



**How easy is it being “green” in  
sustainable housing? Residents  
experiences with smart housing design**

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# **How easy is it being “green” in sustainable housing?**

## **Residents experiences with smart housing design**

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Minimising the impact of domestic housing on the environment is an important focus for planners and designers of sustainable homes, however little is known about how consumers interact with and view sustainable housing design. With research indicating consumer reluctance towards the uptake of sustainable or “smart housing”, this project was designed to monitor the day-to-day experiences of living in a Smart House. Research House in Rockhampton, Queensland has been a living laboratory over two years (2002-2004), called “home” by two adults. They shared their experiences of living in a smart house, interacting daily with sustainable housing design. This paper investigates the functional aspects of adaptation to living in smart housing. The focus is on resident’s satisfaction with the design and physical layout of the house, specifically the surface design, airflow, natural lighting, access, security and spaciousness. Findings from this study contribute to evaluations of the impact of eco-friendly housing, providing consumer feedback and perceptions of smart house design after prolonged firsthand experience.

Keywords: sustainable housing; smart housing; qualitative report of smart housing design;

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## Introduction

Australia has one of the highest levels of greenhouse gas emissions per capita in the world, with up to one-fifth of these emissions coming from households (Queensland Department of Housing, 2004). With the Australian population expected to double by 2101 (ABS, 2002), minimising emissions from households is a key goal for researchers promoting and implementing sustainable housing initiatives. Research has shown that energy efficient homes produce 70% less greenhouse gas emissions per year than an average family home (Tweed Shire Council, 2002). In Australia, a range of organisations (Australian Housing and Urban Research Institute, 2003; Council of Australian Governments, 1992; Institute for Sustainable Futures, 2003; Total Environment Centre, 2003) acknowledge that reducing the ecological footprint that housing places on the environment is necessary and vital for long-term sustainability. Sustainable housing can, therefore, significantly contribute to reducing greenhouse gas emissions, urban air pollutants, water demand, materials use, waste and land degradation (Institute for Sustainable Futures, 2003). Given these facts, the fastest growing state in Australia, Queensland, is addressing this challenge by developing and researching environmentally sustainable housing.

Sustainable housing is built to minimise energy consumption and to maximise living comfort via housing design and layout. This is achieved through design features that orient the house to capture breezes; insulate ceilings and walls; and incorporate natural lighting. Household energy consumption is thus reduced as there is little need for heating and cooling mechanisms within the house. Human comfort levels are achieved with little cost to the environment. Sustainable housing design and smart house design aims to elevate comfort levels by improved airflow and incorporate natural lighting such as the use of skylights. Smart Housing embraces the idea of universal design. Universal design incorporates design features that suit people with varying abilities, such as step-free thresholds, open-plan rooms with flat non-slip flooring and wider halls and entrances that increase movement and safety (The Center for Universal Design, 1997).

For sustainable housing to be successful it must be adequately established, accepted and used by consumers. The success of the Green and Smart House products depends upon social uptake, unfortunately “building 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). In fact, current research suggests that there is a stigma attached to sustainable housing that is inhibiting the uptake of eco-friendly, smart housing designs and products (Department of Industry, Technology & Commerce [DITC], 1991). For example, inaccurate perceptions of sustainable and smart housing include consumers’ ideas that it is expensive; it has a high risk with regards to financial investment; it is less aesthetically pleasing than traditional housing; and may adversely affect personal safety and security (DITC, 1991; Minnery, McFallan, Mead, & Fedrick, 2003; Sibley, 2003). Attitudes to housing in Australia indicate that traditional housing provides status, security and functionality, which is an integral part of the Australian lifestyle. Consumers are afraid that changes to the “status quo will adversely affect property values” (DITC, 1991). Nevertheless, over half of Australian community residents are reportedly

willing to make environmentally sustainable changes to their homes but are unaware of high quality housing options that maintain their security (DITC, 1991).

Surprisingly little research to date has been focused on consumer interaction with smart housing and eco-friendly designs. Limited research suggests that consumers are either unaware of, or unconvinced about, the value of Green House and Smart House products. Given this, it is therefore timely to investigate how real-life experiences might change consumers' perceptions of sustainable housing design and products. For example, sustainable housing design and products need to be directly evaluated by consumers and, if necessary, redesigned to ensure consumer acceptance and uptake. To date, however, researchers have not explicitly explored how consumers interact with the sustainable housing design and products in a real-life context.

