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# Designing User-Friendly Passive Buildings

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**Figure 1: Building-user engagement 101: using a louvre blind**
(Image: iStock)

## ABSTRACT

Passive design is a fundamental feature of good building design. Going further than just good orientation and fabric design, designers are looking to integrate natural ventilation and other passive comfort control strategies with, or instead of, traditional electrical and mechanical services.

This note focuses on engaging building users in the operation of passively designed public buildings. The note will assist architects and program managers of sustainable buildings to understand what their clients really want, and to deliver a building that its users can and will operate. It provides examples of common disconnects between client expectations and their experience of a building; and it shows how those problems can be avoided with some basic building-user engagement strategies.

# Introduction

Building owners and users alike are reaching for the stars – Green Stars, NABERS Stars or generic, unspecified stars. A project brief that doesn't require a high level of sustainable building design is rare these days; but the greenest building is still a failure if it doesn't meet the requirements of its occupants.

Passive design is the very foundation of any green building. Passive design is the utilisation of the sun's energy to provide comfort, daylight and replace services otherwise provided by mechanical means. It includes things like solar heating and cooling, thermal mass, natural ventilation and daylight.

This paper discusses some of the most common issues that arise when a passive building fails to meet the client's expectations; it shows that in most cases this is due to a failure at the level of user-engagement. The paper then details basic strategies to motivate and empower building users to take control of their building and take full advantage of its passive design.

# Passive Buildings in Design and Operation

As designers, most of us have been guilty of imposing our own beliefs or ideals upon a client and delivering a building that doesn't adequately meet their needs and requirements. This is as true of passive building designers as it is of any other kind of building designer. Fundamentally, a building is for the occupants. If the space delivered does not meet the needs of its occupants and does not provide a habitable, usable and easily controlled facility, it has failed – however green it may appear on paper.

## The Benefits of Passive Design

Passive design provides building services that would otherwise require mechanical or electrical power. The benefits of passive design are well documented and include:

- Improved health and concentration through increased fresh air (Heschong-Mahone Group 1999)
- Improved learning and working performance from natural daylight (ibid)
- Reduced energy consumption, and associated environmental benefits
- Reduced plant size, capital and maintenance costs
- Psychological benefits associated with being connected to the external environment and of being in harmony with it
- Potential higher rental premiums and resale value

**Mixed-mode strategy:** A design strategy where a combination of natural ventilation and air-conditioning is used. Integration can be very complex, i.e. when do you switch to natural/mechanical ventilation? Who is responsible for opening/closing windows when the air-con is switched off/on?

The demand for passively designed buildings is growing. While this is a very good thing, it is also leading to a growing number of clients who think they know what they want – 'a green building' – but are not fully aware of what their vision implies.

# What Clients Say They Want

Building owners and users are becoming better versed in sustainability-speak and will often request high sustainability standards for their building. Project briefs will often request the following:

- 'Minimised energy use'
- 'No air-conditioning'
- 'Abundant daylight'
- 'Natural ventilation'
- 'Utilising high levels of passive design'
- 'Educational – the building must be a lesson in sustainable living'

Translated, clients are looking for a building which will use minimal energy without compromising their level of comfort. They usually know that there will be many

**Figure 2: What a client might say they want: Living Graft Prefab Structure**

(Concept: Mitchell Joachim, Lara Greden, Javier Arbona. Image: www.terreform.org)

compromises, but they do expect that comfort will be maintained every day of the year, usually with minimal input from them. They have been 'conditioned' by air-conditioning: press a button, instant comfort.

Challenging clients' notions of thermal comfort is therefore critical to the success of the project, as passive design simply cannot deliver 21–24°C all year round. Building users will have to appreciate that the building will be slightly warmer in summer and slightly cooler in winter than they may be used to. (Bearing in mind that for many people, this is actually more comfortable: on a 40°C day, a 22.5°C office can feel uncomfortably cold.)

