THE EVALUATION OF ENVIRONMENTALLY SUSTAINABLE RESIDENTIAL DEVELOPMENT USING A BUILDING SUSTAINABILITY INDEX

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Green homes or eco-homes have been built in many countries and have played an important role in setting a benchmark in ecologically sensitive housing and guiding industry in the design and construction of sustainable houses. According to the Department of Infrastructure, Planning and Natural Resources a new dwelling is built every 14 minutes in New South Wales, Australia. This paper examines the introduction of an online tool the Building and Sustainability Index (BASIX) as mandatory to all residential developments in New South Wales. It is two and half years since the introduction of the index and yet no attempt has been made to ascertain its impact on the construction industry. An online survey was conducted to ascertain this impact and it was found that free access to the tool via internet was one of the main reasons for its success. It was also generally accepted that the tool has played a significant role in providing a general guideline for the sustainability performance of a proposed development. This paper discusses the results of the survey.

Keywords: housing, green buildings, sustainability.

INTRODUCTION

According to the Department of Infrastructure, Planning and Natural Resources (DIPNR) a new dwelling is built every 14 minutes in NSW, Australia. The population growth predicted to rise from 20 million in 2005 to 25 million in 2021 (Australia Bureau of Statistics 2005), will continue to create demand for new housing. The increasing demand for new dwellings will no doubt affect the environment in terms of land use, energy and resource consumption. In NSW, sustainable housing has become the main focus of the government's housing policy (DIPNR 2004a). In terms of sustainability and environment performance, most new houses are no different from houses built in the last decade.

In response to the need for sustainable housing, the NSW government launched a sustainability assessment tool (called BASIX) in July 2004 to assess and establish energy efficiency targets and sustainability levels. This paper provides an overview on the development of sustainable housing in NSW. BASIX was introduced two and a half years ago however its impact on the construction industry is yet to be ascertained. There is very little knowledge on the magnitude of the environmental benefits that the index measures or of which goals were achieved. The aim of this paper is to present the framework of the index for the planning, design and construction of sustainable residential development and to discuss the role of sustainable performance measures on the promotion of sustainable residential development. This paper also presents the

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results of an industry-wide questionnaire survey to investigating the impact of the tool in enhancing sustainability in the construction industry.

THE CONCEPT OF SUSTAINABILITY IN RESIDENTIAL DEVELOPMENT

In recent years, a growing number of sustainable housing projects have been completed and sustainable housing is increasingly becoming part of common building practice. Sustainable housing was one of the issues addressed in the United Nations Conference on Environment and Development at the Earth Summit in Rio de Janeiro in 1992 (Bhatti 2001; Li and Shen 2002). Bhatti (2001) states that sustainable housing can make major contributions towards the environmental future. The method by which housing is produced, consumed and managed, and the way it contributes to social and cultural life has major impacts on the environment.

From this viewpoint, a sustainable house is characterized by futurity and equity issues which aims to ensure that everyone today and the generations to come have a decent place to live that is cheaper to run than existing houses. In addition to considering land use, orientation, shadow and light, concern needs to focus on the long-term costs - social, environmental and economic. The purpose of sustainable housing is to raise the standard of living and to offer an opportunity for people to have a decent house to enhance social unity, well-being, economic growth and social improvement. Sustainable housing concerns not only the fabric of buildings but also the social and environmental context of construction practices. In sustainable housing construction, the concept of eco-efficiency is important and implies that a reduction in the environmental impact of housing construction can be undone by trends such as an increase in the average size of houses, and decreasing the average number of persons per house (Klunder 2004). Sustainability is not just about low energy, it also means that people are happy to live where they live and that they live in a healthy environment.

According to the Communities and Local Government in the UK, in 2004 a quarter of carbon dioxide emissions came from energy consumption by houses (CLG 2006). Therefore it is important that houses are built in a more sustainable way. Sustainable housing will be a growing part of the housing industry, making it a business opportunity waiting to be explored. There are multiple advantages to sustainable housing which directly brings energy cost savings to owners. The lower energy consumption during the operating period contributes significantly to saving energy bills in the long run and will further save energy cost if energy prices continue to increase in the future.

