BEDP ENVIRONMENT DESIGN GUIDE

# Applying Expert Opinion to Domestic Building Energy Assessment

**Emilis Prelgauskas**

***Summary of***

# Actions Towards Sustainable Outcomes

## Environmental Issues/Principal Impacts

- There are building designs where traditional energy assessment methods cannot be applied.
- There are building elements not recognised in traditional energy assessment methods.
- Some buildings when measured by traditional energy assessment methods, are given scores that under value their real world performance.
- Traditional energy assessment methods cannot effectively distinguish between conventional, and best practice building.
- Only the expert opinion method allows for a building proposal to be assessed having regard to its full range of contributors to energy efficiency, and the diverse range of data sources that can be called upon to calculate their expected performance.

## Basic Strategies

*In many design situations, boundaries and constraints limit the application of cutting EDGe actions. In these circumstances, designers should at least consider the following:*

- Be aware of the deficiencies present in rating housing energy performance via conventional methods.
- Attempt to gain rating via the method most likely to account for a building's climate conditions.

## Cutting EDGe Strategies

- The contribution from innovative and individual building elements towards the energy efficiency of the whole building
- The measured, post-occupancy, real world performance of operating buildings with similar features and climate
- Working with expert opinion.

## Synergies and References

- *BEDP Environment Design Guide*:
  - Des 20 Arid Climates and Enhanced Natural Ventilation
  - Des 59 Passive Cooling Building Systems
- Post occupancy building energy data sources
- Prelgauskas, E, 2003, *Performance Outcomes: Free Running Building Achieving Energy Efficiency*, Self-published by Emilis Prelgauskas Architect, Adelaide.

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*This Note considers expert judgement as one of several stated assessing methods approved for compliance with the Building Code of Australia's Performance Requirements for housing energy efficiency. It discusses both the matters considered by, and the nature of the 'independent technical expert', arising from the use of the expert opinion method.*

## 1.0 Introduction

Formal building energy assessment has been integral to the Building Code of Australia (BCA) regulatory requirements for a number of years. This applies to new housing, and in some states, legislation requires compliance with the BCA energy efficiency requirements for substantial additions as well.

The BCA in each section sets out its broad 'Objectives'. These are followed by a list of 'Functional Statements', and then a list of more detailed 'Performance Requirements' are mandated (ABCB, 2006; vol 1, p16). The BCA recognises options for compliance with its Performance Requirements. Several assessment processes are allowed across a spectrum; which fall under either 'Deemed-to-Satisfy' or 'Alternative Solutions'.

For Class 1 these 'alternative solutions' can include the following methods:

- computer simulation
- reference building
- expert opinion.

Section J of Volume 1 of the BCA specifically deals with 'Energy Efficiency' requirements for buildings other than Class 1 (housing). These requirements, which include commercial buildings, have been introduced more recently and are generally outside the scope of this Note.

## 2.0 Building Code of Australia (BCA)

The BCA (as the national document for building codes), sets out the minimum provisions required for a building to achieve compliance. As well, Performance Requirements are described with a range of assessment methods, and measurable criteria for assessment.

This is shown in the diagram below, which is from the BCA (ABCB, 2006; vol 1, p 16 & vol 2, p 16).

The energy efficiency 'Objective' of the BCA for housing is "*… to reduce greenhouse gas emissions by efficiently using energy*". The functional statement that follows this is: "*To reduce greenhouse gas emissions, a building, including its domestic services, is to be capable of efficiently using energy.*" The Performance Requirements that follow call for a "*level of thermal performance to facilitate the efficient use of energy for artificial heating and cooling appropriate to … the function and use of the building … the internal environment; and … geographic location …*" etc (ABCB, 2006, vol 2, p73–74).