**Automation:** Automated systems don't rely on people to operate openings, but are more expensive and complex than manual systems. They include things like sun-sensing blinds, switches that close windows before turning the air-con on, and high-level louvres that open and close to catch the breeze.

What many clients do not anticipate is the level of hands-on user control that is required in order for their passive systems to work properly.

## The Ideal vs. the Actual Occupant

A passive building requires an active occupant. This fundamental tenet of passive design is often forgotten, and from that oversight stems a host of issues in the operation of passive buildings.

What do we mean by an 'active occupant'? Active occupant are in tune with their surroundings. They tolerate a wider range of 'comfortable' conditions, knowing that a constant 22.5°C is unrealistic in a low–energy building (Leaman et al 2007; Deuble and de Dear 2010). They are willing and able to modify their building to maintain their necessary comfort: they'll turn on a ceiling fan, close a window, open a blind and switch lights on and off (just as they do at home!). Most of all, they are engaged, motivated and able (see EDG 66 GH). They know what needs to be done, and they do it.

Often – and in particular in schools, child care centres and community buildings – the brief requires a high level of building user engagement. This is because the building is conceived partly as a learning tool for the occupants. The client will require that systems be simple to control, so that a wide variety of occupants, including children, can use them and be able to see how their actions affect their environment. Passive features must be manually operated, with the controls obvious and plainly visible.

It would be wonderful if all building users had similar high levels of motivation and ability, but in reality:

- 'I'm really keen to use our building's natural ventilation features and try to get the kids to help me. But try looking after five toilet-training toddlers: it's just easier to switch on the air-con.' – Ghada, child care worker
- 'Every time I walk past his classroom, he has the lights on. I've tried pointing out that our classrooms are identical, that we both have enough natural light and we should be teaching the kids to use less energy, but he just doesn't care.' – Andrew, teacher
- 'I left the window open when I ducked out for a quick meeting. It went way longer than expected, the cool change came through earlier than forecast and now tomorrow's presentation is soaked and scattered about the office.' – Brian, marketing manager with a corner office
- 'I'm always hot and stuffy and want the windows open. But Debbie, who sits next to the windows, complains about the draught and shuts them again.' – Huang, accountant in open-plan office
- 'We've tried having the windows open but with the noise from the kindergarten and street plus a crying baby, I can't hear a word the poor mother is saying!' – Helen, maternal health nurse
- 'Of course I close windows overnight! No one told me they needed to stay open to cool the place down.' – Bernard, cleaner
- 'I have to pull the blind down in the morning because of the glare but then I always forget about it. Before I know it it's the middle of the afternoon, they're still down and I've wasted all that electricity on the lights! Plus I've missed out on the view.' – Anthea, administrative assistant
- 'We were warned that the new building would be warmer, but school policy is that male teachers must always wear ties and long pants. It's unbearable in there!' – Marcus, science teacher

## Common Complaints – Three Case Studies

As it is with many buildings – whether or not they set out to be green – problems in building operation can usually be traced back to miscommunication at the briefing stage.

### The Office Building

**The Brief:** A state-of-the-art building to showcase ESD for a state government tenant/client. Reduced energy

consumption was the driving factor, as well as staff's consensus that the building was to 'breathe' and 'not always feel like you're stuck inside the office'. The site presented several constraints, not least that the main façade had to face west.

**The Design:** The building utilises a sophisticated mixed-mode natural ventilation strategy with automated windows and louvres (with manual override) for natural ventilation. Reed switches sense open windows and motors close them prior to conventional air-conditioning and heating taking over. Automated blinds sense the sun on the western façade and provide solar protection in the afternoon without compromising daylight the rest of the time. High levels of exposed thermal mass stabilise internal temperatures.

**The Complaint:** Staff hated the fact that they had no control over the windows and doors (or felt they didn't). They proudly showed their inventive methods to trick the system into running the air-conditioning constantly: part of this involved tricking the air-conditioning into thinking windows were closed when they weren't, thus increasing HVAC energy use. Friction developed between staff who wanted the windows open and those who didn't.

