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Smart Housing and Social Sustainability: Learning from the Residents of Queensland's Research House

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Abstract

One fifth of greenhouse gas emissions in Australia are generated by the everyday activities of households (Commonwealth of Australia 2005a). Higher consumer awareness of the impact of housing on the environment (Commonwealth of Australia 2003, 2005b) and of sustainable housing alternatives (The State of Queensland 2005a) is essential. One of the drawbacks to mainstreaming ecologically sustainable housing designs is consumer resistance, based on perceptions of eco- or green- housing as being less aesthetically pleasing, and less economically attractive for resale than traditional housing (Minnery et al. 2003). This paper reports findings from a small social study about the experiences of a family who lived in 'Research House', Australia, for a two year period monitoring product performance and household economies in a sustainable house. Residents reported satisfaction and improved feelings of safety when living in the spacious, airy and secure home, providing feedback to enable product improvement and assist consumer decision-making about sustainable housing.

Keywords: sustainable housing, Smart Housing, Research House, social sustainability, design evaluation.

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Introduction

Statistics indicate that 20% of greenhouse gas emissions in Australia come from households alone (Commonwealth of Australia 2005a), and 40% of all energy use in the USA is consumed in buildings (Roodman & Lessen 1995). Thus, the financial, social and environmental benefits of incorporating energy-efficient designs, products and renewable energy technologies into commercial and residential buildings are obvious. Yet, to date, despite increasing consumer awareness regarding the importance and benefits of reducing overall energy consumption and emissions (Commonwealth of Australia 2003, 2005b, 2005c; Ellington 2004), the uptake of sustainable housing designs and smart technologies remains relatively low.

While once making full use of the earth's resources to support development and progress was unquestioned, the 21st century has seen a significant turn towards a more responsible approach. For instance, there has been a stark realisation that the resources of the earth are finite, requiring determined efforts to preserve the environment for future generations and acknowledge the need for balance to ensure sustainability (Barr 2004; Dunlap 1994; Haque 2000). The upsurge of interest in eco-friendly products, recycling, and environmental protection, combined with the proliferation of Internet sites such as the Sustainable Living Guide (Blanchard 2003) and the Green Consumer Guide (Green Media 2005), demonstrate that citizens care about environmental problems, and can be motivated to act. Yet, while many consumers report being relatively amenable to buying and using environmentally friendly products (Centre for Design RMIT 2004), the reality is that to see significant improvements in resource management, larger-scale changes are needed. The authors propose that the most beneficial, yet challenging, large-scale change in which ordinary people can be involved regarding the reversal of environmental degradation is to choose environmentally and socially-sustainable housing options.

In Australia, many government, housing and environmental research organisations (for example, Australian Housing and Urban Research Institute [AHURI] 2003; Council of Australian Governments 1992; Institute for Sustainable Futures [ISF] 2003; Total Environment Centre 2003) promote and implement sustainable housing alternatives. Reducing the ecological footprint that housing places on the environment is viewed as vital for long-term sustainability (AHURI, 2003; ISF, 2003). Sustainable housing principles guide the use of structural designs, building products, domestic appliances and electronic devices in a way that minimises energy resource use, prolongs the life of the house, and improves liveability for residents. Sustainable housing can significantly contribute to reducing greenhouse gas emissions, urban air pollutants, water demand, materials' use, waste and land degradation (ISF 2003), with Australian research demonstrating that energy efficient homes produce 70% less greenhouse gas emissions per year than an average family home (Tweed Shire Council 2002). Sustainable housing initiatives, therefore, demonstrate a significant turn towards reducing Australia's ecological footprint on the environment.