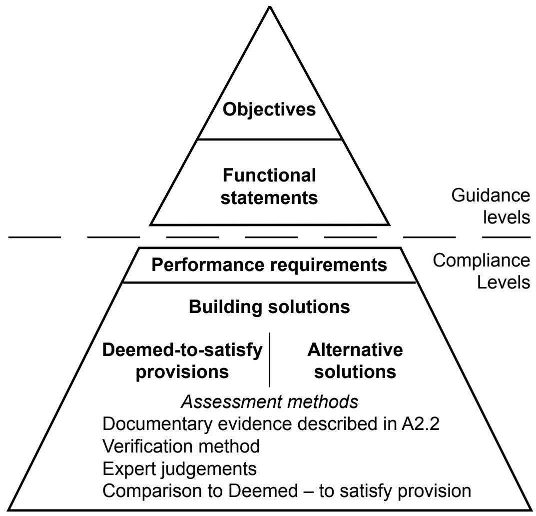


**Figure 1. BCA Structure**
(ABCB, 2006, Diagram provided coutesy of the Australian Building Codes Board, http://www.abcb.gov.au)

The documentary evidence that is acceptable for energy efficiency assessment is also outlined in the BCA:

- "*A certificate from a professional engineer or other appropriately qualified person which certifies that a material, design or form of construction complies with the requirements of the BCA, and sets out the basis on which it is given and the extent to which relevant specifications, rules, codes of practice or other publications have been relied upon*" (ABCB, 2006; vol 1, p37).
- "*Any other form of documentary evidence that correctly describes the properties and performance of material or form of construction and adequately demonstrates its suitability for use in the building.*" (ABCB, 2006; vol 2, p31).

Verification for alternative solutions can be offered for complete buildings, or their components (services or building elements). Supporting information can be drawn from the deemed-to-satisfy sections in Volume 2, Section 3.12 for housing (and Volume 1, Section J, for other classes of building).

In the deemed-to-satisfy section, the Code identifies individual elements such as walls, glazing, seals, air movement, and services for lighting, air conditioning, ventilation and hot water (these are grouped more simply in Volume 2), and details approved constructions for these.

Alternative solutions can be used with the evidence to support them coming from a variety of sources which include:

- use of a computer software program that models a comparative simulation building model for reference, and accredits the thermal performance of this model with a 'star' rating
- reference data (heat flows or energy use) taken from comparable built, and operating buildings, and/or their elements
- heat flow or appliance energy consumption calculated by engineering predictions
- a certificate/statement from an 'expert', drawing on all such data sources.

In the context of this Note, all these evidence sources can be aimed at the energy performance standard, by either meeting the energy use goal, which suits mechanically conditioned buildings, or by meeting the comfort performance goal, which is applicable to 'free-running' buildings (without mechanical conditioning).

In this way, buildings with features not envisaged in the formulation of prescriptive requirements can be validated.

# 3.0 Assessment Methodologies

## 3.1 Deemed to Satisfy Provisions

The deemed-to-satisfy method uses prescriptive building elements, which are listed in detailed tables within the Code, and is the most commonly applied approach.

## 3.2 Alternative Assessment Provisions

### 3.2.1 Computer Simulation

The next most common verification method is computer simulation. This can be done using software, such as NatHERS, FirstRate, Accurate, and others. Some states limit the use of this verification method to accredited software, (with accreditation of programs varying from state to state).

Both this and the deemed-to-satisfy approach are focused on, and suited to, housing proposals based on conventional layouts with conventional construction, materials and methods.

### 3.2.2 Reference Building

The lesser used verification method is that of the 'reference building' method. This is based on a stated mix of both the deemed-to-satisfy and the computer simulation methods above, and is set out in BCA training material (ABCB, 2007). In this method, a hypothetical, parallel, compliant, computer building model is set as a benchmark, against which the proposal is compared (ABCB, 2006, vol 2, p78).

This approach can be useful where a proposal is generally conventional, but has some additional out-of-the-ordinary building elements. (Such individual non-standard elements encompass items like vertical vane shutters, or horizontal angled eaves, which change the direct solar inflow to openings compared with the baseline assumptions in software).

The building proposal is assessed against a compliant, fully conventional theoretical equivalent which has deemed to satisfy characteristics. The comparison proposals are run under computer simulation. The proposed building model needs to perform at least as well as that modelled with deemed-to-satisfy elements.