SUSTAINABLE RESIDENTIAL DEVELOPMENT – THE CASE OF AUSTRALIA

Population growth in Australia was the driving force behind the increased demand for housing. The population growth predicted to rise from 20 million in 2005 to 25 million in 2021 (Australia Bureau of Statistics, 2005) will create demand for new housing. The construction industry is struggling to keep pace with the housing requirements of a growing population. The increasing demand for new dwellings will no doubt affect the environment in terms of land use, energy and resource consumption. In terms of sustainability and environmental performance, most new houses are no different to houses built in the last decade. The issue of how housing

can be made more sustainable has become the main focus of governments in Australia in relation to minimizing adverse effects on the natural environment (Gurran 2003, Department of Planning 2005).

Due to population growth the houses constructed during the next 15 years will form a considerable part of future housing stock and it is therefore an important opportunity to improve the environmental performance of houses. Conventional housing construction has a far higher environmental impact than has new houses. Residential development is just as important as any other type of construction. The environmental impact of an individual house may be minimal but the construction of all residential developments together will make a significant impact on the environment. More solutions are required to reduce the environmental impact of houses construction.

Australia's first demonstration green house was completed in March 1993 at Roxburgh Park, Melbourne (Okraglik 2003). It demonstrates sustainable principles and acts as a guide for housing sector towards sustainability. Others such as Michael Mobb's sustainable house in Chippendale[2], NSW, the EcoHome[3] in Deer Park, Western Melbourne and Subiaco sustainable home[4] in Perth were developed to educate and raise awareness of practical and innovative solutions to sustainable housing and living. The completed projects set a new benchmark in ecologically sensitive housing. Apart from green houses being built to promote sustainable housing, the Housing Industry Association, in collaboration with Australian Agencies Environment and the Australian Greenhouse Office, the community and the construction industry has developed GreenSmart[5] to promote and to achieve sustainable housing. It is a package of practical environmental measures that emphasize environmental and affordability considerations of environmentally sustainable housing design.

According to Okraglik (2003), improving environmental performance of existing houses often depends on a range of conservative measures such as adding appropriate insulation, using energy efficient appliances, and substituting conventional energy sources with alternative ones such as solar. However, new housing design enables an integrated and optimal approach to environmental sustainability which should be recognized and adopted in order to achieve improved environmental performance. Constructing sustainable dwellings depends on recognizing and addressing environmental issues such as embodied energy and the using recycled materials.

THE DEVELOPMENT OF THE BUILDING AND SUSTAINABILITY INDEX

In response to the need for sustainable residential development, the NSW government launched a sustainability assessment tool called the Building and Sustainability Index (BASIX) in July 2004 to assess and establish energy efficiency targets and sustainability levels. The concept of BASIX evolved as a result of the successful sustainable design, construction and operation of the facilities for the Sydney Olympic Games in 2000. After the Games the Sustainable Advisory Council (SAC) was established and formed by industry experts, government representatives and the environmental community. It was under the direction of DIPNR, the SAC

[2] www.sustainablehouse.com.au
[3] www.cfd.rmit.edu.au/ecohome
[4] www.subiacosustainable.com.au
[5] www.greensmart.com.au

recommended the development of BASIX to ensure that new residential developments be environmentally friendly and resource efficient.

BASIX is the first mandatory requirement for development approval for all residential projects in NSW. In other States only thermal performance assessment for residential development was regulated. Local authorities in NSW have advocated sustainability in residential development for a long time (Department of Planning 2005). However each local authority has its own environmental assessment measures in local planning tools which vary greatly across NSW. Some local authorities may be more pro-active than the others while some are still struggling to develop a single tool. The inconsistencies have caused frustration within the construction industry.

BASIX is designed to meet the needs of local government and the construction industry by providing a systematic assessment of the sustainability components of residential development. These include regional sensitivity where appropriate and, as a means of raising the awareness of sustainability in construction (Department of Planning 2005). BASIX measures energy efficiency along with other sustainability factors like water usage and thermal comfort. It also helps to standardize development practices in areas of water, energy and land use. BASIX simplifies and improves the planning process and provides an easy and effective tool to produce better sustainability outcomes in residential development.

Since July 2004, residential projects are required to complete a BASIX assessment in relation to the proposed construction before an application for development can be lodged with the local council. The details required include the dimensions of the dwelling including the floor and roof areas, number of bedrooms, areas of landscaping, water and energy efficient features, rainwater tank, insulation, shading and proposed hot water system. A BASIX certificate will be provided if a reduction of water and energy consumption and thermal comfort are achieved.