Unfortunately, a stigma attached to sustainable housing has inhibited the uptake of eco-friendly, smart housing designs and products (Department of Industry, Technology & Commerce, [DITC] 1991). Smart housing incorporates the aims of triple bottom accounting, a method of reporting environmental, social and economic responses to sustainability criteria (Elkington 1999). Nevertheless, smart housing, perceived primarily as a 'green' response to environmental sustainability, is often associated with alternative lifestyles (DITC 1991; Minnery et al. 2003), with research indicating that many consumers fear that if they build a sustainable house there will be little resale appeal. Inaccurate perceptions of sustainable and smart housing include consumers' ideas that it is expensive; it is a high-risk financial investment; it is less aesthetically pleasing than traditional housing; and may adversely affect personal safety and security (DITC 1991; Minnery et al. 2003; Sibley, Hes & Martin 2003). Attitudes to housing in Australia are strongly linked to the notion that traditional housing provides status, functionality, and economic security, an integral part of the Australian lifestyle and cultural identity; consumers are, understandably, wary of changes that may undermine the large economic investment they make in a house (Baum & Wulff 2001; DITC 1991). Not surprisingly, then, the first demonstration green home, built in Melbourne by the Australian Conservation Foundation in 1993, did not successfully convince consumers of its value, and for a variety of reasons related to design and pricing, failed to sell at auction (Okraglik & Pollard 1995).

In an effort to test new products and raise awareness of sustainable housing designs, several prototype houses have been developed in the last decade. In the USA, Utah State University built Utah House, a demonstration home built to educate the public about 'new ways of building homes and creating landscapes that promote the sustainable use of resources, energy efficiency, water conservation, universal design, and healthy indoor environments' (Utah State University 2001-2004). In Australia, several research projects have been undertaken to test sustainability. Kawanda Muna, for example, built in South Australia for owner-occupiers, included design strategies for minimising energy use while maintaining the aesthetic quality of the house (Commonwealth of Australia, 2004). The Eco-home project completed the ACF Greenhome in 1993 at Cairnlea Estate, in the outer west of Melbourne, to be a demonstration home that also facilitates research in order to identify 'specific barriers to the mainstreaming of more sustainable homebuilding practices'. This project is responsible for the consumer intervention product, the Your Home design guide (Sibley, Hes & Martin 2003). While aspects of human comfort and security are recognised in many of these projects, most of the focus is on tracking the technical aspects of energy consumption and product performance, and promoting public education and acceptance of environmental housing. Yet, despite such collaborations between governments, planners, researchers and housing industry bodies, little is known about the engagement of consumers.

The purpose of this paper is to report on the real-life experiences of a family living in a sustainable house, gathering their direct feedback and evaluations of various design features and products. While the study is limited, it can provide insights useful to consumers whose only access to information may be from literature and brief visits to demonstration sites. An overarching methodology is guiding the Queensland Department of Housing Smart Housing Initiative (The State of Queensland 2005a) to design and build homes that are sustainable, better for the environment, residents and the economy. The research reported in this paper focuses specifically on social sustainability to contribute to an underdeveloped, yet growing field of interest, understanding human interactions within smart and sustainable houses.

Background to the research

Smart Housing involves design that reduces a house's impact on the environment and community by conforming to sustainable principles (The State of Queensland 2005b). The structural design elements, building products, domestic appliances and electronic devices are chosen to minimise overall energy resource use, and prolong the life of the house, enabling adaptations that meet the changing needs of a family over time. The house also allows occupants to move around easily, feel safe from accidents, such as slips and trips on dangerous flooring surfaces, secure in the knowledge that entry points are protected, and that monitoring devices can detect visitors and potential intruders outside. Thus, having less anxiety about household risks and security can provide a sense of satisfaction and well-being for housing residents.

In order to monitor sustainable and Smart Housing features, Research House was built in Rockhampton as 'a pioneering Queensland first, becoming one of the first houses to test and demonstrate new and innovative technologies, building practices and products in a single, living sub-tropical environment' (The State of Queensland 2005a). Smart Housing embraces the idea of Universal Design, not only minimising energy consumption but, importantly, maximising living comfort by orienting the house to improve airflow and natural light, insulating ceilings and walls, and designing open-plan rooms with flat reduce-slip flooring (Centre for Universal Design 1997). Smart Housing design also incorporates 'future-proofing', that is, providing features in the original construction phase that can be easily adapted, rather than requiring costly modifications, if the needs of residents change over time. Research House includes products, appliances and devices that are being monitored for energy consumption, product performance, durability and usability.

For two years, between November 2002 and November 2004, a family resided in Research House so that product performance in a daily context could be monitored. Because of the unique opportunity the situation offered as a living laboratory, social researchers from Queensland University of Technology, following ethical clearance protocols, were engaged to investigate the social dimension, gathering first-hand information about how the residents experienced the Smart House design principles, building products and technologies in their daily lives. This research, therefore, offers a unique insight about a sustainable home, reporting residents' opinions about, and allowing direct consumer feedback of, sustainable housing. Specifically, the research reported in this paper focuses on residents' assessment of the design and physical layout of the house, the airflow, natural lighting, accessibility and spaciousness, and the impact of various housing features on the family lifestyle.