The Queensland Department of Housing has implemented the Smart Housing initiative, aiming to plan and build homes that are sustainable, better for both the environment and residents. Smart Housing involves design that allows people to move more easily around the house, feel safer, save money, and at the same time reduces a house's impact on the environment by conforming to sustainable principles of building, material and energy use. In order to monitor the specific elements of Smart Housing, a Research House was built in Rochampton. It is described as Queensland's "first ever house to test and demonstrate new and innovative technologies, building practices and products in a single, living sub-tropical environment" (Queensland Department of Housing, 2004). Most importantly, the house can be viewed as a living laboratory, with tenants experiencing first-hand smart house design principles, building products and current technologies.

Research House was planned to be a living laboratory for two years between November 2002 and November 2004, during which time two adults (husband and wife) provided information about their actual experiences of living in smart house, interacting daily with sustainable housing design and technologies. This paper focuses on the functional aspects of family adaptation to living in smart housing and using smart products. Specifically, we focus on resident's satisfaction with the design and physical layout of the house, specifically surface design, airflow, natural lighting, access and spaciousness. These findings will contribute to evaluations of the impact of eco-friendly housing, particularly consumer feedback and perception of smart house design.

## **Method**

Research House provides an ideal setting for a qualitative case study to explore how residents interact with a house designed for sustainability and assessed as smart and environmentally friendly. The case study method implies an empirical investigation within a real life context (Yin, 1994), not sampling to cover a wide scope, but maximising understanding of one case (Stake, p. 4). Participants for the study were the couple living in Research House. Their participation in the interviews for this research project was subject to the ethical protocols of Queensland University of Technology.

**Procedure**

Interviews were conducted using open-ended questions developed around the following aims:

- Investigate the experience of the residents in interacting with the unique features of Research House during everyday life;
- Explore the overall satisfaction with living in a home with unique features;
- Investigate the impact of the design and features on the residents’ perception of incidents that cause injury within the home;
- Explore the residents’ feelings of security and safety while living in the house;
- Explore the residents’ experience with respect to liveability, comfort, ease of use and management, cleaning and
- Investigate the experience of individual members living in Research House

Interviews with the participants were approximately forty five minutes to one hour in duration, and were audio-taped and later transcribed.

**Data Analysis**

Transcribed interviews were analysed using a thematic approach. “Thematic analysis focuses on identifiable themes and patterns of living and/or behaviour” (Aronson, 1994). Data was reduced by identifying and categorising data into areas relating to residents experiences with the physical features of the house. Positives and negative human responses were then recorded relating to each physical feature in the context of residents everyday lifestyle. Data was been recorded in a matrix, presented below in Table 1.

**Results**

Design incorporates all the larger features of the house, that is, the interior and exterior design. This includes such elements as the floor plan, access, atmosphere and lighting. The following table provides an overview of the residents’ positive and negative assessments of the design features of the house.

**Table 1**

Physical Features	Human Responses	
	Positive	Negative
Airflow by design insulation, windows	<ul style="list-style-type: none"> <li>• House ‘cooled quickly’ and ‘stayed cool’ on hot days</li> <li>• ‘Cosy’ in winter</li> <li>• ‘Positive transition’ from previous dwelling</li> </ul>	<ul style="list-style-type: none"> <li>• Felt insecure at first by leaving the house open to capture the breeze</li> </ul>
Lighting via skylight	<ul style="list-style-type: none"> <li>• Open, airy, and positive</li> <li>• Not gloomy</li> <li>• Not claustrophobic</li> </ul>	<ul style="list-style-type: none"> <li>• ‘Too bright’ with electrical lights</li> <li>• ‘Too much light’</li> </ul>
UD – Open plan, larger than normal spaces	<ul style="list-style-type: none"> <li>• Increase in movement</li> <li>• Not crowded even while entertaining</li> <li>• Not encroaching on each others personal space</li> </ul>	
UD – Flat Access to House	<ul style="list-style-type: none"> <li>• Lowered risk of injury</li> <li>• Assisted in moving in and out of the house with heavy objects</li> </ul>	

