HOW TO ACHIEVE SUSTAINABILITY – REGULATORY CHALLANGES

M.AMBROSE
CSIRO, Manufacturing and Infrastructure Technology
PO Box 56 Highett, Victoria, 3190, Australia
e-mail : michael.ambrose@csiro.au

A.MILLER
CSIRO, Manufacturing and Infrastructure Technology
PO Box 88, Kenmore, Queensland, 4069
e-mail Anne.Miller@csiro.au

Abstract

The importance of designing sustainable buildings is gaining greater acceptance worldwide. Evidence of this is how regulators are incorporating sustainable design principles into building regulations and requirements. The aim being to increase the number of sustainable buildings and move from a traditional voluntary compliance to one that is mandatory. However, developing regulations that actually achieve these aims can be a difficult exercise.

Several countries in South East Asia, such as Singapore and Malaysia, have performance based building regulations that are supplemented by prescriptive measures for achieving the desired performance. Australia too has similar building regulations and has had energy efficiency regulations within the Building Code of Australia for over a decade. This paper explores some of the difficulties and problems that Australian regulators have experienced with the performance-based method and the prescriptive or "deemed-to-comply" method and measures that have been taken to try and overcome these problems. These experiences act as a useful guide to all regulators considering the incorporation of sustainable design measures into their countries building regulations.

The paper also speculates on future environmental requirements being incorporated into regulations, including the possibility of non-residential buildings being required to meet minimum energy efficiency requirements, and the possible systems that would need to be in place before such requirements were included.

Finally, the paper looks at a possible way forward using direct assessment from electronic designs and introduces several software tools that are currently being developed that move towards achieving this goal.

Keywords: Sustainable buildings, Performance-based, Regulations, Energy efficiency, Assessment tools.

1. Introduction

The importance of designing sustainable buildings is gaining greater acceptance worldwide. Evidence of this is how regulators are incorporating sustainable design principles into building regulations and requirements. The aim being to increase the number of sustainable buildings and move from a traditional voluntary compliance to one that is mandatory. However, developing regulations that actually achieve these aims can be a difficult exercise.

Many countries are now moving towards performance based building regulations, including many in South East Asia such as Singapore and Malaysia. One of the main reasons behind the use of such regulations is to allow greater flexibility within the construction industry and help drive innovation in the way buildings are designed and built. However, how to achieve the required performance level has not always been clear and consequently these building regulations are usually supplemented by a series of prescriptive measures for achieving the desired performance. These prescriptive measures have been seen as essential for small building projects where the resources are not often available to undertake testing and analysis of design solutions that may be required to achieve the performance based requirements.

Australia also has performance based building regulations and has had sustainable design principles, in the form of energy efficiency regulations, within the Building Code of Australia for over a decade, although they have generally been State based rather than national regulations. However, national energy efficiency standards have now been adopted for house construction and focus on a minimum energy efficiency requirement for housing with the aim of bringing about reductions in energy use and consequently a reduction in greenhouse gas emissions. Methods for determining whether a house design meets these requirements has been mainly through prescriptive based or "deemed-to-comply" provisions by providing designers with basic insulation levels for ceilings, floors and walls. A performance-based option is also available by using an accredited assessor and simulation software to obtain a performance rating for their design. Both these methods continue to be the two options within the new energy efficiency section, although some States have now moved to the performance-based method as the only allowable method for new residential construction. However, future trends in environmental requirements and the possibility of including commercial buildings within energy efficient and environmental requirements may see that the deemed-to-comply options become increasingly difficult to structure and undertake.

2. Need for Energy Efficient Regulations

Buildings are one of the leading consumers of energy. In highly urbanised countries such as Singapore, it has been estimated that more than half the electricity generated is consumed by buildings (Building Energy and Information Centre, 2004).

In Australia, the use of energy in the home is the largest source of greenhouse gas emissions from households. The average Australian household's energy use is responsible for about eight tonnes of carbon dioxide (CO_2), the main greenhouse gas, per year (Reardon, 2001). Consequently, the need for regulations that cover the energy efficiency of dwellings constructed within Australia is clearly warranted. Voluntary schemes such as the Australian Housing Industry Association's GreenSmart program have proven to be very successful where implemented and show a desire by the housing industry to educate and promote energy efficient principals to their members and the general public. However, the take up by the general public of such homes has been very small and there continues to be a lack of understanding by many builders of the principles of energy efficient design. Energy efficient requirements by local government through their building permits system has allowed for localised improvement in house energy efficiency, but has also lead to a rather disjointed and inconsistent methodology for implementing energy efficient principles at the state and national level.

