Subtropical Subdivisions:

Toward a lot-rating methodology for subtropical climates

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Abstract

What role can climatically appropriate subdivision design play in decreasing the use of energy required to cool premises by maximising access to natural ventilation? How can this design be achieved? The subdivision design stage is critical to urban and suburban sustainability outcomes, as significant changes after development are constrained by the configuration of the subdivision, and then by the construction of the dwellings. Existing Australian lot rating methodologies for energy efficiency, such as that by the Sustainable Energy Development Authority (SEDA), focus on reducing heating needs by increasing solar access, a key need in Australia's temperate zone. A recent CRC CI project, Sustainable Subdivisions: Energy (Miller and Ambrose 2005) examined these guidelines to see if they could be adapted for use in subtropical South East Queensland (SEQ). Correlating the lot ratings with dwelling ratings, the project found that the SEDA guidelines would need to be modified for use to make allowance for natural ventilation. In SEQ, solar access for heating is less important than access to natural ventilation, and there is a need to reduce energy used to cool dwellings. In Queensland, the incidence of residential air-conditioning was predicted to reach 50 per cent by the end of 2005 (Mickel 2004).

The CRC-CI, Sustainable Subdivisions: Ventilation Project (CRC-CI, in progress), aims to verify and quantify the role natural ventilation has in cooling residences in subtropical climates and develop a lot rating methodology for SEQ. This paper reviews results from an industry workshop that explored the current attitudes and methodologies used by a range of professionals involved in subdivision design and development in SEQ. Analysis of the workshop reveals that a key challenge for sustainability is that land development in subtropical SEQ is commonly a separate process from house design and siting. Finally, the paper highlights some of the issues that regulators and industry face in adopting a lot rating methodology for subdivisions offering improved ventilation access, including continuing disagreement between professionals over the desirability of rating tools.

Keywords: Subdivision, subtropical design, sustainable development, lot, lot-rating methodology, ventilation, energy-efficiency.

Introduction

As our cities expand, developers are transforming more and more land into suburbs. A sustainable approach is essential, in order to avoid unnecessary demand on natural resources, to prevent environmental degradation and to safeguard the natural and built environment for future generations. Significant retrofitting after development is constrained by the configuration of the subdivision, and then by the construction of the dwellings.

Throughout Australia, energy use continues to increase. In Queensland, residential air-conditioning was forecast to reach 50 per cent of dwellings by the end of 2005 (Mickel 2004). In subtropical South East Queensland (SEQ), the fastest growing region in Australia, regulators and developers plan to house an increasing population. What role can climatically appropriate subdivision design play in decreasing the use of energy required to cool premises by maximising access to natural ventilation?

Just like dwellings and appliances, building allotments (lots) can be rated for their energy efficiency (AGO 1999). The Sustainable Energy Development Authority (SEDA) developed one such set of guidelines several years ago (SEDA 2003). The aim was to increase solar access to reduce the energy used to heat the dwelling. A recent Cooperative Research Centre for Construction Innovation (CRC CI) project, Sustainable Subdivisions: Energy examined the SEDA guidelines to see if they could be adapted for use in SEQ (Miller and Ambrose 2005). Examining a range of recent subdivisions, the project found that although subdivisions with larger lots (defined as those over 560m²) could meet the SEDA guidelines, the increasingly popular smaller lot subdivisions could not. Correlating the lot ratings with dwelling ratings, the project found that the SEDA guidelines need to be modified to make allowance for natural ventilation.

The current CRC CI project, Sustainable Subdivisions: Ventilation (in progress), aims to verify and quantify the role of natural ventilation in cooling residences in subtropical climates. This paper reviews the findings from an industry workshop that explored the methodologies and positions of a range of professionals involved in subdivision design and development in SEQ. With its purpose of providing insight into industry practices and opinions, this workshop was a key methodological component of the overall research project. This paper highlights some of the issues that regulators and industry face in adopting such a lot rating methodology. The findings are particularly relevant to regulators, designers and industry in the warmer climate states of Queensland, Western Australian and the Northern Territory.