### 3.2.3 Expert Opinion

The BCA 'expert opinion' can be applied to any building proposal, and is mainly evoked where buildings have elements not dealt with by other assessment methods. Expert opinion can be applied to verify compliance on any building, although this Note is concerned with its' value in assessing housing proposals, that achieve energy savings by means beyond those codified by prescriptive regulation and computer simulation.

In contrast to all the other assessment methods, the expert opinion approach rests on a determination by an independent technical expert. Opinion is applied using first principles, existing post occupancy data, and inputs from the other assessment methods (Prelgauskas, 2003). These can include quantitative, qualitative, and comparative, as well as score components. Conventional assessment methods are only able to assess a part of the possible score range. The term 'first principles' refers to the use of 'passive solar design' (in temperate climates), and 'climate responsive design' (in warmer climates). For example, in a passive solar building, this would include assessing the effect of orientation, insulation, thermal mass, glazing and shading on the particular design.

Another example of the application of expert opinion would be to acknowledge the value of a pergola on the south side of a Southern Australian house, as a cool air storage device. Computer simulations would not currently acknowledge the value of such a device, beyond shading. The value of such devices can be backed by real world post-occupancy data from built and operating buildings with similar features.

Despite the value of expert opinion in assessment, it has seen relatively limited application, when compared with the bulk of housing projects assessed by conventional methods. The reasons for this include: the routine acceptance of conventional methods, the broader range of issues that need to be considered to assess non-standard buildings, the complexity of integrating energy conservation credits and debits, and limited formal agreement on the definition of what constitutes 'expert opinion' between industry and regulators.

Thus any new building proposal which can be compliant with standard assessment is often encouraged to be so, even if the actual, expected, real world energy efficiency performance is massively understated and misrepresented. The result is that both barely compliant, and best practice projects may achieve the same '5 star' score. This masking of innovation is contrary to legislated intentions. Legislation for energy efficiency was intended to encourage the development of better quality buildings through the differentiation of those that are ordinary (barely compliant) and best practice. Further recognition of expert opinion will aid a move away from minimal complying performance, toward best practice; and help to embed innovation in construction.

# 4.0 Assessment Considerations

## 4.1 Issues with Computer Simulation

In the early days of housing energy simulation, common base faults, identified in the algorithms included:

- small floor area buildings rated poorly compared with those that had large floor areas, despite real world evidence to the contrary (i.e. a large building volume is encapsulated within a relatively small area of building envelope)
- the contributions of passive cross-ventilation, and the effect of low-energy fans on comfort were understated (resulting in a bias against buildings in warm climates for comfort and energy use predictions).

Even with the resolution of some of these limitations, there is still an impression that computer simulations are based on inflexible algorithms, which do not recognise non-standard buildings. This applies in particular to climates different to that of the temperate areas where the simulations were first developed.

The simulation of specific sites does not match real world experience, through the effect of differing micro-climates created immediately around a building. *Environment Design Guide* note Des 20 describes in detail how placing a building on a site can create multiple micro-climates). For example: it is known that the common 2°C temperature variation between the sunny and shaded facades of a house is sufficient to create some cross ventilation. And if the same facades were painted with nano-ceramic paint, the paint's reflective qualities would deliver an insulation benefit to the facade in sun (up to +R2), but with no insulative benefit to the shaded facade (AU+E et al, 2006). These and similar micro-climate effects are not covered by any algorithm known to date.

## 4.2 Issues in Assessing Non Standard Buildings

Tony Isaacs in his description of AccuRate in *Environment Design Guide* note Des 23, records some of the building elements which are not modelled well, or at all, by existing accredited building energy simulation software. These include:

- trombe walls
- earth berm walls/underground housing
- attached greenhouses
- solar chimneys
- earth tubes
- insulated shutters
- heat recovery ventilation
- renewable energy systems
- roof ponds
- active solar systems such as heated/cooled rock beds.

The experience of other commentators has shown that software is appropriate for comparative assessment, but is not necessarily reliable as an absolute predictor of energy usage. Some rating protocols such as ABGR (Australian Building Greenhouse Rating) include cautions about using simulation as a direct predictor of energy consumption (DEUS, 2005).