Within Australia a star based rating system is used to assess the relative energy efficiency of residential construction. The number of stars achieved is determined through a computer based thermal modelling program that determines average annual energy usage required to maintain a house within a particular thermal comfort range, over a set time period and in a particular climate zone. The resulting energy total, in MJ/m2/annum, determines which star band a house falls into. A recent study into energy efficiency of new homes in Queensland, where until recently no energy efficiency regulations existed, showed most homes performed very poorly in terms of energy efficiency (Tucker, et. al., 2002). The study of 100 typical homes built in South East Queensland over the last three years showed that 91% achieved only a 1 star rating or worse. Fig. 1 shows the distribution of star ratings achieved by the homes rated. The temperate climatic conditions in this part of Australia should allow homes to easily achieve a good result, yet they do not. A lack of regulations and poor community and industry understanding of energy efficiency issues was considered the main cause for the poor result and it is reasonable to assume that similar results would be likely in other parts of the world where specific mandatory regulations do not exist.

The study also looked at the types of improvements that would be needed to bring those poor performing homes up to the new required standard of 3.5 stars and the additional cost involved in doing so and found that in 45% of cases the additional improvements cost under $AU2000 extra, averaging at $AU1669. Only 10% of homes required additional improvements in excess of $AU5000 while the overall average for all the homes considered was only $AU3015, which is less than 3% of the cost of building any of these homes. The relative minimal cost involved highlights why mandatory national energy efficiency regulations have been adopted and appear to be the only viable method for achieving universal improvement in Australia's housing stock.

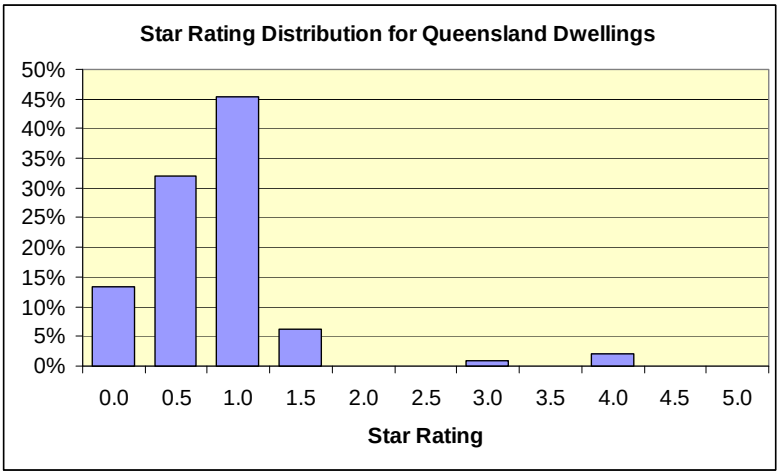

Fig. 1 Star rating distribution for sample Queensland dwellings

3. Prescriptive Based Regulations

Although performance based regulations have been in place in Australia for over a decade, the prescriptive measures or deemed-to-comply method has traditionally been used for meeting the energy efficiency requirements. A study into building practice in Victoria showed that the deemed-to-comply method was used in almost every building approval (Australian Greenhouse Office, 2000). The study into the Victorian experience with minimum energy performance requirements also revealed that although the original intention of the deemed-to-comply provisions was to try and equate to a 3 star rated home (the performance based requirement), in reality 80% of homes failed to meet 3 stars with some only achieving 1 star. On average, homes were achieving 2.2 stars. Fig. 2 shows the distribution of star ratings for the sample group of homes that were rated for the study.