Planning for growth in subtropical South East Queensland

Subtropical SEQ encompasses eighteen local governments, and extends from Brisbane north to Noosa, south to the New South Wales border and west to Toowoomba. This region:

- has experienced sustained population growth since the 1980s;
- is growing by an average of 55,300 persons each year; and
- requires some 575,000 new dwellings to be constructed by 2026 (OUM 2005).

In response to a coastal subtropical climate with warm humid summers and mild winters, SEQ has developed dwelling styles that differ from the more populous and cooler southern states. As the population increases, mountains to the west of the region limit the amount of flat land available for residential development, forcing developers, designers and builders to adapt to an increasing number of sloping lots. These factors combine to place different pressures on regulators, developers and dwelling designers from those faced by their southern counterparts and require innovative responses that address our subtropical climate, lifestyle and amenity.

The Sustainable Subdivisions: Ventilation project focuses on reducing energy use in subtropical climates, where solar access for heating is less important[1], but where orientating lots to increase access to natural ventilation to reduce energy used to cool dwellings is becoming increasingly important.

Increasing residential energy consumption patterns

The use of energy in the dwelling is the largest source of greenhouse gas emissions from Australian households. The average household's energy use is responsible for about eight tonnes of carbon dioxide (CO2), the main greenhouse gas, per year (Reardon 2001). Figure 1 shows the typical Australian breakdown of energy consumption within the dwelling and shows that space heating/cooling and water heating dominates the energy use profile. Reducing a dwelling's need for such energy or seeking alternative renewable means of energy for these areas will greatly reduce Australia's overall environmental impact and greenhouse gas production.

Energy use in Queensland is quite different from the pattern for the rest of Australia. Figure 2 shows that in Queensland, the single biggest consumer of energy in the dwelling is heating water rather than rooms (Queensland Conservation Council 2004). Figure 2 also shows that heating and cooling energy accounts for only five per cent of the total, compared with 39 per cent as the Australian average (Figure 1). This difference is due to the subtropical climate where the need for conditioned spaces should be minimal. While the percentage of energy used to cool dwellings is small compared to the 'southern' figure for heating and cooling, savings in this area are still important. In any event, this percentage is set to rise as Queenslanders install air-conditioning at an increasing rate.

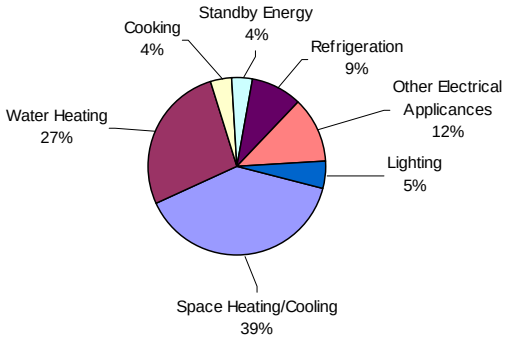

Figure 1 Australian household energy use (Miller and Ambrose 2005)

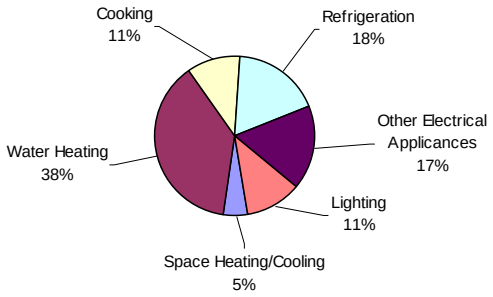

Figure 2 Queensland household energy use (Miller and Ambrose 2005)

Rating subdivision design to decrease energy consumption

Energy-efficient subdivision design is concerned with manipulating the key variables of aspect, shape and density with site or lot characteristics such as topography and slope, to achieve an optimal mix of lot sizes, appropriately oriented for solar and ventilation access. When lots are correctly aligned and proportioned, individual energy-efficient houses, with good solar access, can more readily be provided.