Staff complained about the blinds not working properly and comfort not being maintained, with the building especially cold in winter.

**In Retrospect:** Some problems were a direct result of design flaws. While the office layout had been designed for effective natural ventilation, there were pockets of very low air movement and without mechanical cooling these areas became unbearable. The external blinds were a relatively new product in the market and thus still had some flaws. The exposed thermal mass was not located where it would receive direct sun and so in winter it became very cold and the resulting radiant cooling effect was uncomfortable for staff.

Remaining problems could be attributed to a flawed consultation process. It turned out that the client's 'staff consensus', as put forward in the brief, was actually a vocal minority and that most staff admitted they would have preferred a conventionally conditioned building.

Staff seating was rearranged so that those who wanted open windows could sit next to them. Window openings were limited so that the entire office was not affected by an open window. The HVAC control strategy was reset to provide mechanical conditioning at all times. When the system operated in economy cycle, 'window' staff were advised through the company's intranet and could open their windows (this turned out to be quite simple for the IT department to set up). The understanding was that energy use would be monitored and that if it was still excessive, windows would be locked shut. This did not prove necessary.

**Economy cycle:** When outside air is supplied without conditioning to provide free cooling, works in moderate to cool external conditions around 16–19°C, depending on the air-conditioning system.

Automatic solar sensors for the blinds were replaced with simple timers, which the staff much preferred.

Carpeted screens were installed between workstations and exposed thermal mass to protect staff from radiant cooling effects.

## The School Building

**The Brief:** The redevelopment of a two-storey primary school block including classrooms and a covered courtyard. The building was to showcase sustainable design and was required to achieve the equivalent of a 5-star Green Star design. Of overriding concern was that the building was to be naturally ventilated, with no air-conditioning.

**The Design:** The two buildings enclosed a courtyard covered with a shade sail. Natural ventilation and

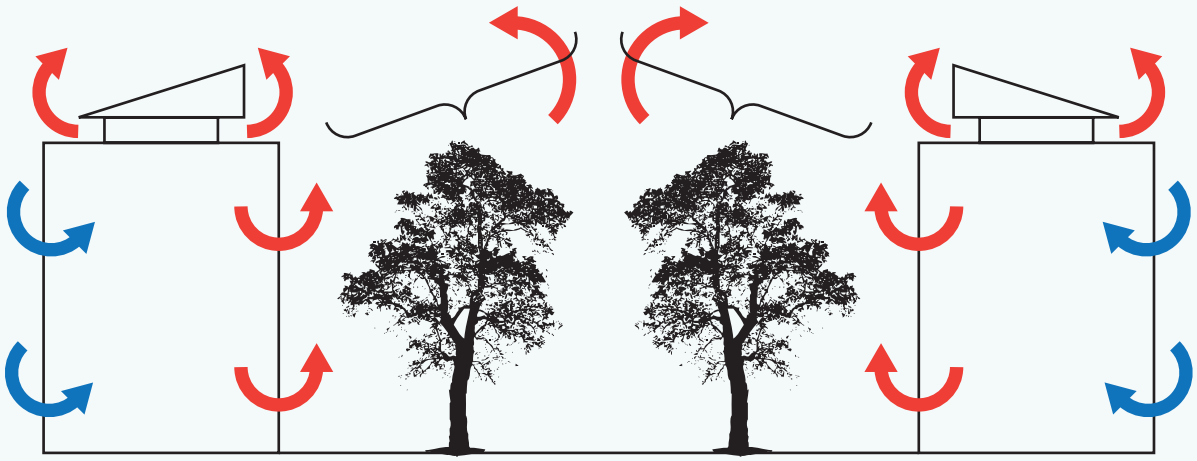

**Figure 3: Natural ventilation strategy for school**

daylight was facilitated through pop-up clerestory windows and openings designed specifically for cross-ventilation. Blinds and louvres were selected to allow portions of windows to be opened depending on requirements. External automated blinds protected the western façade. The courtyard cover was designed to allow airflow within the courtyard and to expel hot air trapped beneath the canopy.