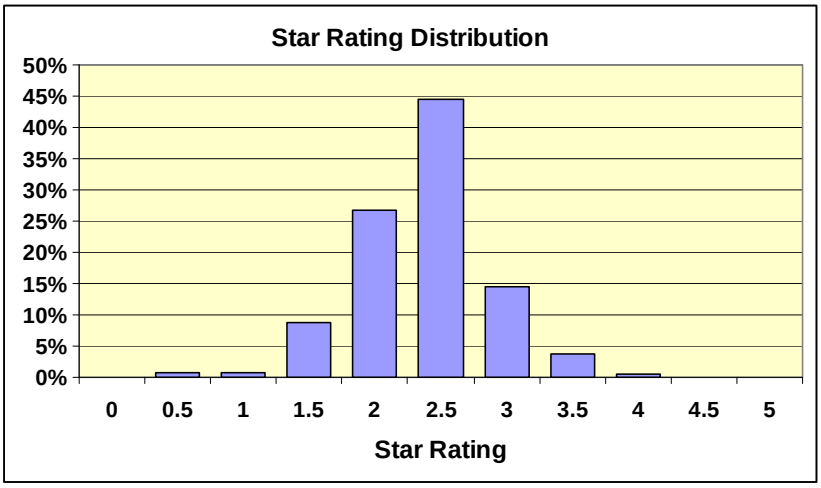

Fig. 2 Star rating distribution for sample Victorian housing

The main reason cited for the significant under performance of the deemed-to-comply option was the almost non-existent take up of passive solar design principles in the homes built. Sadly, the researchers concluded that they saw "*no significant improvement in the thermal efficiency of new buildings since the introduction of regulations in 1991*." Increasing insulation levels set by the deemed-to-comply option was seen to offer little hope of improving the performance of homes and that the greatest improvement would have been achieved through a mandatory minimum energy performance standard such as a minimum star rating. The fundamental failing of the prescriptive based regulations was due to the fact that they contained a series of simple measures that failed to take into account the interaction of design and

materials in achieving good performance. The prescriptive measures focused solely on materials which when combined with poor design resulted in poor performance.

However, the poor performance levels achieved by prescriptive methods appear to be reversed when the performance level is significantly increased. Recently, the Victorian State Government with the desire to significantly improve the performance of new dwellings increased the performance requirement to 5 stars, resulting in Victoria having the toughest regulations in Australia for energy efficiency. Studies carried out to assess how best to achieve this performance level and avoid the problems encountered with the previous regulatory arrangements found that with the increased prescriptive measures required to meet the new standards many dwellings well exceeded the performance based target (Energy Efficient Strategies, 2002). This resulted in the prescriptive based method delivering higher performing dwellings, but at a greater cost. A cost benefit analysis carried out found that the increased benefits associated with the prescriptive based approach were consistently outweighed by the associated increase in costs. Conversely, it was estimated that Victorian builders using performance based methods would save between 40 to 50 million Australian dollars in investment costs per annum, with even greater savings possible with the likely reduction in costs associated with undertaking energy efficiency simulations. Consequently, the prescriptive based option has been removed for dwellings in Victoria with all new dwellings having to undertake a performance-based simulation.

4. Performance Based Regulations

Despite the problems that have been found with prescriptive methods, the overwhelming popularity of the method suggests that builders and designers hold serious reservations with the performance-based method. Certainly, the relatively simple prescriptive nature of the deemed-to-comply option is attractive but probably the overwhelming factor is the need to use a qualified assessor to rate a design if using the performance-based method. This results in additional cost and delays in getting the building compliant with energy efficiency requirements. Builders who have used assessors have cited that when their designs fail, no feedback is given as to why they have failed and it is only through trial and error that they develop a design that meets the requirements. It is this uncertainty and the cost involved that seem to be a significant barrier to the uptake of the performance-based provisions.

However, as has been discussed earlier, as performance requirements increase, the associated costs with achieving this through prescriptive methods increases dramatically and thus the benefits of performance based methods are likely to be adopted. The ability of performance simulations to model design solutions, such as orientation, window positioning, etc which can often be achieved with no additional cost, rather than prescriptive methods which usually rely on additional materials, is where significant cost savings can be achieved. Indeed, some builders who have adopted performance-based assessment have reported that they have reduced improvement costs by up to 50% over using the simplified prescriptive method (Energy Efficient Strategies, 2002). Such significant savings dwarf the additional cost of simulations.

Nevertheless, many builders have expressed a need for a simple approximation method which would give them guidance and greater certainty that the formal assessment would succeed.

5. Future Regulations

A countries building regulations are not a static document. As situations change regulations are modified and amended to reflect these changes. The drivers for this change may be political, social, technical, physical or a combination of these and they can have an effect on any aspect of countries building regulations. As has been seen in Australia and many other countries, sustainability issues are growing in importance and the role that the built environment has on sustainability is being reflected in changes to building regulations. Energy regulations are an excellent example of this evolutionary process and often represent the first step in the delivery of increasingly stringent sustainability requirements for buildings. Additional regulations could deal with water consumption, greenhouse gas emissions, indoor air quality, resource use, solid waste and a range of other environmental measures. It is likely too that such environmental regulation would not be restricted to housing but extend to all building types. Programs

such as GreenStar in Australia, LEED in the United States, BREEAM in the United Kingdom and HK-BEAM in Hong Kong all have a significant focus on commercial buildings and although largely voluntary, many new government buildings are required to meet the various requirements of each program as part of their tender documents. It would seem likely that many countries in the near future will incorporate at least some aspects of these programs within their building regulations for commercial buildings.

