mud-brick and straw-bale construction. Environmentally autonomous building was a common ambition. Eventually the housing industry also began to produce some 'low-energy' buildings and advertise them as such; estate agents began to advertise that houses for sale had north-facing gardens / living rooms.

New 'green' myths joined the common-place misconceptions, and over time have become almost dogma. A design manual [11] claimed to 'reduce all information to simple statements answering basic questions that a designer would ask'; setting out 'correct principles', it claimed to offer a framework that 'automatically creates functional designs'. The requirement for major windows to be oriented to the north (in the southern hemisphere) was translated into a 'rule-of-thumb' rectangular plan, 1.5 times as long eastwest as north-south, with shade provided by fixed eaves (on the incorrect assumption that the highest solar altitude coincides conveniently with the hottest period of the year). These 'recipes' or check-lists fail to produce optimal energy-conserving design solutions, and generally ignore the user. [12, 13] 'Lumping together [mutually dependent] variables limits design subtlety and flexibility, and begs important questions as to the priorities of designer and user. What is the design trying to achieve? What are the priorities of the building's inhabitants? Summer days, summer nights, winter days or winter nights? Money saving or energy conservation? Twenty-four-hour comfort, environ-mental purity or 'green hedonism'? A sunny study / bedroom for a child, [or] a westerly view [of an inconveniently located sea]?' [14]

REGULATIONS AND PASSIVE DESIGN

Such simplifications are reflected in the Nationwide House Energy Rating scheme (NatHERS) incorporated since 2003 in the Building Code of Australia (BCA). Comparison of predictions by the first NatHERS rating tool with actual energy consumption (heating+cooling) found no correlation between its predictions and actual measured energy consumption: an important factor in the failure of NatHERS was seen to be 'built-in exaggerated occupant assumptions' [15]. In 2007, in spite of concerns expressed by industry and research bodies, a second-generation rating tool (AccuRate) was introduced, with increased stringency. Williamson et al. again found 'no significant correlation between the present NatHERS ... rating ... and indices of actual heating and cooling energy consumption' [16].

A minimum 'rating' is required for a building permit. A number of award-winning houses built before the scheme's introduction would have 'failed'. [17] According to Kordjamshidi et al. [18] the rating scheme under-rates the effectiveness of buildings designed, on 'passive' principles, to dispense with energy-consuming heating and cooling plant, the very buildings with the best low-energy potential. This is a paradoxical result, given that the scheme forms part of the National Greenhouse Strategy. Williamson et al. suggest that 'for situations where no heating or cooling appliance is intended to be installed an alternative indicator ... would have to be developed' [16].

NatHERS's assumption that houses are artificially heated and cooled understates both the importance of characteristics of the building envelope other than its resistance to heat flow, and the effects of human actions. The most effective building with both artificial heating and cooling is likely to be a well-insulated box: internal thermal mass is of little use in this situation. (Perhaps the regulator's ideal would be a fully auto-matic house

with thermostatically programmed and controlled heating, cooling, shading, lighting: but a house is not a washing machine.) On the other hand the performance of a 'passive solar' house depends crucially on interactions between shading, fenestration, thermal mass, insulation and ventilation. The paradox arises because a well-insulated house of conventional design and construction responds very little to external conditions, whereas a 'passive solar' house is intentionally a highly responsive mechanism, whose good functioning depends on its inhabitants' competence in controlling its responses. In effect, the rating scheme assumes occupants who are careless, or unintelligent or absent: like a highly rated refrigerator (or ricecooker), the house assumed to remain cool (or warm) without human intervention. Of course if some-one leaves the refrigerator door open ...

No rating system can impose low energy consumption. At best it can encourage the construction of buildings with energy conservation potential. But a regulatory 'straitjacket' such as NatHERS can and will influence community attitudes and actions. So if the desired result is environmentally 'virtuous' behaviour, a rating tool (or suite of rating tools) should provide realistic evaluation of the potential of conventional buildings, but not discourage creative and innovative design. Incompatibility between the two approaches may mean that newly enlightened owners of a 'NatHERS' house (due to environmentalist children, or rising energy prices), may find it hard to convert it to 'passive' design. Just as the original rating system based on 'predicted' energy use per square metre led to an increase in house sizes, the application of the scheme may be counterproductive.