	<ul style="list-style-type: none"> <li>• People with varying abilities can easily enter the house</li> </ul>	
UD – Garage close to Kitchen with Flat Access	<ul style="list-style-type: none"> <li>• Resident’s would reuse this design in next house</li> <li>• Ease of use to carry groceries to kitchen</li> </ul>	<ul style="list-style-type: none"> <li>• Resident’s did feel vulnerable leaving garage door up and entry door open as people on the street can see straight through the house</li> </ul>
UD– Non-slip tiles	<ul style="list-style-type: none"> <li>• Tiles are cool in summer</li> <li>• No injuries have taken place</li> </ul>	<ul style="list-style-type: none"> <li>• Perception that the tiles were hard therefore could possibly cause injury</li> </ul>
UD – Flat Access to Shower	<ul style="list-style-type: none"> <li>• Elevated safety</li> <li>• Resident did have problems with previous dwellings – this shower has made their life easier and safer</li> </ul>	<ul style="list-style-type: none"> <li>• Concern with water flowing out of the bathroom to the carpeted areas</li> </ul>
UD – Elevated Benches	<ul style="list-style-type: none"> <li>• Minimises back strain</li> </ul>	
UD – Floor Oven		<ul style="list-style-type: none"> <li>• Increases back strain due to bending to place food into the oven</li> </ul>
UD = Universal Design		

Residents had very positive responses to the design features that contributed to comfort by maximising airflow and natural lighting, and spaciousness:

The main features we've found was 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.

### ***Airflow***

The findings highlight the positive responses to the design features that improved airflow and, thus, elevated residents' comfort levels. Residents found the house "cooled quickly and stayed cool" on hot days, yet stayed warm and cosy during cold days. Resident's were at first "perturbed" about leaving doors open to allow breezes through the house, however, once they had gained trust in the security doors they realised the benefits of leaving the house open on extremely hot days. They found that the temperature changed within the house allowing them maximum comfort. Residents were also able to compare the house with their previous dwellings, noticing how effectively the hot air escaped the house. Moving into the research house had been a "positive transition" with regards to airflow. When visiting friends' houses, the resident's have noticed that they felt confined and stifled. As a result of their own experiences with the design features in Research House, they have offered advice about how to best circulate air throughout a house.

### ***Natural Lighting***

Open and airy lighting has had a positive affect on the residents' well-being. They have noticed that the atmosphere is not "gloomy" and does not make them feel closed in or "claustrophobic". However, residents had noticed that there were too many electrical lights making the use of natural sky lighting and electrical lighting somewhat overpowering. They had, therefore, adjusted the lighting by physically removing some light bulbs, commenting that they are too bright and a bit "ridiculous".

By manipulating the lighting they made the atmosphere more comfortable and liveable. Again, when visiting friend's homes they noticed the closed surroundings and poor lighting and tried to change their friend's environment.

### ***Universal Design features***

The design features of space, access, surface design and security have been of great benefit to the residents.

Also the way that the house is open, it's more of an open plan house, so you don't feel in anyway restricted and even with, when we've had a number of visitors, you feel like there's room to move, so comfort wise it's been terrific really, all those benefits.

### ***Space***

Residents experienced the spaciousness of the house, a feature that was evident when the house was crowded. Residents were not "tripping over one another", especially while entertaining guests. As a family unit they felt they were not encroaching on each other's space as each could maintain privacy.

### ***Access***

The house has many access points that are flat and level to the ground, and residents noticed that it both lowered their risk of injury and assisted in easy movement. Importantly, they stated that it was easy for someone in a wheelchair or handicapped in anyway to easily move in and out of the house. Access points also assisted in easily moving garden furniture in and out of the house while entertaining. Garage access to the kitchen was very helpful and a feature they would continue to use in their next house because of the 'short walking distance into the kitchen with the shopping' all on flat surfaces.

In a negative context, however, residents reported feeling vulnerable when leaving the garage door up and entry door open as this allows people from the street to view straight through the house. Therefore, while they kept the house open on hot days to maximise air circulation, they remained cautious about moving to the other end of the house where they could not view the garage entry door.

### ***Surface Design***

Tiles throughout the house are non-slip, raising initial concern for the residents who equated the hard floor with risk of injury. However, these fears have been unfounded as they have not had any slips or trips and were quite pleased at how cool the floor tiles become in summer, adding to their comfort levels. Other designs such as the non-step shower also improved safety levels. While there was some concern about water leakage into other rooms the residents had altered their behaviour to minimise this risk.