6. Way Forward

Although the need for greater sustainability from our built assets has been well recognised for many years, the great difficulty has been how to implement it. Voluntary programs are good initial steps and provide opportunities to explore the different ways that schemes can be developed and implemented and their relative success can be assessed without the complexities of a mandatory requirement. However, as has been shown, voluntary schemes have little overall impact and for sustainability measures to have any significant benefit to the environment, legislated mandatory regulations appear to be the only practical solution. However, a significant problem is that as these regulations become more encompassing and demanding, the ability to assess the compliance with the regulations becomes increasingly difficult. For example, the 5 star energy rating requirement for Victorian homes was considered too difficult to achieve through prescriptive methods as fundamental design issues are essential for compliance. Thus the performance-based method was adopted as the only way to rate dwellings.

The implementation of wider ranging and tougher regulations will lead to a need for different ways in which these regulations may be assessed and complied with. Present rating tools are one method of undertaking these assessments, but like energy simulation software, are often considered time consuming and costly. Future systems need to be quicker and more cost effective if wide acceptance is sought.

7. Automatic Assessment

With the movement towards more electronic means of design and documentation, such as computer aided design (CAD) systems, an opportunity exists to utilise this vast amount of design information to undertake automatic checking of building regulation compliance. Energy efficiency compliance is an ideal area to investigate the effectiveness of such systems. One system that is presently being developed utilises CAD information to undertake environmental assessments on residential buildings, including energy efficiency ratings. The Life-Cycle Housing Energy Estimator system (LICHEE) is able to take elemental and dimensional information direct from a CAD based building design and performs a series of sophisticated environmental assessments on the design. One of these assessments utilises the energy rating software NatHERS, which is used in Australia for complying with the performance based energy efficiency regulations. In addition to the NatHERS assessment and rating, LICHEE also assesses the embodied energy and CO_2 emissions of a dwelling design for a given lifecycle. However, it is LICHEE's ability to automatically perform NatHERS ratings that has generated the most interest and which has the most immediate benefit for designers.

LICHEE utilises the power of the next generation of CAD systems. Presently, most CAD systems produce drawings with little 'intelligent' information, that is, the drawings are simply lines with no inherent information as to what the lines represent. The software cannot determine whether the line represents a wall or a toilet. However, object-oriented, three-dimensional CAD systems are leading the way for the future of the CAD industry. One such system is ArchiCAD and this has been utilised by the LICHEE developers to demonstrate the power of the LICHEE system. Fig. 3 shows a typical example of an ArchiCAD drawing.

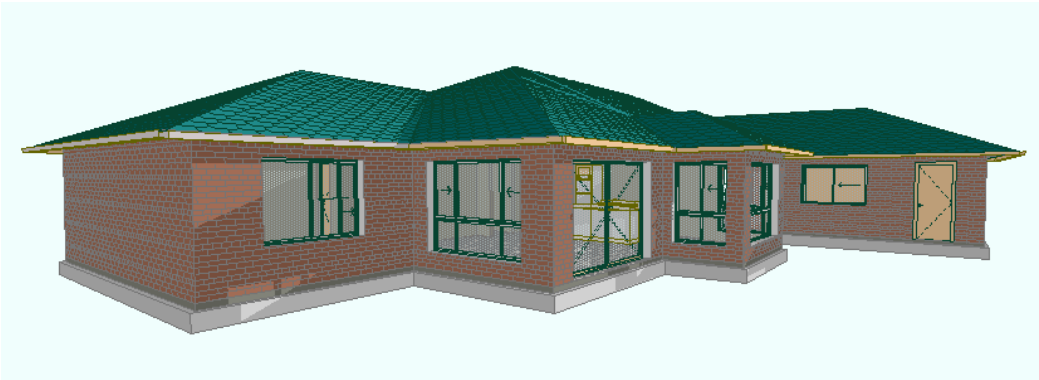

Fig. 3 Typical 3D CAD image generated by ArchiCAD

Of course, it has been recognised that it is imperative that a tool such as LICHEE not be restricted to a single CAD platform and as such LICHEE employs Industry Foundation Classes or IFC's as its input file standard. The IFC's have been developed as the international standard for defining architectural and constructional CAD graphic data as 3D real-world objects and are being implemented into CAD systems, such as ArchiCAD, as the vendor neutral file sharing system. The IFC standard has been embraced by the Singapore government as part of its CORENT (Construction and Rela Estate Network) program, a major IT initiative aimed at reengineering the business process of the construction industry (Graphisoft, 2002).