Building lots – like dwellings - can be rated for their energy efficiency. One such methodology was developed several years ago by Sustainable Energy Authority of Victoria (SEAV), and later modified by Sustainable Energy Development Authority (SEDA) (SEDA 2003). In the southern states of Australia, the focus is on designing to increase solar access and reduce the

[1] But not unimportant, especially in the inland and higher altitude parts of the region.

energy used to heat the dwelling and in New South Wales, SEDA required that developers assess subdivision designs. Using the SEDA tool is a simple paper based process:

- the rating scale is 1–5 stars, with 5 being the highest;
- the lots are rated on their ability to accommodate a dwelling with good solar access;
- the methodology applies to separate lots between 300–1000m² in area;
- for lots under 300m², solar access is closely integrated with building design and siting;
- lots over 1000m² offer a better chance of achieving good solar access;
- the slope of the lot will either improve or hinder solar access, however lots with a slope of over 20 per cent automatically receive a 1-star rating, regardless of slope orientation;
- the goal is to achieve 5-star lot ratings for 80 per cent of the total, with the remainder rating either 4 or 3 stars.

The aim of the recently concluded CRC CI Sustainable Subdivisions: Energy project was to test the SEDA tool for its appropriateness for SEQ (Miller and Ambrose 2005). In SEQ, climatically appropriate design focuses on increasing solar access in winter, reducing excessive solar gain in summer and on capturing the prevailing breezes to reduce internal temperatures.

Sustainable Subdivisions: Energy - assessing subdivision design in SEQ

Assessing a number of subdivisional layouts, the 2005 project found that, although subdivisions with larger lots[2] could achieve the SEDA guidelines, the increasingly popular, smaller lot-size subdivisions were falling well short of the mark. The following example illustrates this point. This subdivision (Figure 3) had a high proportion (50 per cent) of smaller lot sizes averaging 520m². This resulted in a low percentage (47 per cent) of 5-star lots as shown in Figure 4. Examining a range of sub division layouts, the project found that the SEDA tool is a good starting point for subdivision design (Miller and Ambrose 2005). At the very least, it quantifies the number of lots that are likely to require more intensive design solutions.

Figure 3 Case study subdivision

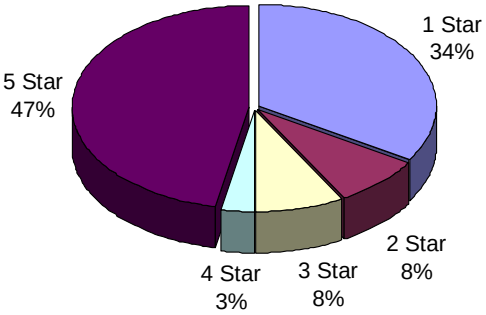

Figure 4 Lot rating profile for case study subdivision

[2] Based on terms used by the key informants, larger lots were defined as being over 560m².

Correlating the lot ratings with dwelling ratings proved more problematic. Using the latest thermal modelling tool, AccuRate[3], the project examined the performance of nine current dwelling designs throughout 360 degrees of rotation. When the results were compared with the lot rating methodology, the project found that in a third of the cases, the existing methodology predicted neither the optimum nor the worst orientation for the dwelling. The project concluded that the SEDA guidelines would need to be modified for use to make allowance for natural ventilation. However, more knowledge is needed regarding the role of ventilation in cooling dwellings in our increasingly densely constructed suburbs.

Quantifying the impact of increasing suburban densities on natural ventilation

Pressures to increase suburban residential densities mean smaller lot sizes and this, combined with high solid fencing, close and dense foliage or high retaining walls, has the potential to reduce access to natural ventilation. Examining a dwelling known to be located in close proximity to its neighbour (Figure 5) provided insight into the impact of increased suburban barriers for all the dwellings.