BASIX is a web-based self-assessment tool. The eight main indices are site ecology, social, transport, water, stormwater, energy, waste and recycling and materials and are categorized into water, thermal comfort, energy, landscape and stormwater. The outcome is that residential developments are required to achieve a 40% reduction in potable water consumption and a 40% reduction in greenhouse gas emissions, as measured against existing dwellings of the same type. Simpson (2003) describes BASIX as the first integrated sustainability tool of its kind in Australia, and one of the first internationally that aims to encourage better sustainable building using a web-based planning tool. DIPNR (2004a) states that the introduction of BASIX has led to the construction of more sustainable houses which have incorporated sustainable design features and providing user comfort. Segalla (2005) goes on to state that BASIX has brought compulsory sustainability into construction and will continue to play a significant role in all residential development.

COSTS OR BENEFITS?

Building professionals' reaction to the importance of the environment in a development is significant. From the literature, the perception of building professionals is that the consideration of environmental issues means higher building costs, and higher cost means lower return which is of concern. This is understandable given that the main objective is to make money (Kats 2003; Okraglik 2003; Ding 2004). Even though most building professionals recognized the importance of environmental issues, they retain this perception that looking after the environment

will inevitably cost more. There has been a widespread perception that building green is significantly more expensive than traditional methods of development. It was estimated that green buildings cost 10% to 15% more than conventional buildings (Kats 2003). This is particularly serious in the private sector. When it comes to the actual incorporation of environmental considerations in project selection, environmental issues rank as the least important (Kats 2003). Maximum financial return remains a deep-rooted requirement of a development in construction in the private sector.

Segalla (2005) states that the extreme view of sustainability has put it out of reach of builders or developers in terms of construction cost and time. However BASIX does not necessarily lead to a significant increase in time, frustration or cost. The cost of constructing a sustainable building should take into consideration the use of green methods and the long term benefits of low ongoing maintenance and operating costs (Kats 2003; Segalla 2005). Segalla (2005) goes on to state that improving a building's sustainability is a real and viable option for residential development as house owners in Sydney, who had building approvals immediately prior to the introduction of the BASIX, have indicated concern about the saleability of their non-BASIX compliant properties alongside their BASIX-complying neighbours.

While the environmental sustainability measures captured in BAXSIX are undoubtedly relevant to domestic construction, the tool cannot be considered all-encompassing. BASIX is a user friendly and simple to use tool. However BASIX may be too simple to capture the complex nature of the environment and its inter-relationship with building activities. Environmental issues are a broad area and difficult to capture by using a pre-designed set of sustainability criteria. For thermal comfort, BASIX is simply a pass or fail assessment. The options for various areas in BASIX such as glazed shading, external wall options are limited and there is no ability to input new materials or construction methods. BASIX also tends to be too generalized to capture most environmental criteria within the evaluation framework. Striking a balance between completeness in the coverage and simplicity of use will be one of the challenges for further developing BASIX.

In addition, building life cycle has not been incorporated in the evaluation process in BASIX. As Curwell (1996) states, life-cycle analysis is important in environmental assessment of buildings as it gives a balanced assessment between a development and the environment. Therefore, a whole-of-life approach is an essential method to evaluate and integrate the costs and benefits associated with sustainable housing construction (Bhatti, 2001). Kats (2003) states that the lack of life cycle costing is one of the obstacles to sustainable buildings. Therefore the ongoing maintenance, repair and replacement of the building should also be included in the evaluation process.

Further, embodied energy has not been included in the evaluation process. Only operational energy is assessed in BASIX with a target of reducing energy consumption by 40%. However construction consumes energy in two principal ways. Firstly, it consumes energy through the construction of buildings and related facilities. In general the energy is used to produce building materials and their subsequent on-site assembly at their final destination. Secondly, it consumes energy in the later use of these building and related facilities in the form of heating, ventilation and cooling, lighting, hot water, and appliances and equipment. It is important to assess the building's entire life cycle on the environment including energy consumption embodied in the process of recovery of raw materials and the manufacturing process.

Therefore using low embodied energy materials and recyclable materials become extremely important (Weir and Muneer 1998). In Australia, the energy embodied in construction can represent up to one-fifth of national energy consumption (Treloar *et al.* 2001) and it is significant because it occurs immediately and the total energy consumed in the production of building materials can be equal, over the life cycle of a building, to the temporary requirements for operational energy (Pullen 2000).