**The Complaint:** The school complained that the natural ventilation did not provide suitable comfort for students and staff.

What Went Wrong? The natural ventilation strategy relied on teachers and/or students operating windows, louvres and clerestory openings. While some teachers welcomed this as a teaching opportunity, others did not and did not operate the ventilation features as needed. Additionally, airflow within the courtyard was lower than necessary for good cross-ventilation.

Teaching staff were not consulted during the design phase – the facility manager spoke on their behalf.

The increasing use of computers in classrooms caused higher than expected internal temperatures, while the issue of glare meant that blinds were often drawn, obstructing airflow. The problem might not have been so bad had the blinds that had been specified been installed, as they could have allowed upper sections of windows to be opened while preventing glare at the working level. However due to capital and maintenance costs, they were replaced with traditional blinds.



**Figure 4: Warema Daylight Guiding Systems, dual-control blind permitting glare-free natural light**
(Image: www.warema.com.au)

In Retrospect: The building form and surrounds meant that successful natural ventilation was always going to be a challenge. The design team was overly optimistic about how well their design would perform despite the obvious difficulties. Rather than hoping for the best, perhaps they would have done better to have counselled the client against hoping for too much.

Teaching staff should have been consulted during the design phase. Subsequent training of staff has improved satisfaction but issues are ongoing.

The original blinds were a key feature in enabling ventilation during computer use and their deletion should have been more strongly challenged.

## The Community Building

**The Brief:** A council-operated community centre – including maternal health nurse (MCH), kindergarten, occasional care and offices – was to be the benchmark green building for the municipality. Incorporating the highest level of sustainable design, the building had to use minimal energy, with air-conditioning only to offices and MCH suites. Passive design was to showcase ESD features and also to be used as an educational tool for the children.

**Cross ventilation:** openings on either side of a building draw air through the building.

**The Design:** Despite difficult site constraints, the building was carefully designed around passive building principles – solar gains in winter but not summer, and cross and stack-ventilation using louvres, clerestory windows and ceiling fans to aid circulation. Insulation and thermal mass were used to stabilise temperatures and reduce heating and cooling loads.

**Stack ventilation:** Hot air is buoyant and will naturally rise upwards so can be exhausted through high level openings. This is the principle behind thermal chimneys. The effectiveness of stack ventilation is reduced through the use of ceiling fans, as these mix up hot and cold air, so is most effective in areas without fans (e.g. circulation spaces) or at times when fans are not being used (e.g. during night purge or teaching breaks).

**The Problem:** Staff complained that the unconditioned areas of the building were too hot.

**What Went Wrong?** Key shading features were deleted by Council during construction, resulting in excessive early-morning solar gains.