The Energy project found that increasing the external suburban barriers decreased the amount of natural ventilation available to that dwelling and increased the amount of energy required to cool the dwelling. In fact, increasing the external barriers had the same potential to negatively affect the dwellings energy efficiency as poor lot (and dwelling) orientation.

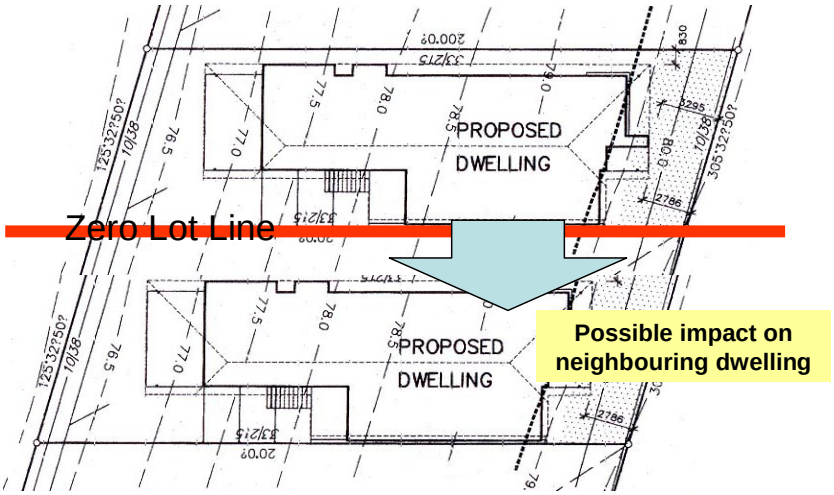

Figure 5 Impact of minimal boundary clearance on adjoining dwellings

To date designers and thermal modelling tool developers have had to rely on Bureau of Meteorology (BoM) wind data to determine natural ventilation impacts. However, BoM data is generally collected in large, open, undeveloped spaces that have unimpeded breezes, such as airports. These data do not take account of micro-climatic effects of local terrain, vegetation and adjacent constructions. Anecdotal evidence suggests that the breeze patterns in increasingly densely constructed inner and outer suburbs are very different to those experienced at BoM sites. This is an area of ongoing contention between regulators (Mills 2005), developers, planners, designers and thermal engineers. Quantifying this impact is the subject of a recently commenced research project, Sustainable Subdivisions: Ventilation.

[3] AccuRate is the thermal modelling tool being developed by CSIRO for the Australian Greenhouse Office

Sustainable Subdivisions; Ventilation - toward a lot rating methodology for subtropical South East Queensland

The aim of the current research project, Sustainable Subdivisions: Ventilation, is to determine the difference in natural ventilation between BoM monitoring stations and a variety of dwelling types through monitoring wind conditions in SEQ. Wind speed and direction will be monitored in twelve dwellings over a twelve month period and the results compared with data from the nearest BoM station. The dwellings, and the lots, will represent the range found throughout SEQ. The dwellings will range from those constructed in new suburbs through to mature suburbs to capture the impact of increasing urban barriers as suburbs mature and change.

The research will verify and quantify the role natural ventilation has in cooling residences in subtropical climates. It will inform the development of a lot rating methodology for SEQ and may also make a recommendation that the existing lot rating methodology in use in other parts of Australia, be modified to allow for the impact of ventilation. The research is also expected to highlight the importance of good design and may also inform the ongoing development of thermal programs.

As a first step, in April 2006, CRC CI researchers held an industry workshop to explore the methodologies currently used by a range of professionals involved in subdivision design and development in SEQ.