Working heights of benches and workspaces have been elevated to minimise back strain, and this was a "simple thing but it makes life ... easier". On the other hand, resident's found that the oven was poorly placed at floor level in the kitchen meaning that they had to bend over to access the oven and they found this quite a challenge. Residents would have preferred having the easier access of a wall oven.

### ***Security***

The house is designed with security in mind. Resident's have an unobstructed view of the street and the back yard. Multiple barriers have been placed around the house

as to deter criminals trying to enter the house contributing to residents' feelings of security. One resident stated:

I've heard people outside, I know that they can't just walk straight in, they have to come through the gates, then there going to come into the garden, then they have to through the Crimsafe (security screens)"

The garden has also been designed to eliminate hiding places for intruders. Plants in the front garden have been kept low. However, this has given one of the occupants a sense of vulnerability with the plants, at one stage, not being well established, "because the plants...were a bit lower there was more visibility for the public". Due to these aspects of the design the resident felt visible to the public and therefore possibly open to danger.

Overall, the design of the house can be regarded as a success. The resident's reported that their well-being was elevated due to increased comfort via airflow, appropriate natural lighting and easy movement due to the open design of the house. When asked to grade the house according to the design 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 was 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.

Universal Design elements such as flat access, non-slip tiles and elevated benches minimised the risk of injury and alleviated potential strain on the body. There was some negativity with design elements of the house such as the feeling of vulnerability when leaving the house open to capture breezes and the perception that tile surfaces were hard and therefore could potentially be dangerous during a fall. However, resident's perceptions had changed over the time they had been in the house, and they felt comfortable, safe and secure within the house.

## Discussion

The success of Smart Housing and eco-friendly housing depends upon its acceptance in the consumer market. In order for products and designs to be successful they are required to be socially sensitive. That is, they must create a positive impact upon the lives of housing residents. Three key concepts have been identified within the built environment which promotes social sensitivity that enables 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 casual 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.

Design features that focus on social sensitivity have been purpose built into the Research House and allow researchers to validate their social sustainability. The findings can now be discussed in terms of the three key concepts to discover whether the design features truly promote social sustainability.

### *Safety, health and well-being*

A smart and sustainable house will use quality design principles during 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 accidents and allow ease of movement. Research House has indeed tackled these issues during the construction phase. But, as an example of sustainable and smart housing, do these features actually assist in promoting safety, health and well-being? In the following sections, safety and health will be addressed separately at this implies a certain outcome to a human's physicality such as an injury or a strain to the body. Well-being will be discussed in relation to emotional outcome such as comfort and perception.

Residents found that Smart Housing design elements assisted their health and safety. No slips or trips took place, which can be attributed to the non-slip tiling and open spaces. Flat access to the house assisted with movement and allowed heavy objects to be moved in out of the house without any risk of strain or injury. A major factor that the residents were pleased with was the flat access to the shower. In previous dwellings there had been accidents climbing in and out of the shower, in this situation the risk of injury is mitigated. However, not all elements of the house were satisfactory as some were poorly designed such as the garage door being unusable during black outs because of its electronic operation, and the low design of the oven that contributed to back strain or could aggravate an already injured part of the body. Need for change is evident in these designs so residents can enjoy the benefit of a healthier living environment.

The resident's wellbeing was possibly the most highly affected area within this study. Residents wholly enjoyed the positive airflow and lighting within the house. Open spaces did not hamper their movement and gave them a sense of greater personal space than previous dwellings. One resident who had previously experienced claustrophobia did not suffer this condition within the house, even when all windows and doors were closed. As a measure of success in terms of wellbeing, the positive elements of the house have changed the resident's outlook on how houses can be designed. So much so that residents try to offer advice to friends and manipulate other environments to increase positive airflow, space and lighting.

It is important to recognise that a period of adjustment was needed before residents gained trust in certain design features. For example, residents initially felt vulnerable leaving the house open to maximise airflow. They also perceived the non-slip tiles to be a hindrance as the tiles have a hard surface and could possibly cause injury during a fall. After living in the house residents were instead pleasantly surprised at how the tiles felt cool during hot weather and have not resulted in falls. Undoubtedly, the design of the house has had a positive impact upon the resident's well-being.