Method

The social research component reported in this paper is situated within the overarching methodology that has been established to monitor products and technologies in Research House from November 2002 – 2004, and which will continue until December 2005:

> The research is investigating whether the design principles and materials applied in the Research House assist in reducing energy use, conserving water, and in improving indoor air quality and ventilation. The research aims to establish that the house is more comfortable, affordable and environmentally friendly because of these features. (The State of Queensland 2005c)

An essential part of the strategy by Department of Public Works and Department of Housing for collecting information on product performance, water and energy management, and costs of household utilities was to base the research on real life data from a single living environment. Thus, a call for expressions of interest was made to existing Department of Housing tenants in the Research House neighbourhood in order to select a family to occupy the house. A family was selected, and a number of follow-up interviews were held to assess their suitability to live in the house and test the products and technology. The interview process was also to advise them of how being part of the project could impact on their day to day lives, in regard to the necessity of having regular visits from University staff and project members, as well as official visits from government and community groups. The social study, therefore, was designed to use qualitative, in-depth interviews in order to gather specific information that would be based on participants' own descriptions of their everyday experiences in the house (Holstein 1995, p. 52).

Procedure

The selected resident family consisted of two adults (one male, one female) and their two teenage children. The adults only participated in interviews that were conducted at two timelines in the residency period, in March 2004, and in September 2004, to gather data about their initial experiences and on-going family adaptations to the house. In March, the researcher had a detailed tour of the house with the residents, followed by individual interviews and a joint interview, each lasting approximately 30 – 45 minutes. In September, a joint interview with the male and female resident was conducted for approximately 45 – 60 minutes. Both interviews were based around a set of open-ended questions developed to investigate residents' experiences of the following:

- interaction with the unique features of Research House during everyday life;
- overall satisfaction with living in a home with unique features;
- the impact of the design and features on perception of incidents that cause injury within the home;
- feelings of security and safety while living in the house;
- liveability, comfort, ease of use and management.

The open-ended interview format enabled residents to express themselves in their own terms, and expand in detail on the topics of the questions in a conversational manner.

Data Analysis

Transcribed interviews were analysed using an approach consistent with the qualitative perspective, and focused on finding 'identifiable themes and patterns of living and/or behaviour' (Aronson 1994). Two researchers worked separately to list the experience mentioned in the data, such as the effect of the floor plan, access, atmosphere and lighting; appliances and devices; overall satisfaction; feelings about safety, security; health and injury. Recurring items were combined and catalogued into sub-themes which included: comfort; access; ease and time; space, mobility and movement; aspects of injury and safety; security; awareness; product appearance, durability and practicality. A process of data reduction identified, categorised, and summarised sub-themes into positive and negative responses, and recorded these responses against each feature.

Results

The positive and negative responses that emerged from the data are displayed below.

Table 1: Residents' perceptions of the design features of Research House

Physical Features	Human Responses	
	Positive	Negative
Airflow by design, insulation, windows	• House cooled quickly and stayed cool on hot days • Cosy in winter • Positive transition from previous dwelling	• Felt insecure at first by leaving the house open to capture the breeze
Lighting via skylight	• Open, airy, and positive • Not gloomy • Not claustrophobic	• Too bright with electrical lights • Too much light
UD* – Open plan, larger than normal spaces	• Increase in movement • Not crowded even while entertaining • Not encroaching on each others personal space	
UD – Flat Access to House	• Lowered risk of injury • Assisted in moving in and out of the house with heavy objects • People with varying abilities can easily enter the house	
UD – Garage close to Kitchen with Flat Access	• Residents would reuse this design in next house • Ease of use to carry groceries to kitchen	• Residents did feel vulnerable leaving garage door up and entry door open as people on the street can see straight through the house
UD– Non-slip tiles	• Tiles are cool in summer • No injuries have taken place	• Perception that the tiles were hard therefore could possibly cause injury
UD – Flat Access to Shower	• Elevated safety • Resident did have problems with previous dwellings – this shower has made their life easier and safer	• Concern with water flowing out of the bathroom to the carpeted areas
UD – Elevated Benches	• Minimises back strain	
UD – Floor Oven		• Increases back strain due to bending to place food into the oven