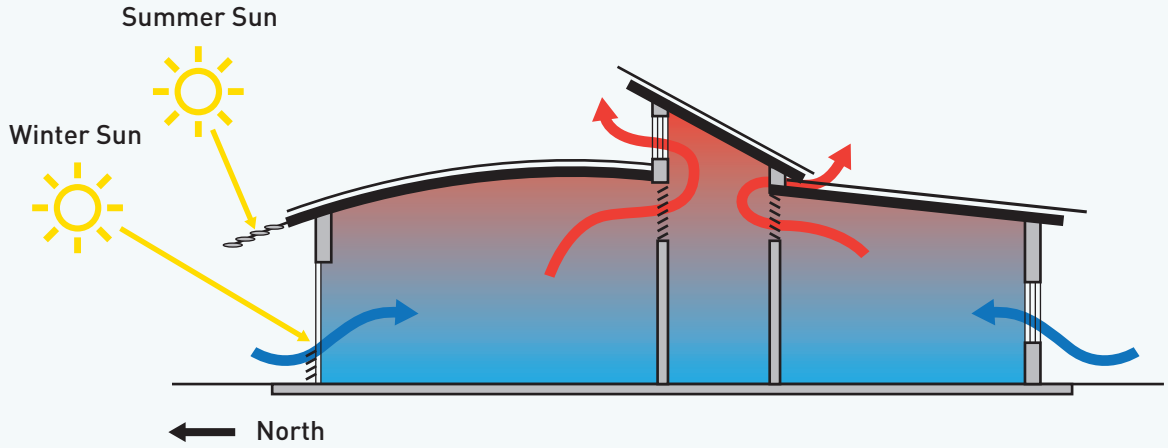


**Figure 5: Passive design strategy for community building**

Despite assurances to the contrary, staff were not trained in the operation of the natural ventilation features. Additionally, staff had from the outset expressed a desire to have the childcare rooms fully air-conditioned, despite Council insisting they would accept a naturally ventilated space.

The cleaner was closing the louvres overnight as he was afraid insects would get in. He did not see the flyscreens and had not been told the louvres needed to stay open to cool the building overnight.

**In Retrospect:** This was a clear case where the building owner (Council) did not consult enough with the actual users of the building. Staff repeatedly petitioned for air-conditioning, which was eventually retrofitted. A short training session for staff in the operation of the natural ventilation features, as initially recommended by the building designers, resolved many of the complaints.

# How to Avoid Complaints

A successful passive building is a true delight for designers and occupants alike, but a poorly performing one is guaranteed to come back and bite you. The keys to avoiding the latter outcome are: consult widely and with an open mind during briefing; do everything possible to engage users in the building's operation; and moderate user expectations.

## Talk to the Right People

How many times have you been in a meeting with a facility manager, a very senior manager and an external stakeholder (e.g. an education bureaucrat). These people may not be familiar with delicate staff relationships and may not even be about to work in the space you are designing. If you are designing a passive building you need to talk to the occupants – not their representatives.

Ask the client to set up a small task group from within the staff and make sure that as well as vocal environmentalists you also get a healthy sample of less 'motivated' staff. It's essential to get a broad cross-section of people on board from the start, because it only takes a few dissenters to make a good idea turn bad.

**Example:** During a workshop early in the design process, the senior managers admitted they didn't really know how their staff would react to a mixed-mode office. The design team set up another meeting and this time the managers' PAs came along, each bringing two friends from the office. This user group became very excited by the possibilities of their new building and took it upon themselves to make it work. They set up workshops in each department and came up with strategies to ensure all staff were engaged. They set about making a number of small changes in their current behaviours to prepare them for the new behaviours – they increased air-conditioning set points, modified the company's dress code and initiated a host of environmental initiatives that the whole company became involved in. They now have a very successful mixed-mode building – and their bosses didn't think they'd be interested!

## Look and Listen

When you are talking to the building users, note whether they enthusiastic or blasé. Does one passionate person dominate or is the attitude consistent among the staff? What can you tell about the company culture?

The answers to the questions will give you a very good idea of how likely the occupants are to appreciate and operate their passive building. One very excited and committed person is not enough if the rest of the staff are not on board as well. Don't forget that staff leave – when the environmental champion quits, who takes over?

**Example:** The Environmental Officer of an organisation was well educated in passive design techniques and was convinced that the new headquarters could be naturally ventilated. He had seen examples of quite sophisticated passive buildings (which required significant and constant management to maintain comfort) and felt that adopting such a design would not only benefit occupants but also consolidate the organisation's environmental values. This sold the idea to the CEO and other key stakeholders. However during the design process it became very clear that the nature of the business was quite intense; staff were under a lot of pressure and worked very long hours. It was obvious that they would not have the time or energy to operate the building as well as complete their daily tasks. The compromise was to install an efficient air-conditioning system to office areas and provide a mixed-mode break out space where staff could enjoy fresh air and abundant daylight. Anecdotally this has been highly successful, and staff say they work better by being able to enjoy a nice break. Interestingly, most staff admit to not being able to operate the natural ventilation system: they just like that it is there.