Investigating the importance of ventilation to sustainable subdivision design: a workshop

The twenty participants in the workshop are leaders in national and regional development firms, consultancy, local and State government, and peak industry bodies including the Urban Development Institute of Australia, Housing Industry Association, and the Royal Australian Institute of Architects. Building Codes Queensland was also represented.[4]

The workshop opened with presentations by Associate Professor Glenn Thomas and Dr Nur Demirbilek. Using the example of a typical outer Brisbane subdivision, Thomas demonstrated the influence of the slope and orientation of lots on climate comfort and energy demand in summer and winter. He illustrated how permeable shelterbelt planting maximises ventilation benefits, and noted that research is needed into the ventilation effects of increasingly popular barriers such as high walls along property boundaries.

In her presentation, Dr Demirbilek defined 21 degrees Celsius as the most comfortable indoor temperature (assuming 40 per cent humidity), and 21-26 degrees as the outdoor comfort range (in the shade). She outlined six elements of thermal comfort:

- dry bulb air temperature;
- relative wind speed;
- relative humidity;
- mean radiant temperature;
- activity level; and
- clothing level.

Workshop participants debated whether the ventilation aspect of sustainable subdivision is principally a technical and biophysical issue relating to energy usage, or whether it is primarily a social and cultural issue. There was considerable agreement that currently inexpensive-to-install and relatively cheap to run air conditioning has become the standard expectation in SEQ, with one producer of house and land packages claiming that air conditioning is a

[4] Key leaders who were unable to attend are currently being followed up in key informant interviews; a further workshop will be held in 2007 to obtain industry feedback on the directions of the research project.

necessity for three months of the year in this subtropical region. Rosie Kennedy, Coordinator of the Centre for Subtropical Design, cited studies supporting the argument that SEQ's heat and humidity is uncomfortable only one per cent of the year, while it is too cold in the shade for 20 per cent of the time (Kennedy 2006). The house and land packager argued that they can no longer find buyers for non-air conditioned houses, particularly as there are no price signals to deter the installation and use of air conditioning.

Critical challenges identified by the workshop participants:

Fourteen critical challenges, to improving ventilation access at the subdivision stage, were identified by the workshop participants. Key challenges were raised by individual participants, and debated and elaborated via group discussion. At the end of the workshop, participants were asked to indicate, individually, their highest priority for attention, by nominating the most important issue. In the list below, the first nine points were identified as of high priority, and points 10-14 were not specifically ranked. Points 1-5 (in that order) were identified as being most critical.

1. ***Fashion***
   Fashion is a key driver, influenced by television imagery and personal lifestyle aspirations. Can energy efficiency, or energy efficiency codes, become fashionable? Participants proposed that climatically responsive design and development should be made more fashionable by setting the trend amongst those who can afford it, as others seek to emulate the housing preferences of the wealthiest. It was agreed that housing fashions may also be able to be shaped by advertising, education, economic incentives, and legislation.

2. ***Covenants and legislation***
   Best practice should be seen as the starting point not the finishing point in any legislative approaches. Covenants are not enforceable, and people will challenge them if they are too restrictive. Legislation is only capable of preventing the worst practice, rather than encouraging best practice – effective incentives are more important. Legislative approaches need to be accompanied by education. One participant claimed that it would be an important achievement if the one per cent of the population who want a naturally ventilated home can actually do it.

3. ***Consumer attitudes and consumer education***
   Consumer education is urgently needed, as the size of house and the number of visible luxury inclusions is more important to consumers than energy efficiency. Consumers are becoming more energy and water conscious, but energy efficiency and household running costs do not rate highly in the decision making process. The increasing cost of energy will force energy issues to the forefront of consumer thinking. It was noted that housing energy cost and usage is low compared to transport, but that this does not yet seem to be having a major influence. One participant pointed out that buyers of west facing houses report them to be hotter and less comfortable. Consumers have become accustomed to air conditioned workplaces and cars, and are now less tolerant of non-air conditioned dwellings. In rapidly growing SEQ, people have apparently not acclimatised to the subtropical zone. The health impacts of living in artificial air have not yet been determined. Incentives are needed, to encourage consumers to exercise more sustainable preferences.