*UD = Universal Design

The information condensed in Table 1 shows that the residents had very positive responses to the design features such as the window designs and skylight that increased airflow and natural lighting, and the open plan layout that provided interior spaciousness. These features were mentioned frequently as being conducive to comfort and liveability:

> The main features we've found were the lighting, everything is so well lit, so you don't have to have lights on so much or they are turned on later. The airflow is terrific as we were saying earlier with the hot weather, but as soon as we had that breeze, the afternoon change, it cools down very rapidly.
>
> Also the way that the house is open, it's more of an open plan house, so you don't feel in any way restricted and even with … a number of visitors, you feel like there's room to move, so comfort wise it's been terrific really, all those benefits.

Overall, the findings indicate that the residents regarded the design of the house very favourably. There was some negativity expressed about some of the design elements initially. For instance, residents felt vulnerable when leaving the house open to capture breezes, although the windows and doors were protected by heavy-duty screening, and they thought that the tiled surfaces could potentially be dangerous. However, these initial concerns were allayed over time. The Universal Design elements such as flat access points, reduce-slip tiles and variable height work benches minimised the risk of injury and alleviated potential strain on the body. The most positive responses were about the natural lighting, ventilation and spaciousness, feedback that confirmed how the design of the house contributed positively to their physical comfort and their appreciation of personal space. They felt that many features of the house impacted positively on the entire family in terms of their well-being, health, safety, and overall feelings of security. All of these attributes also added to their enjoyment of the house. When asked to grade the house out of 10, according to the design and features, one resident commented:

> I can't say ten because that would be bordering on perfect; nothing's perfect, but really, really high, yes very, very good. I mean even if we ever were to have the opportunity of having a home ourselves again we would most definitely use, if the opportunity would arise, we would use a lot of features. In fact we've learnt a considerable amount living in the house so, you know really it's umm, they might seem small things in certain areas, but those small things turn out to be an added positive towards living in comfort.

Research House, built for environmental sustainability, durability and economy, concurrently delivered significant social benefits to the family's lifestyle and domestic activities. While the residents reported that the design features improved comfort and liveability, most notably, they intended to apply the knowledge gained from their exposure to sustainable housing principles to their future traditional housing destination, specifically in terms of maximizing natural ventilation, airflow and lighting.

Discussion

Clearly, the success of housing designs and products aimed to maximise environmental, social and economic sustainability depends upon increased social uptake, yet, 'buildings designed with excellent "green" performance standards can be severely compromised because the specification and technical performance fail adequately to account for the inhabitants' needs, expectations and behaviours' (Cole 2003, p. 57). For sustainable housing to be widely accepted it must be adequately established, and promoted to become the preferred housing choice of consumers. There has been little emphasis on the benefits of living in a house designed for sustainability, that is, on the social sustainability of the house. Sustainable housing, planned for environmental and social sustainability by using durable products and universal design, should produce significant long-term economic benefits; it may also provide health benefits for the house occupants. An important relationship between residential housing type and its impact on health status has been identified (Smith et al. 2003). In terms of environmentally sustainable innovations introduced into large commercial buildings, there has been a noted increase in worker productivity and health (CSIRO 2002), and a similar positive health benefit for families living in sustainable residential housing is highly likely to occur.

The family in Research House has provided mainly positive feedback about the house design and products. Further to this is the assessment of their perceptions and experience against social sensitivity indicators. That is, housing products must provide a positive impact on the lives of residents in terms of three key concepts related to the built environment that enable long term social sustainability. The concepts include:

- safety, health and well-being which incorporates features that minimise the risk of injury to people in the home environment and improve indoor-air quality;
- security which includes features to improve house security such as natural surveillance, security screens on windows, and front and rear security doors and;
- Universal Design which includes features to make the house comfortable and easy to use for people who have different abilities and/or who may be at different stages of their lives.

These are the design features that have been purpose-built into Research House and have allowed researchers to validate their social sustainability. The ways in which such features assisted in promoting safety, health and well-being in the study family are considered in the following sections.