Field experience has shown that computer simulations do not attribute the energy use credits achieved by a range of measures found in best practice projects that limit the emission of greenhouse gases such as:

- Energy conserving building designs which provide comfort via nil or low energy means. (Refer to *Environment Design Guide* notes Gen 12; Des 20 and 59 for discussion on angled eaves, safari roofs, and subsidence towers).
- On-site renewable energy generation systems like solar cells that may feed 'Green Power' back into the electricity grid.
- Bio-fuelled systems development (that use methane harnessed from sewerage), where operation contributes to greenhouse emission abatement.

As well, these simulations do not give credit for initiatives that create carbon sinks such as:

- treed groves irrigated with wastewater.

None of these features which reduce 'real world' in-building energy use and the greenhouse emissions attributable to such buildings, are measured in the deemed-to-satisfy computer simulation or reference building assessments. It is because of this, that such buildings are better assessed by expert opinion.

The expert opinion method addresses the past problem, where portfolios of energy efficient buildings from some leading practitioners, have consistently been given low, or non-compliant scores, under conventional assessment methods. At the same time these buildings may achieve real-world, post occupancy measurement of exemplary, high comfort, and low energy use records (Williamson, et al).

Regulators initially feared that certified best practice buildings would not maintain their performance. For example, the fear was that a free-running building, when initially built, would perform well, but, would in the hands of subsequent owners have mechanical air-conditioning fitted; resulting in much higher energy usage. Actual experience over the decades has been that subsequent owners attracted to a best-practice building, tend to be those with sympathetic attitudes, because they have been prepared to pay the most for free-running buildings. Conversely, the general consumer who values conventional building features tends to willing to pay less, which would be consistent with their attitudes (based on post occupancy inspections of houses by the author over 3 decades).

As a result, the evidence is that free-running buildings tend to operate with lower energy use than computer simulations would currently assess.

### 4.3 The Effect of Occupancy Patterns on Energy Performance

An occupied building experiences higher internal heat loads because of heat generated by the occupants, and the appliances they use. Simulations have been built on an understanding of the flow rate of heat across known materials and assemblies for a presumed occupancy level.

The actual use of buildings may be quite different. For example in a cooler climate, a beach-house that may only be occupied for short, intensive periods, could be served better by light-weight construction that does not 'hold' heat, whereas a more continuously occupied house would be better served by heavy-weight construction that can hold heat, and even out diurnal temperature variances.

Occupants are also able to adjust a building's energy control systems. Building owners and operators effectively become the building management system, and can intelligently respond to daily variances in weather. If educated about a building's thermal operation, the occupants can be a major determinant of energy efficiency. Design for a free-running building often presumes occupant manipulation in systems, such as night purging, and responses to the local climate advantages (such as sea breezes, and thermal effects around buildings) to maintain comfort. Conventional assessment assumes only additional energy usage to achieve the occupant comfort (e.g. for mechanical air conditioning).

Conventional assessments profiles for occupancy patterns assume steady state heat flows in materials, to make provisions for compliance manageable. Expert opinion can allow a finer grained consideration of building occupation and ability to interact with local climates.

## 5.0 Rated Buildings on the Energy Spectrum

Figure 2 sets out the potential housing energy efficiency performance range; from traditional development at the bottom, moving upward toward best practice development. This places compliant '5 star' rated buildings into an overall context of what can be achieved. This context is validated by post occupancy evaluations for completed buildings as described in *Environment Design Guide* note Des 59.

In the South Australian context, an occupied building with minimum compliance can be attributed a 21kWhr/day energy use; however at the top end of the scale, a building that has carbon credits (e.g. with on-site renewable energy generation greater than it needs), generally requires less than 5kWhr/day. Such carbon credit developments would rate up to '38 stars' in equivalent terms (Prelgauskas, 2005). These buildings embody low energy use, greenhouse abatement methods, and renewable energy generation (with excess energy exported to public mains as 'Green Power').

Post occupancy data studies conducted by architectural practices, research collaborations and academe, on the buildings that inhabit the higher end of the range, provide a further resource to the expert in assessing a proposal with similar building features.