4. ***Benchmarking***
   Benchmarking is required to provide proper information for comparison, for example regarding ambient temperatures, climatic extremes, average home size, average household size, tracking, benchmarking and comparing results. Performance criteria need to be developed.

5. ***Project home building practices***
   Project builders from the temperate southern states are importing designs that are not suitable for the subtropical Brisbane climate. The influence of the project home market is significant. Incentives can be put in place to encourage best practice. One size does not fit all when it comes to housing; strong arguments were put forward that:
   - a consultative design processes involving local community groups has revealed a design that did not match the market expectations; and
   - people buy what is available – if houses are available that do not consider climatic influences, people will buy them.

6. ***Knowledge of climate appropriate design in housing production***
   Some participants argued strongly that this knowledge appears to be diminishing at all levels – designers, builders, customers. Those designers and builders with the required knowledge are currently too expensive for the majority of consumers. Although not rated as critical by the participants, this perception is of considerable concern to those engaged in promoting climatically appropriate design.

7. ***Affordability of more sustainable approaches***
   Improvements in this area will require education and legislative intervention targeting the industry, the professions and the consumers of housing. Demonstration projects and workshops could play an important role in educating these sectors.

8. ***Point of sale energy rating***
   The idea of using energy rating schemes at the point of sale was discussed. National standards developed in Australia's temperate states are not currently adapted to the subtropical zone.

9. ***Density issues***
   Residential density can be achieved without compromising the amount of landscape planting and space, despite the increasing scale of residential development. Maintaining significant vegetation on site will reduce urban heat island impacts. Technical knowledge is not yet matched by the design process or consumer preferences.

10. ***Housing Expectations***
    It was agreed that the size and form of houses, supplied and demanded, represents a poor match with the demographic profile of the occupants. 60 per cent of households are 1-2 person households, whereas the large houses supplied could accommodate large families. Increasing residential densities (which support more sustainable transport) increase the difficulty of designing for the air movement that is essential to thermal comfort in hot humid climates.

11. ***Household turnover and the payback period for innovation***
    Average ownership turnover rates were reported to be every 7 years for owner occupied housing and every 5 years for investment properties. Rental tenancy turnover rates are higher again. The high turnover rate conflicts with the long payback periods for some energy efficient features – for example it takes 19 years to recoup the cost of a rainwater tank in savings on the cost of water. Rebates are required to support the installation of sustainability features as the payback period is not viable at the moment. The public needs to be made more aware of life cycle costs.

12. ***Leadership***
    There is more to subdivision design than carving up land – it involves roads, lot size, housing density issues and consideration of amenity and views. The design can be

informed by the subtropical place - the character and identity of the subtropical identity of SEQ (the “subtropical vibe”). There is a role for leadership in sustainable subtropical subdivision and design. Although architect designed houses are only a small percentage of the market, they are potentially significant due to their leadership role in design. One participant argued that the professional elite represented in the workshop cannot generate the change that is needed because they are not involved in the majority of SEQ development and house building.

13. Inertia of the building industry

Effecting change creates enormous logistical difficulties and high costs for developers. The initial cost of housing purchase is extremely price sensitive. The inertia or flexibility of the land development industry (as distinct from house building) was not addressed by the main proponent of this point or by other participants.

14. Rating Methodologies/Tools

There is considerable disagreement between professionals as to the success and desirability of rating tools. Some are wary of introducing lot rating tools for subdivisions as it is difficult to achieve 3-star ratings on some lots, particularly those under 450 square metres. Smaller lots represent an increasing proportion of the market. Lot rating methodologies need further investigation before introduction of any rating system.