RESEARCH METHOD

In order to examine the impact of BASIX in promoting sustainability in residential developments, an online questionnaire survey was undertaken to investigate its usage and impact. The questionnaire survey was designed and distributed online so that it could obtain a wider coverage and provide a quick and easy platform to return the completed survey. The purpose of the survey was to examine the level of acceptance of BASIX since its introduction in July 2004 and to explore the role of BASIX in the construction industry in enhancing sustainability. The survey also assessed the impact of its implementation as mandatory to development application for residential projects. The online survey was distributed to practitioners in the construction industry in March 2006 and the participants were also encouraged to forward the URL to other practitioners in the industry. Therefore it was difficult to determine the exact response rate. At the end of May, 120 completed questionnaires were received via online.

The questionnaire was divided into three parts. The first part was intended to obtain general details of the respondents. Part two was intended to obtain the viewpoint of respondents in respect to their understanding and acceptance of the tool. The questions were designed as a standard Likert scale where respondents were asked to rate each questions from low to high or from strongly disagree to strongly agree. Part three was designed to identify the level of expertise the respondents have on the operation of the tool. The questions in this part were also on a standard Likert scale similar to questions in Part two.

OBSERVATIONS AND ANALYSIS

At the end of May 2006, 120 completed surveys were received via online. Within the returned survey 80% were from male and 20% were from female respondents. In NSW women comprise less than 10% of the total employment in the construction industry (ABS, 2005). The 20% response rate for female participant was already satisfactory in respect to the small proportion to the total employment and will make a significant contribution to the outcomes. The majority of the participants, approximately 40%, have over 10 years work experience.

The design consultants and sustainability assessors have made up of 56% and 24% respectively of the total returned questionnaires whilst the remaining 21% of the respondents were distributed amongst contractors/sub-contractors, project managers, developers and others. The sustainability assessors comprise of 89% of BASIX assessors and 11% of the energy assessment assessors. The design consultants are the main users for the tool and the participation of BASIX assessors offers a balance in providing important feedback and opinion on the impact of BASIX in the construction industry with regards to their knowledge and expertise with the tool.

Approximately 85% have used BASIX before and 15% have not heard of it so far. Within the 85%, approximately 62% have used BASIX for up to 15 times since its introduction, 11% between 15 to 35 times and 27% have used it for over 35 times.

Approximately 46% of the respondents found out BASIX and it information from the website and 21% from BASIX consultants, 20% from company internal information and 13% from local councils. The BASIX website has fulfilled its original purpose in promoting the tool and providing information for its application.

Since the introduction of BASIX there have been substantial discussions on increased construction cost and time for development approval. On one hand the mandatory use of BASIX in the development application process has created a new role of BASIX assessors and it will be one of the fastest developing services in NSW and may be throughout Australia in the near future. On the other hand the design consultants and developers have been busy learning to use BASIX as it was designed for self assessment on the internet. From the survey it indicates that 65% of the respondents (not including BASIX assessors) undertook BASIX assessment for the projects themselves, 17% engaged BASIX consultants and 18% used both. The results indicated that BASIX has been widely used by practitioners in the industry and has been successful for its ultimate purpose of self assessment. The tool being accessible via the internet has been successful too and widely accepted as people can access the tool anywhere in the world at any time at no cost. It is not the same as other energy assessment tools such as NatHERS that requires an accredited assessor and constant updates. The free access and self assessment are the main features of BASIX which have contributed to the success of its implementation.

Part two and three of the online survey were designed to obtain opinions and feedback from professionals in the industry with regards to the introduction of BASIX and the results are summarized in the Appendix. The questions were designed using a standard Likert scale from strongly disagree to strongly agree. Based on the returned survey the professionals in the construction industry are generally well aware of the importance of BASIX in the development of residential projects. Only about 51% of the participants agree that the role and aim of the tool are clear whilst 49% disagree. Some respondents state that the tool lacks specific guidance on definitions and interpretation of the requirements. Approximately 83% used BASIX as a design tool rather than a marketing tool. This indicates that sustainability of houses is not the essential requests of house buyers as compare to the statutory requirements.

The respondents agreed that the mandatory requirement of the tool has significant impact in achieving a sustainable future as people are now ‘forced’ to do what they should be doing in using less energy and water. It encourages good design practice without excessive additions to the cost of new buildings. The tool is also regarded as user friendly and the resources are sufficient either on the online help notes or the help line. Approximately 47% of the respondents found the structure of the tool was clear and 61% found it user friendly. These users had assessed their projects themselves without engaging a consultant. However some respondents consider the tool to be too simple and insufficient to capture the sustainability issues. Some participants raised concern about the nature of website repairs that caused a loss of data and the time delay with screen changes. The website was particularly slow when assessing multi-unit developments. Some participants are also concerned that the tool is not broad enough to provide sufficient scope choices and lacks versatility for different design solutions such as cross ventilation, external wall and window types. The tool does not handle unusual construction methods.