Safety, health and well-being

A sustainable house will incorporate quality design principles at the construction phase to promote safety, health and well-being. Designing a house using these principles will increase airflow, utilise natural lighting to eliminate gloom and incorporate flat access and open spaces to reduce opportunity for injury and allow ease of movement. Research House has indeed tackled these issues during the construction phase. Residents found that Smart Housing design elements impacted positively on their self-assessed feelings of well-being and safety. No slips or trips took place, which can be attributed to the reduced-slip tiling and spaciousness of the house. Flat access points in and around the house assisted with movement and allowed heavy objects to be moved in and out of the house without any risk of strain or injury. A major benefit to the residents was the flat access to the shower that minimised the risk of injury, an important point for one of the residents who suffered with back ailments.

Residents enjoyed the positive effects of airflow and lighting within the house, and perceived this as contributing to their sense of comfort and well-being. The open-plan living areas gave them a sense of greater personal space and eliminated feelings of claustrophobia they had experienced in previous houses. As a measure of success in terms of well-being, the positive elements of the house have changed the residents' outlook on how houses can be designed.

However, some elements were poorly designed such as the garage door being entirely reliant on electronic operation, and the low design of the oven that could aggravate back strain. These findings indicate the need to modify some of the features in the house to improve safety and liveability. While it is important to recognise that a period of adjustment was needed before residents gained trust in certain designs features, over time, the design has had a positive impact on their sense of satisfaction and ease within the house.

Security

Security is maximised in a smart house by including features that reduce break-ins. The features are consistent with Principles of Crime Prevention Through Environmental Design (CPTED), whereby effective design of the built environment reduces crime and increases people's sense of security (Crowe 1991). Within Research House a number of crime-deterrent principles have been implemented, including 'natural surveillance': residents have a clear view of the front street and back yard; 'natural access control'; access to the front of house is visible from the street and barriers have been created to access the backyard; 'territorial reinforcement': a large fence encircles the backyard; 'image and maintenance': no tall plants obstruct the entry points of the house, and the house generates a sense of pride of occupancy; 'target hardening': the house is equipped with many features including alarms, security screens, door-viewers, intercom, security locks, security louvers, exterior sensor lights, and smoked glass sidelights (Crowe 1991).

Over the time of their residency the family did not experience any criminal episodes. Nevertheless, one of the residents had an initial feeling of vulnerability. Of all the features that contribute to security, the residents made most mention of those that incorporated 'target hardening': the heavy-duty security screens and the smoked glass sidelights. Residents also mentioned 'natural access control', and felt secure knowing that there were multiple barriers to access before an intruder could reach the house. It is interesting to note that 'image and maintenance' and 'natural surveillance' that facilitated clear views around the house's exterior initially had quite the opposite affect. Instead of providing added security it gave one of the residents the feeling of being exposed and vulnerable to public view from the street. While they were appreciative of smoked glass, higher windows and security screening, visibility of the interior from the outside was an issue, resolved when the garden became fully established.

Universal Design

'Universal design is the design of products and environments to be usable by all people, to the greatest extent possible, without the need for adaptation or specialized design' (Centre for Universal Design, 2003). Universal Design is one of the most effective contributors to sustainable housing. It prolongs the use of the house through design and products that are durable, adaptable, and suitable to the changing lifestyles of people over time, outlasting houses built with cheaper alternatives. This means that, theoretically, a family can occupy a sustainable house for the length of their life; the features built in from the start alleviate the need to move house if or when lifestyles and physical abilities change. Importantly, the exterior of a universally designed house looks like a traditional home - it is the universal design principles and products that make the difference. Universal Design incorporates features such as flat access, wide passage ways, and larger entry ways, and roomier spaces, assets likely to be highly appreciated by consumers.

Seven design principles have been developed by The Centre for Universal Design, North Carolina State University (NCSU). These principles have been adapted to underpin the design of Research House and in this context the following points are summarised:

1. equitable use: design for everyone and every ability;
2. flexibility in use: design should accommodate a wide range of users;
3. simple and intuitive (to use);
4. perceptible information: the design should be easy to see;
5. tolerance for error: the design should minimize hazards and error;
6. low physical activity; minimizing injury;
7. size and space for approach of use: regardless of users body, size or ability.

(Copyright © 1997 NC State University, The Center for Universal Design)

The following table provides a visual audit of the Universal Design features assessed by the residents of Research House based on the research findings.