## Engage Users from the Start

The ultimate success of a passive building depends on how well the building users are engaged in its operation. If the occupants are motivated and able to control their building's passive systems, they will do so. Then, assuming the building is designed well, it will work.

A workshop at the start of schematic design can help identify user priorities and expectations and get them thinking about the possibilities. Questions to get the ball rolling include:

- 'What are some sustainable things you do at home?' This connects users to initiatives they already undertake, which are simple and don't cost them much. They probably don't even realise that opening windows to catch a cool breeze is a sustainable behaviour.
- 'What are things you do in the office?' Users may find they already do more than they thought.
- 'Have you heard of any other green buildings? What are some sustainability features you've heard of?' A brainstorming session will generate some great ideas (and the staff will then own these ideas).
- Pick a few features that are relatively easy to implement, e.g. widening the temperature setpoint in the office: 'How do you think that would work here? Can you foresee any problems?' You will be pleasantly surprised how quickly the users find solutions!

**Figure 6: The ABC of good passive design: Always Be Consulting**
(Image: iStock)

- 'What wouldn't work here?' By now you probably have a list of potential strategies: it is time to identify and resolve potential roadblocks. Some won't have a solution; it is OK to move on and focus on things you can do.

Ask your user group to go back to the office and talk to their colleagues. Surveys are useful to anonymously assess user attitudes. Identify any problems or misgivings early on and tackle these head on – time spent now will result in a better overall outcome.

## Modify User Expectations and Attitudes

Changing corporate culture is a topic all of its own. It can be a long and involved process, and can take up to seven years to effect (Shere 2006). Fortunately, promoting occupant control of passive systems does not usually necessitate a profound cultural shift, but it will still necessitate some degree of change.

For a passive building to work effectively, occupants' perceptions of thermal comfort is the first thing that needs to change. The traditional comfortable band of 22.5±1.5°C no longer applies – but that shouldn't worry most people. Many users of passive buildings actually report improved comfort (Wickham 2010; Deuble and de Dear 2010). The usual reasons for this are:

- **Clothing:** Users dress more appropriately for the weather. In summer they will wear less, in winter more. In one naturally ventilated office, workers wore shorts and t-shirts all day and kept a shirt and slacks in the locker for important meetings. Visitors were seen to remove their tie at the door with obvious relief!
- **Expectations:** Humans have settled the entire planet, from the polar ice caps to equatorial deserts. Yet the increasingly common subspecies Homo officus melts at temperatures above 24°C and freezes below 21°C. Fortunately, this creature

can be trained to adapt to a much wider range of temperatures than previously thought.(Wickham 2010)

- **Attitudes:** The greater the sense of pride, responsibility and ownership occupants feel for their space, the more motivated they will be to operate it successfully. These attitudes must come from the top: management must show that it is committed to sustainable behaviours before staff can be expected to follow suit .(Shere 2006)
- **Control:** Give people control over their environment and their tolerance for its variability increases. (Leaman et al 2007) But too much control will annoy them – people do not like to be fiddling constantly to be comfortable! (Leaman & Bordass 2006; Bordass et al. 2007)

**Example:** An organisation wanted to trial increasing the temperature setpoint of their air-conditioning to reduce energy use. Staff were engaged from the outset with regular communiqués and updates. Not only did energy consumption reduce significantly but the number of complaints about comfort actually decreased. One senior manager stated emphatically at the beginning of the process that 'I don't do layers and I only wear stilettos!'. Three weeks later she proudly sported a new look involving a sweater and sensible shoes.

# Design Considerations

Keep it simple! If you can't explain the control strategy of your building to your children, then it probably won't work in practice. Building-user operated systems can work well, as long as people are easily able to use them. In a mixed-mode building, users should be able to manually operate windows and air-conditioning. Naturally this works best in small offices where consensus is either easily obtained or where definite metrics are agreed to, e.g. 'When the thermostat on the wall shows 28°C, we close the windows and turn on the air-con'.