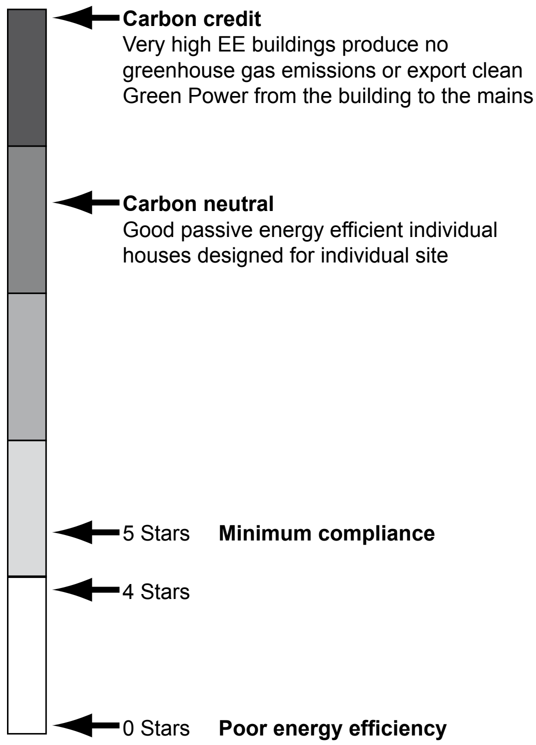


**Figure 2. Building Energy Spectrum**
Diagram by Paul L Whatnell

## 6.0 Data Sources for Informing Expert Opinion

The independent technical expert, in reaching an opinion with regard to an individual building proposal, can draw on a range of quantitative, qualitative, measured and anecdotal sources.

### 6.1 Quantitative

Direct quantitative supporting information includes sources such as:

- post occupancy evaluations that measure comfort and energy use from comparable, existing, operating buildings
- measured performance and energy use, for individual building elements, services and machinery in use in similar existing installations. (Refer to the 'Performance Outcomes Folder' noted in the references).

## 6.2 Qualitative

Qualitative supporting information can include insights from relevant parts of other assessment methods – deemed to satisfy provisions, reference building and indicative computer simulation. An expert may use energy efficiency rating software that meets ABCB (Australian Building Codes Board) energy modelling protocols (such as EcoTect, Enerate, etc) but which are not accredited under their state's legislation, to inform an opinion of how a building will perform.

## 6.3 Measured and Anecdotal

Measured and anecdotal sources include applying the full, attributable value of real world performance characteristics to materials. The expert may be informed by manufacturers data in determining 'equivalent R values' (resistance to heat flow) for materials where that performance occurs secondary to its primary function, and would otherwise not be measured by rating software (e.g. a compressed strawboard favoured for its' sustainability also provides an insulation benefit that is not published).

This would allow for the insulating effect that some thermal mass materials have, to be taken into account – such as rammed earth, adobe, pise, mud brick, wattle and daub etc, or use a heightened insulation value for reflective insulation membranes within wall assemblies – when isolated from linings on each side with an air cavity.

## 6.4 Other Unquantified Built Examples

It is known that some passive and low energy design elements are significant contributors to energy efficiency, but may not have been quantified because of difficulties in measuring their performance. Some of these techniques would include the insulating value of:

- static air volumes against external surfaces of glazing, created under overhanging verandah roofs
- vines and creepers grown over a trellis, in front of a thermal mass wall, with a separating insulating air gap
- venting air from under safari roofs and roof-mounted, photovoltaic module arrays.

# 7.0 Built Examples Inform Expert Assessment

Experience is one further data source used to inform expert opinion. It should be noted that the bulk of information used to formulate the existing deemed to satisfy and computer simulations in Australia has been generated from temperate climate sources, and therefore, has less relevance in tropical and hot dry climates. The comparison to built examples in a similar climate, gives the expert confidence in the performance of a building's elements.