Conclusions from the workshop

While there was agreement, in the workshop, that it is necessary to focus attention where the greatest gains can be made, further research is required to identify precisely what that focus should be. Natural ventilation is a complex challenge that requires the combination of subdivision design and planning and house design to get it right. A key challenge, evident in the workshop but not consistently acknowledged by the participants, is that land development in subtropical SEQ is commonly a separate process that precedes house design and siting by builders. Most consumers select a house design and building lot via separate processes. In contrast, the workshop participants, as key built environment professionals, find it difficult to address the ventilation issue in other than an integrated fashion that integrates subdivision layout, siting and building design. Of concern is the perception that knowledge of climatically appropriate design appears to be diminishing at all levels.

A sustainable approach to climate-responsive residential subdivision and development will require design for climate comfort in the absence of air conditioning, even if in the short to medium term the majority of households can afford to run air conditioning. Sustainable design requires flexibility, so that dwellings are comfortable in the event that future energy constraints make air conditioning less viable. It is not sustainable to entrench a system of housing production that makes it hard to ‘turn the air conditioning off’.

In the key informant interviews that follow the workshop, an effort is being made to focus attention on the subdivision stage (that is, prior to house building), and to elicit more information on industry methodologies aimed at delivering a greater proportion of lots having ‘sustainable’ levels of ventilation access to maximise natural summer cooling.

Overall conclusions

The importance of sustainability is slowly gaining recognition within all industries and the land development and building industry is no exception. Presently, although rating tools and methodologies exist for assessing dwellings, there are no such tools or well-established methodologies applying to land development in Australia. The Sustainable Subdivisions: Energy project found that there is a correlation between energy efficiency of a dwelling and

the lot it is built on and that lot related issues play an important role in the overall efficiency that a dwelling is able to achieve. The challenge for land developers is to assess the likely impact their subdivision design will have on the climate comfort and energy use of future dwellings. This will become important if dwelling energy efficiency requirements increase in future. Regulators need to be aware of the potential improvements in energy-efficiency through better matching subdivision layout and dwelling design and local influences such as ventilation, lifestyle and amenity.

Assessment of the existing lot rating methodology has found that it goes only part of the way in assessing developments in subtropical SEQ. The SEDA methodology only assesses the impact of solar gain/protection. For SEQ, ventilation, ventilation barriers and small lot sizes need to be addressed in any future methodology. The Sustainable Subdivisions: Ventilation project aims to provide the empirical data to develop this methodology. The first stage of that research, an industry workshop highlighted that natural ventilation is a complex challenge that requires the integration of subdivision design, planning and house design. This challenge is a difficult one, given the common separation of these processes.

Subdivisions that are designed to encourage climatically appropriate sustainable dwellings will provide residents with a home that is more comfortable to live in, has lower running costs and so has less impact on the environment. These are critical factors as subtropical SEQ continues to expand to accommodate more residents while striving to maintain its subtropical lifestyle and amenity.

Acknowledgments

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Has been Senior Lecturer and coordinator of the postgraduate Urban Design Program at QUT since 1993. He holds a PhD and coursework Masters in Urban Design from Oxford Brookes University, and Bachelor of Town Planning from UNSW (University Medal). His main research interests are urban design for tourism; cultural landscape interpretation and management; and urban design for walkable cities. He has a number of publications in these areas, in journals including *Urban Design International, International Journal of Heritage Studies*, and conference proceedings published by Australian, UK, and Chinese universities, government departments and professional organisations.

Anne Miller

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Is an environmental scientist with the CSIRO Sustainable Ecosystems Division. She is the Project Leader and researcher for this project and undertook the research, analysis and reporting of the case studies and prepared the report for the preceding project Sustainable Subdivisions: Energy Project. Before joining CSIRO in April 2004, Anne was a researcher with the Australian Housing and Urban Research Institute Queensland Centre. She undertook research in various projects on social policy issues associated with urban development, design and associated social issues and from a national and international perspective.

She holds a Bachelor of Built Environment (2000) and a Graduate Diploma [Interior Architecture] (2001) from the QUT. Prior to this recent re-training and career period, Anne's had more than twenty years experience with the Australian Government focusing in a range of property related areas including project management, commercial property management and construction administration.