## *Security*

Security is maximised in a smart house by designing fixtures to reduce crime. *Principles of Crime Prevention Through Environmental Design* (CPTED) can be implemented, that is, through effective design of the built environment crime can be reduced and a person's sense of security increased (Crowe, 1991). Within the Research House a number of principles have been implemented to alleviate crime and fear of crime. These include: natural surveillance (observation), resident's have a clear view of the front street and back yard; natural access control (barriers), access to the front of house is visible from the street and barriers have been created to access the backyard; territorial reinforcement (clear boundaries), a large fence encircles the backyard; image and maintenance (appearance), no tall plants obstruct the entry points of the house; target hardening (extra physical features), the house is equipped with alarms, security screens, door-viewers, intercom, security locks, security louvers, exterior sensor lights, smoke glass and more (Department of Housing, 2003). Do these factors contribute to a reduced crime and reduced fear of crime?

It is true that the resident's have never experienced crime within Research House. However, as mentioned, one of the resident's has felt a pervading sense of vulnerability. Resident's made most mention of the extra physical features of the house that incorporate "target hardening". These include security screens and the smoke glass windows. Resident's feel secure with these extra features. Another principle that the resident's mentioned was one of natural access control. Resident's stated that they felt secure knowing that there were multiple barriers to access before a burglar could reach the house. The principle "territorial reinforcement" was not mentioned.

It is interesting to note that "image and maintenance" and "natural surveillance" had quite the opposite affect on the residents. Instead of providing them with the feeling of security it gave one of the residents the feeling of being exposed and vulnerable to public view from the street. While they are appreciative of smoke glass, higher windows and screening, visibility still seems to be an issue that arises in the data.

## *Universal Design*

Universal Design is one of the most effective contributors to sustainable housing. It prolongs the use of the house through design and products that suit the lifestyles of people over time. This means that a person can occupy a house for the length of their life; this alleviates the need for more houses to be built to suit differing lifestyles and varying abilities. A universally designed house's exterior looks no different to a traditional home - it is the smart design changes and products that make the differences notable. Universal Design incorporates designs such as flat access, wide passage ways, larger entry ways, roomier spaces, higher bench-tops, easy to use and reach switches.

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 can be 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;
  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 as experienced by the residents of Research House and based on the research findings.

**Table 2**

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 using a visual representation of issues of social interaction with smart housing and eco-friendly design. The elements that excel are the design elements of the house. These include: airflow, natural lighting, open plan areas, flat access, non-slip tiles and step-free thresholds. The designs that caused most concern with regards to injury was the automatic garage. The automatic garage works quite well in suiting varied abilities, as long as it is operational. As we found in this study, if a black out occurs resident’s are either locked out (if they have forgotten their keys) or need to open the garage manually which may be impossible if a person’s body movement does not allow it.

Finally, one feature within the house that failed to meet almost all of the principles of universal design was the operating manuals. The manuals seemed to be inoperable and therefore were not equitable, flexible, simple and intuitive nor perceptible. Such a

failure in product features can result in a high level of error negating the “tolerance for error” principle, causing frustration and confusion on the part of the resident’s and upset to their comfort levels. 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.

## **Conclusion**

In summary, three key concepts of Smart Housing theoretically make a house social sustainable, namely safety, health and well being, security and universal design. These concepts have been assessed to discover whether they promote social sustainability, and as the results of this study indicate, the design used in Research House has been generally highly appreciated when tested in a real-life context.

Safety, health and well-being have been elevated due to positive design based on universal design principles. Some issues did arise in the context of design features, with the operation of the garage creating problems when electricity supply was interrupted. Security had not been an issue, and while no crimes have taken place, there was a sense of vulnerability expressed by one of the residents. Operating manuals are the main frustration within the house. If the manuals could be redesigned to embrace the concept of universal design, this problem could be solved.

Overall, Research House can be seen as well on the way to social sustainability with only a few items needing to be redesigned. Houses such as these are a commendable example of user friendly, socially sustainable homes that have a low impact upon the environment. They are sustainable over time and have features that are conducive to improved safety, health and well being, and security. The design features significantly improve comfort and social interactions in the home. Based on the day-to-day experiences of the residents’ in Research House, the benefits of smart housing design have been clearly seen. More needs to be done to examine consumer resistance to environmental designs. Currently, the dominant preference for traditional styles remains, with environmental designs perceived as less aesthetically pleasing, less safe and secure and less likely to provide a sound return on investment. The challenge now is to make the consumer society more aware of the essential (and quite pleasing) benefits of a smart and sustainable home. Once this hurdle has been overcome, consumers will be better informed about housing choices that have a positive impact on the environment, as well as on the social and economic areas of life.

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