In the future, economically successful inhabitants of the 'Third World' are likely to join those who demand comfort at the flick of a switch (Fig. 1a). The pleasures of modern life often involve waste and prodigality, and the jouissance of architecture can seem incompatible with care for the earth; predictions of high extra costs for ESD often combine with dire prophecies of 'freezing-in-the-dark'. But for an increasing number of people in the already affluent 'West' the quality of life in a well-designed 'passive' building, and the need for commitment, understanding, knowledge, time, patience and attention to manage it, can be a source of pleasure rather than a burden (Fig. 1b). If people are to be convinced that environmentally responsive and responsible buildings do not entail an ascetic life of iovless thrift, and extra first costs are an investment in more economical and pleasurable environments, the aim must be an architecture of 'frugal hedonism'.





low-energy house

ELECTRICITY will change the air so you'll never feel hot and you'll never feel cold. Just perfectly comfortable all the year.

la: Flick of a switch: 1960s advertisement Figure 1: Australia

NEPAL

The idea of frugal hedonism comes into relief in Nepal. The environment can be harsh, resources are few, but the Nepalese display a combination of serenity, ceremony and merriment. Few rural districts have electricity; firewood is scarce and if available involves long trips into the *jangal*; the alternative, cow dung, means wasting fertiliser. But wherever long-proven responses to providing shelter with minimal resources have survived the impact of modernity, there is a rich mélange of regional building techniques, evolved in a context of severe environmental pressures and serious poverty. The communal, ceremonial nature of labour, and the reservoir of traditional skills / knowledge, mean that Nepalese building practices are embedded in a pragmatic mix of ritual and social custom, with an economy of means unmediated by technological 'fixes'. In the mountains, where clear skies in the dry season (winter) mean severely cold nights but sunny days, the stone or brick walls of traditional houses provide thermal inertia, thick thatched roofs provide insulation, and verandahs and courtyards oriented to the sun provide a space for drying crops, working and socialising. On the southern Terai plain, the tropical conditions require good shading and cross-ventilation: bamboo lattice structures, plastered with a mud / dung mix, and with roofs and verandahs thatched with banana leaves, function well (Fig. 2a). The less maintenance-intensive corrugated iron is gaining popularity, depriving people of their well-insulated roofs: it is to be hoped that in time a practical thatch / steel solution may be found.

Ironically, inaccessibility and poverty save many rural Nepalese from the situation of suburban Kathmandu, where the lure of 'Progress' has led to the rejection of traditional materials and techniques for concrete frames and slabs, uninsulated brick infill and concrete slab roofs. For many newly affluent middleclass Nepalese, social status reflected in conspicuous consumption is more important than thermally effective buildings. Low expectations of comfort are conditioned by previous poverty: at the precipitous drop in temperature at sunset in winter, people wrap them-selves in quilts. (Solar hot water services on the flat roofs have uninsulated tanks and no return valves; with heat loss to the night sky, the sun reheats the water every new day.) An elderly patriarch, persuaded by his family to sell the traditional house to foreigners and build a new house, complained: 'concrete above me, concrete below me: truly the old ways were best'. The new owners of the old house lowered the ground floor to suit non-Nepali headroom requirements, but other-wise had little to do but replace the timber shutter panels with glazing and add a passive greenhouse-heated bathroom off the sunny courtyard (Fig. 3a).



Figure 2a : Terai house

Figure 2b: Italian shutters

ITALY

In rural Italy the situation is in many ways similar to Nepal. Italy emerged from poverty and under-development only after the Second World War, and there is a socio-cultural gap between the generations. The notion of frugality currently finds little favour in Italy. The cultural imperative of bella figura often leads the children of the *contadini* to abandon their rural family houses for the city, leaving the traditional buildings, merely symbols of poverty to many Italians, for foreigners free of such cultural baggage to buy and restore, bringing their embodied energy back to life. The potential for 'passive' design in existing towns and cities of pre-industrial origin is of course limited by the existing built form and heritage protection legislation. But whether in the city, the suburbs or in country towns and villages, new houses are almost universally built in concrete frame and slab with hollow brick infill, with no attention to orientation, and with relatively small windows. The first cost of conventional concrete and hollow brick construction is lower than alternatives; there appears to be little appreciation of life-cycle costs. The versatile traditional shutters (Figs. 2b, 3b) are often replaced with less effective aluminium 'modern' types; walls and roofs are inadequately insulated, and much thinner than the walls of the traditional houses. The culture of instant gratification is on the side of switches, central heating and air-conditioners; the experiential / practical knowledge of earlier days is being forgotten, and not being replaced by technical / scientific knowledge.



3a: Bathroom3b: Versatile shutters3c: 'Passive' houseFigure 3: a: Nepal •b: Italy•c: Australia

Mistaken assumptions abound. The idea that stone walls insulate is current as in Australia. The assumption that heavy construction is always better than lightweight construction may relate to the Italian concern for bella figura: to the average Italian, lightweight construction looks 'cheap'. Shutters are so seldom used to permit the sun to enter, even in winter (Fig. 2b), that it would appear that for many Italians the sun has little importance, or is seen only as a problem. (The common response to my question as to why a local rural house, although land abounded, had been built in the shade of a hill which deprived it of sun all winter, was that it would be cool in the summer – when in fact the hill would no longer shade it.) Building regulations are numerical, legalistic and bureaucratic, demonstrating little appreciation of buildings as human environments.