From the IFC file, LICHEE is able to interpret what the various building elements are (walls, windows, roofs, etc), the product type (brick wall, concrete wall, plaster wall, etc), their dimensional information (area, length, width, height and volume) and their orientation. Coupled with climate zone information, LICHEE is able to pass the data automatically to the NatHERS program for an energy efficiency rating. The results are then passed back to LICHEE for display. Graphical displays are also available detailing the progressive and cumulative life cycle energy and details on energy and CO_2 emissions based on building elements and building products.

The LICHEE system has been developed for residential buildings. However, the basic principles behind its design can be applied to commercial buildings as well. Prototype software has been developed designed to perform environmental life cycle analysis of commercial buildings from their CAD drawings. The tool is called LCADesign and provides designers with the ability to perform detailed analysis of their designs and deal with possible future environmental regulations with relative ease. As with LICHEE, LCADesign utilises 3D CAD information via an IFC file and performs a wide ranging environmental life cycle analysis on the proposed design, which is then able to be compared with alternative design variations. **Fig. 4** shows a typical example of a resulting analysis.

Tools such as LICHEE and LCADesign will greatly benefit designers, enabling them to quickly assess designs against both voluntary and regulatory environmental requirements. This will also enable performance based building regulations to be widely adopted and used which will thus deliver buildings that meet the true intent of such regulations.

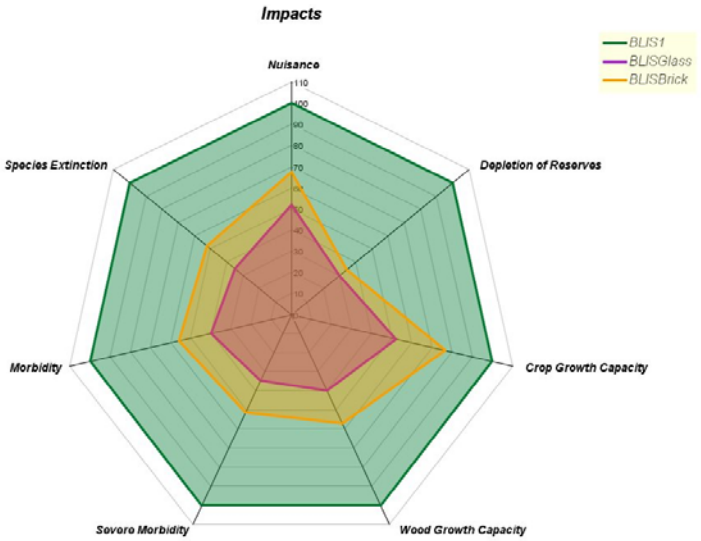

Fig. 4 Example design comparison graph from LCADesign

8. Conclusion

Energy efficiency and other environmental regulations are becoming an increasingly important aspect of many countries building regulations. Such regulations not only help reduce our impact on the environment such as reducing greenhouse gas emissions, but also deliver buildings that are more comfortable and healthy to live and work in. However, such regulations need to be implemented in a way that enables the designers and builders to assess their designs and ensure compliance with relative ease. Performance based regulations have generally been backed up by prescriptive options and this balance has worked relatively well for most aspects of the regulations. However, in Australia energy efficiency has proved to be a difficult area to ensure that the deemed-to-comply provisions achieve the intention of the performance based regulation. As energy efficiency regulations have expanded and enhanced the use of deemed-to-comply provisions have been found to be increasingly difficult to effectively implement and have consequently been abandoned. Other sustainability related regulations are likely to suffer the same problems with the prescriptive methods and as such performance based is likely to be the only option.

Reliance on the performance regulations alone requires a system that does not disadvantage or discouraged designers from achieving compliance. Tools such as LICHEE and LCADesign provide an example of the type of systems that designers could utilise to aid their design process, meet energy and environmental regulations and provide the public with buildings that are more comfortable to live and work in while reducing their impact on the world. The tools also enable the regulatory bodies to look forward into the future and develop codes that build on the existing codes to strengthen their environmental emphasis, knowing that effective methods exist for helping ensure compliance.

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