With regards to the online resources 70% found the help notes on the website useful and 42% found the help line useful in answering queries on the assessment tool. The

help line is developed to provide support when needed but only 50% agree that the help line has provided sufficient support to the use of the tool. Relating to the resources on the website 40% agree that the resources on the website were sufficient whilst 42% disagree. However, there is no indication to the type of resources that are missing from the website. With regards to assessment criteria 72% believe that BASIX can help to provide better sustainability outcomes in residential developments. The majority of respondents found the assessment criteria for thermal comfort, a 40% reduction in water and 25%[6] reduction in energy consumption achievable. The thermal comfort compliance is too simple and the specification is too general. The levels of required insulation are less than required for NatHERS while the cooling caps are also different. It is recommended that thermal comfort should be conducted by an accredited assessor.

The energy target has increased from 25% to 40% since July 2006. However there is no information about whether the 40% reduction of energy consumption is achievable and further investigation in this area will be undertaken later. Some respondents worry that they may have to struggle to achieve the 40% energy saving targets. Others also suggest that embodied energy needs to be addressed in the manufacturing process of building materials and components as well as the on-site process. Window area input by m^2 regardless of height or width with shading factors were considered far too vague to give accurate readings.

As discussed before, BASIX has impact on the overall construction costs and additional elements such as sun shading, insulations to walls and ceilings, water tanks for recycling storm water and so on are required in order to pass the requirements. Approximately 85% of the respondents agree that the implementation of BASIX has increased the overall construction cost of residential development by about 10% which is different from the DIPNR report of BASIX-compliance cost of 3-4% (BMT and Assoc 2005). The economic savings may take a few years to come to fruition and this is where this system is not popular with developers. This, in turn, can be an advantage for house buyers because all new houses may cost more upfront but the water and energy bills will be a fraction of what they used to be. From the returned survey only 42% agree that BASIX has increased the overall time for development application approvals and it has increased the approval duration by about 10%. However even though energy costs over the long term will be offset by energy savings the much higher construction costs resulting from BASIX are already beyond the affordability of house buyers.

With regards to using BASIX for other types of construction 47% agree that BASIX should be applied to other types of construction as commercial buildings equally contribute to the consumption of energy and other natural resources. It should not be solely the responsibility of the residential sector to contribute to saving water and energy. Approximately 56% agree that BASIX should be applied throughout Australia. However many believe that the tool is still in its infancy and more development will be needed to improve it usefulness. Thermal comfort is one of the variables that are assessed within the BASIX programme. It addresses insulation, heat transfer through glazing, shading and active heating and cooling. There is a field of thought in the industry that this section should have given attention to the thermal mass which also has a major effect on the indoor environment of a dwelling.

[6] The survey was based on a 25% reduction in energy consumption when the survey was done but it is now increased to 40% since July 2006.

According to those who back this field of thought, the thermal comfort section of BASIX is not a true representation of the actual thermal properties of the building and an accredited assessor may be required in this respect.

CONCLUSIONS

The findings conclude that the accessibility of the tool via internet and free access are the main reasons for the success of BASIX. It was also generally accepted that the tool has played a significant role in providing a general guideline for the sustainability performance of proposed developments. It is a start but there is more to be realized. The key benefit of the tool is that it leads to better thermal comfort to users and to reduced water and energy consumption as well as less greenhouse gases emission. However, there is also the opinion that there is more to be done such as control of waste and energy usage in the manufacturing of building materials, if the tool is to be used for other types of construction. It serves as a means to make people think about water and energy saving initiatives and to encourage good design practice without excessive additions to the cost of a new building.

Irrespective of the advantages and disadvantages that the BASIX system may have, it has come into effect quite smoothly and with continued improvement and updating, it could become one of the most important planning and design tools in the construction industry. There may currently be shortfalls in the system and eventually they will be rectified, but the point is that new residential dwellings will have less environmental impact than their predecessors. A step forward is better than standing still. The sustainable housing industry needs to appreciate the affordability for house buyers especially those issues relating to design and cost. The reality is that house buyers will respond to environmental issues providing it is affordable and does not come at a cost penalty compared with houses that deliver inferior environmental performance. Professional designers should maximize the environmental performance and concentrate more on achieving lower costs. If additional cost items are to be included, developers, builders and governments will need to consider introducing innovative financial incentives.

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