PASSIVE DESIGN IN ITALY?

Ironically, the discussion of passive solar design on the website of the Italian PAEA (*Progetti Alternativi per l'Energia e l'Ambiente*) demonstrates the distance of 'normal' Italian design and construction from the principles of 'passive' low-energy architecture. To the question 'What is meant by a 'passive house'?' the site gives this definition: 'The term refers to a particular standard for construction based on the integration of appropriate technologies and materials which ensure that the building is a high quality living environment with a significant reduction in energy consumption' [19] (my translation). The explanation is couched in bureaucratic and legalistic terms, and assumes that only heating is involved. Quoting the PAEA web-site:

'These buildings, characterised by a highly insulated building envelope with no heat bridges, with large windows to the south, and a system of controlled ventilation with heat recovery, are capable of exploiting passively solar inputs and internal heat gains (people, equipment, appliances, artificial lighting) without the need for a conventional heating plant Passive houses are buildings which have an annual heating load so low as to allow for the absence of a conventional heating: the necessary heat can be taken from the outgoing air by the

ventilation system. For this the effective value of the heating load must not exceed 10W/m²... Passive house design imposes strict limits: Low U-values ... / Construction without heat bridges / Low infiltration (air changes below 0.6/hour) / Glazing with low U-values and high solar transmission appropriate to the [specific] climate / Fenestration with U-values appropriate to the climate / If necessary, ventilation with heat recovery / Minimal heat losses in hot water production and distribution / Efficient use of electricity. Thermal calculations on which the design of a passive house is based must take account not only of thermal insulation, but also of the impermeability of the envelope and the ventilation of the interior.' [19] (my translation) (The mention of heat bridges underlines their ubiquity in 'normal' Italian construction.)

The list implies a steady-state approach: no mention of design, zoning, shading, mass, or user behaviour. Little hedonism here. The PAEA website pro-motes a Germany software package PHPP 1.0 (Passivhaus Projektierung Paket), with which a building can receive 'official certification as a passive house' [19]. PHPP covers the factors listed above, so like NatHERS is inadequate for 'passive' houses which exploit solar input, for instance with an incorporated greenhouse, and even less appropriate for the hot summers of southern Italy (in spite of amendments in 2007 the package provides no climatic data for Italy). The Passivhaus website [20] shows a graph of the results (space-heating energy requirements) in three example 'passive' housing schemes, and claims that in spite of a 'high (relative) scatter due to user behaviour', 'the [PHPP] calculations were in excellent agreement with the average measurement results' (my italics). True: but the measured values range from 3 to 46 kWh/m²a. The 'scatter due to user behaviour' is fundamental to the functioning of a 'passive' house: some houses were clearly much more successful (3 kWh/m²a) than others.

There are some signs of change in Italy, among the least 'green' countries of the European Union. Due to public reaction the government has retracted a proposal to remove tax concessions for energy-related building improvements introduced by the previous government. Environmental issues draw increasing media attention: a daily paper dedicated a recent double-page spread to rebutting climate-change scepticism [21]; a weekly journal published an article on 'the new frugality' [22].

CONCLUSION

Environmental issues can no longer be marginalised, and the economic crisis may bring a cultural shift. Consumption and confidence will drop, and many will be forced to re-think priorities and values. Excessive consumerism may become unfashionable, the latest frivolous item may no longer bestow social status. Energy prices were until recently too low to dent the assumptions that at the individual level ESD repre-sents an unnecessary extra cost, rather than an invest-ment, and at the government level that addressing the issue would 'harm the economy'. Now the global eco-nomic system has harmed itself, governments should see the current crisis as a challenge. 'Business-as-usual' is no longer an option. It is recognised globally that issues of pollution, climate change, national energy independence and peak oil can no longer be ignored.

Employment prospects in alternative energy technologies may attract those who formerly envisaged careers as bankers or accountants - or plumbers. The economy will benefit from 'green' investment. With reduced or vulnerable incomes people may demand education and training in appropriate technologies for managing their own environments. This will also apply to businesses trying to lower production costs. People with more time / less money may take up DIY projects to make their dwellings more energy-efficient. The internet will be an important means for sharing inform-ation and knowledge. People who are more involved with and more knowledgeable about their living environments may appreciate the pleasure of 'passive' dwellings: visual and functional relationships between interior and exterior, more effective natural lighting, solar input in winter, landscaping providing summer shade. Frugal hedonism will have come into its own.

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