Table 2. Universal Design Features as evaluated by Research House Residents

Physical Features	Universal Design* Features [as adapted for Research House]						
	Equitable Use	Flexibility in Use	Simple & Intuitive	Perceptible Info	Tolerance for Error	Low Physical	Size & Space
Airflow by design insulation, windows	✓	✓	✓			✓	✓
Lighting via skylight	✓	✓	✓			✓	✓
Open plan, larger than normal spaces	✓	✓	✓			✓	✓
Flat Access to House	✓	✓	✓			✓	✓
Garage close to Kitchen	✓	✓	✓			✓	✓
Non-slip tiles	✓	✓	✓			✓	✓
Flat Access to Shower	✓	✓	✓			✓	✓
Security Screens	✓	✓		✓			
Sensor Lights	✓	✓		✓			
180-degree door viewer	✓	✓	✓	✓		-	-
Smoke Glass	✓	✓		✓		✓	✓
Automatic Garage	×	×				-	-
Operating Manuals	×	×	×	×	×	×	×

✓Met principle, × Did not meet principle, – Room for improvement, Blank = Not applicable

*According to those who conceived and developed the Principles of Universal Design (Copyright © 1997 NC State University, The Center for Universal Design), 'Use or application of the Principles in any form by an individual or organization is separate and distinct from the Principles and does not constitute or imply acceptance or endorsement by The Center for Universal Design of the use or application.' (The Center for Universal Design 1997. The Principles of Universal Design, Version 2.0. Raleigh, NC: North Carolina State University).

Table 2 provides a concise evaluation of the Universal Design features of Research House based on data from the study residents. The elements that excel include: airflow, natural lighting, open plan areas, flat access, reduced-slip tiles and step-free flat access thresholds. The feature that caused most concern with regard to injury was the automatic garage door. The automatic garage door works well, suiting varied abilities, but if a blackout occurs residents are either locked out (if they have forgotten their keys) or need to open the garage manually and risk injury.

Finally, one feature not previously mentioned, but intrinsically important to the successful management of many features of the house, is the operating manuals. The manuals fared poorly, and such a failure in product features negates the 'tolerance for error' principle, causing frustration and confusion for the home resident. Surprisingly, operating manuals can be an overlooked part of any house, design or product. They need to be more user-friendly and encompass the principles of Universal Design that minimize hazards and errors in product use in the home.

Conclusion

Minimising the impact of domestic housing on the environment is an outcome that planners and designers of sustainable homes must satisfy. Unfortunately, knowledge about what everyday living in such houses might be like is minimal. In summary, three key concepts of Smart Housing theoretically make a house socially sustainable, namely a), health and well being, b) safety and security and c) Universal Design. The results of this study indicate that the design used in Research House has been generally highly appreciated when subjected to consistent everyday use in a real-life family context.

The study family reported favourable perceptions about the liveability of the house. The features that increased safety and security for the occupants, thus, contributed to feelings of satisfaction and well-being. Some issues did arise in the context of design features, specifically the electronic operation of the garage door, the placement of the kitchen oven, and the user manuals. While some sense of vulnerability had been initially an issue, over time, the residents gained more trust in the security features. Most importantly, the design features that incorporated natural lighting, natural ventilation, spaciousness and ease of access were the ones that contributed most significantly to the comfort, liveability and enjoyment of Research House by the family. Overall, Research House demonstrates positive outcomes for sustainability with only a few items requiring modification.

While the limitations of the study preclude making major claims, the initial reports based on the findings of a live-in, family household are encouraging. Houses such as these are a commendable example of user friendly, socially sustainable homes that have a low impact upon the environment. Houses built for sustainability can deliver much more to the residents than simply durability and economic savings. The socially sustainable features that improve safety, comfort, and liveability should be publicized to housing consumers. They will then have the knowledge and information to argue for the inclusion of specific design features, products and devices that adhere to socially sustainable principles in housing and building developments. Ideally, builders should be aware of the marketing edge they could command if they incorporated and publicized the design features that make an enormous difference to the liveability of houses. Sustainability savvy consumers will inevitably be choosing between traditional, initially cheaper houses, and houses built to deliver environmental, social and economic benefits. The challenge is to make the consumer society more aware of the essential and enjoyable benefits of a sustainable home.

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