The greater the number of mechanical and electronic devices, the more sensors, automated motors, switches and control logic required, the more likely it is that your building will not work. A sophisticated system that gets out of control can create more complaints and use more energy than just having a simple, robust system to begin with.

*'Intelligent buildings are those that don't make the user look stupid.'*

Adrian Leaman[2]

## Using Modelling

Modelling (computer simulation) of your building can help to optimise building fabric, ventilation openings, thermal mass and control strategies. It can help quantify expected operational parameters (e.g. 'natural ventilation will provide comfort for around 63 per cent of the time') and determine if the proposed strategy will meet a given target (e.g. 'We will accept temperatures of 26-29°C for not more than two hours in a day').

However modelling can also provide a false sense of security. A building model will make many assumptions about the building's occupation, inhabitants and use. It will probably use an average year of weather, which may not account for the temperature and humidity extremes of an actual year. It will assume users know how to and operate the ventilation systems constantly and perfectly! And the results are numbers on a piece of paper – how people actually feel in a space can never be perfectly simulated.

Modelling is a very useful tool but needs to be treated as just that – a tool, not an end.

## Key Features and Optional Extras

A passive building is not worth the name if it doesn't contain at least three key features:

- ceiling fans
- shading features, including blinds (just go for simpler ones, as long as they don't constrict natural ventilation systems and still control glare)
- insulation and good quality glazing

Unfortunately every project has a budget. When push comes to shove, be willing to give up:

- sophisticated new technology
- non-essential automation
- very high performance materials – e.g. if you need argon-filled low-e double glazing, consider reducing your glazed area

But never, never compromise on commissioning, training and post-occupancy evaluation.

# Training Building Users

Training occupants how to use their passive building effectively is just as crucial as designing its passive features in the first place. There are many strategies to encourage building-user engagement (e.g. see EDG 66

[2]Personal communication by Adrian Leaman to Gerard Healey reported in 'Identifying Skills to Support Appropriate Use of Integrated Controls', Achieving the Green Dream Conference, AIRAH, 2010

GH) but the three indispensible ones are: the Building User's Guide, training and familiarisation sessions, and post-occupancy evaluation.

## Building Users Guide

A Building Users Guide (BUG) must:

- be straightforward and in plain English
- be short and concise (i.e. not run into chapters)
- be kept in a place where it can be easily found. Individual information sheets should be located at the point of use (e.g. next to light switches or louvre controls)
- contain photos and simple diagrams of the items being controlled
- explain what will happen when actions are performed – e.g. 'when you press this button, that louvre will open and air will come in'

## Training and Familiarisation Sessions

As many staff as practicable should be trained in the operation of the building's passive systems. This will probably mean performing the same sessions a number of times, for different staff. Training sessions should be:

- performed by members of the design team
- split into small groups so that everyone can have a turn at operating things and ask questions
- performed one to two weeks after occupants have moved in, giving them enough time to settle in, find where things are and possibly experience some slightly unpleasant conditions that will make them eager to learn about their control systems

## Post-Occupancy Studies

Post-occupancy studies are vital. During the first year, you need to be in contact with the occupants at least once each season. A quick visit or call to ask 'How is it working? Are you happy?' can identify problems which can hopefully be quickly resolved. More training may be required, particularly as summer moves into winter and vice-versa. Most importantly, you'll learn what works, what doesn't and how to do it better next time.

# Conclusion

A building which eschews full air-conditioning in favour of a fully or partly naturally ventilated approach can provide a comfortable, healthy and effective place to live, work and learn. But to achieve such a building, good design is not enough. Just as important is that the building be useable by the occupants and meet their fundamental needs for that space. Achieving both is not only possible but actually not that hard! It is only necessary to engage the building users from the start of the design process, during the design process, and again in commissioning and post-occupancy. Done properly, the result will be a passive building with active occupants. In other words, a high-performance environmental building that really works.[3]

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[3]More information on post-occupancy evaluation can be found in the Soft Landings Framework www.bsria.co.uk/services/design/soft-landings/.

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