The following case study buildings have been designed by the author, and built in South Australia. The use of these buildings of non-typical elements creates a repertoire of proven initiatives that now inform expert opinion. The following buildings have had their thermal performance tested with the energy usage as follows:

**New Fairlamb House, 2004**
*18Whr/day (12 stars)*

The Fairlamb family home in Murray Bridge was designed as a lightweight clad timber structure. It contains glazing areas larger than deemed to satisfy tables can accommodate. It also has a suspended timber floor in the centre section of the building. The design contains examples of elements not assessable by other methods including:

- the pantry is ventilated to the underfloor in order to achieve food storage capacity, and thus offset refrigerator energy use
- a vented verandah that achieves both solar heat reduction, and moderates heat flow at the interface of the roof and wall beneath
- climate driven, cross ventilation (which is effective in the plan's single room depth), that utilises the micro-climate effect between sun and shaded sides of the building, as well as a clerestory exhaust – activated by prevalent summer north winds.
- This project included a grid connected 1.5kW photovoltaic system.

This proposal was assessed by expert opinion based on similar, earlier buildings, in the same climate zone, of similar construction, and with comparable passive elements such as:

**The Monarto House, 1983**
*2.6kWhr/day (25 stars)*

**Five Houses in Callington, 1980-1988**
*3-11kWhr/day (7-25 stars)*

Other useful, built examples that form a data source for the author have been a series of housing retrofits. These existing detached houses have had a 'home audit' completed to assess them for progressive improvement by retrofit, with the aim of reducing their energy use by about 50 per cent. As the buildings were not being extended, the BCA provisions for energy efficiency were not invoked. However the thermal performance of the houses was measured before and after they were retrofitted. Information was gathered on the performance of items like: western wall trellises, double-glazing, and increased ceiling insulation, as well as on optimised position and function of supplementary fixtures (offset ceiling fans and heat shift ducts). The benefit of these projects was in the comparison of the before and after performance figures, thus giving the author a clear picture of how each of the passive and low energy elements perform.

**Retrofitted exiting houses, 2000–2003**
*15-17kWhr/d (12-14stars)*

## 8.0 Who is an Independent Technical Expert?

Energy raters may have extensive experience in the operation of particular software, but a much broader range of experience is required to qualify someone to give an expert opinion in energy efficiency. Appropriate technical expertise can be drawn from all segments of professional training, however experts are generally from an academic or practice background, with a proven research record in logging and studying post-occupancy, thermal performance of buildings. Their knowledge should be appropriate to the climate and construction technologies being employed. Their credentials will be gained through their involvement in research, legislative committees, industry application, and the generation of data sources.

There has been a fear that expert opinion might be applied unscrupulously, with unrealistic assessment of development proposals. That is why it is important that experts are held to be so by their peers; putting them effectively under constant peer review. Some states have defined in legislation who are energy efficiency experts. In other states it remains in the hands of building surveyors, as to whom they consider an appropriate expert.

## 9.0 Further Evolution

Building for energy efficiency, low energy demand, and greenhouse emission abatement/avoidance will continue to evolve, particularly as new building elements are developed.

The achieved energy efficient performance of buildings is primarily about how people live in, and manipulate a building; and far less determined by heat flow through the building construction alone. Using expert opinion permits the inbuilt facility for occupants to control their environment (and hence achieve energy efficiency), to be part of the assessment, which other compliance methods do not.

The continued achievements in energy efficiency will occur through the pursuit of best practice solutions. These are the very solutions that are currently beyond the scope of the BCA deemed to satisfy, and computer simulation methods. Because the expert opinion approach has regard for a more extensive palette of building features and the relative contribution of these features, and is a more specific predictor of their performance in individual circumstances, expert opinion will continues to have a role in assessing buildings' energy efficiency. The continuing innovation of best practice requires the progressive development of methods that are ever ahead of established building methods.

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## Biography

**Emilis Prelgauskas** is an architect in private practice with an extensive portfolio of best practice completed projects. He worked on government committees leading up to the introduction of mandatory minimum energy requirements in South Australia, was peer referred to the SA government Building Rules Assessment Commission, and now is one of the two deemed 'experts' on thermal performance of buildings in South Australia.

Emilis collaborates with Atelier Urban+Environmental on building performance research, and carries out expert opinion assessment on applicable building proposals. AU+E is an Adelaide based collaboration of four architectural practices that share primary research data on post-occupancy evaluations of housing.