This briefing is based on research by Dr John Morrissey, Prof Ralph Horne, Prof Mike Berry and Mr Trivess Moore conducted at the Centre for Design, RMIT University between February 2008 and October 2010. The research examined the relationship between housing cost and provision and long term sustainability limits, considering socio-economic, spatial and inter-generational dimensions.

This briefing reports on the influence of the discount rate on lifecycle costs and benefits of housing at various levels of energy efficiency performance. Findings are of significance to professionals in the field of building energy efficiency, particularly designers, builders, developers and policy and decision makers.

While residential energy efficiency is high on the policy agenda in Australia, the debate is frequently simplified to an argument of ‘sustainability vs. affordability’. One problem has been a dearth of research into the most cost effective means of achieving higher building efficiencies.

The orientation of buildings to maximise passive solar benefits is the most fundamental and cost effective means of achieving higher efficiency. Empirical analysis carried out for Lifetime Affordable Housing provides new insights into the effects of building orientation, and indicate that passive solar design is a concept that can readily be incorporated into house plans at the design stage, to readily achieve environmental and economic savings. Findings have significant policy implications.

Prof Ralph Horne, Dr John Morrissey and Mr Trivess Moore

Key Points

- Design based interventions represent the most cost-effective means of improving residential thermal performance.
- To date there has been a dearth of research in Australia into more innovative means of achieving higher levels of thermal performance through such low / no cost methods.
- In this first major study to investigate costs and benefits of different energy efficiency rated homes, 81 ‘volume build’ project home designs were modeled to assess the implications of building orientation on modeled thermal efficiency, considering both the effect of size and overall thermal performance rating.
- Findings indicate that passive solar design is a concept that can readily be incorporated into house plans at the design stage.
- Building orientation is the most fundamental and generally the most

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easily implemented strategy based on passive solar design principles, requiring minimal plan reconfiguration and no material based intervention.

- In comparison, material based interventions to achieve higher thermal performance incur two additional cost streams; the purchase cost of materials and the cost to integrate these materials to existing designs.

Background and Policy Context

The importance of the built environment from an environmental impact and energy use perspective is well established. Strategies for energy use reduction in buildings need to consider how new buildings are designed and built. The most important decisions concerning building sustainability can be made in the early design stages, by the architect or building designer.

Passive solar building design involves optimal use of the sun’s energy together with local climate characteristics to maintain thermal comfort within a building. By working with, rather than against natural conditions, passive solar design can allow a reduction of fossil energy necessary for space conditioning through heating and cooling.

Of passive solar design principles, including plan proportion and shape and façade glazing design, building orientation is the most fundamental, and generally, the most easily implemented aspect. On a development with appropriately divided allotments, good orientation, location on site and landscaping changes may potentially reduce the thermal energy requirements of a typical dwelling by 20 per cent.

However, while passive solar design is a cost effective and easily implemented means of achieving improved thermal performance, it has not been widely adopted in Australian building practice. An issue is the cost required to acquire new expertise, to train employees or to dedicate resources to change established work practices. Regulation has been the main driver for increased thermal performance in the residential sector to date. However, legislation too has neglected the potentials offered by passive solar principles.

In this context, this briefing seeks to provide empirically based evidence to illustrate the potential economic and environmental savings possible through the adoption of passive solar design principles, specifically focusing on the issue of residential building orientation.

Research Methods

Research questions:

The aim of this study was to identify those building characteristics which made houses more flexible to orientation change, and by extension those housing designs which achieve higher standards of energy efficiency across a range of orientations. Analysis addressed four research questions:

1. What parameters influence the range of energy ratings achieved when a building is rotated through 360°?
2. What design aspects correlate with adaptability to building orientation through 360°rotation?
3. Does the adaptability of ‘standard’ designs and designs with improved thermal performance differ?
4. Does the adaptability to orientation change of analysed houses change with respect to house size?

Sample selection

Focusing on the volume housing market of Melbourne, Australia, this research applied a thermal modelling approach to a sample of 81 dominant house designs.

Heating and Cooling models

The Nationwide House Energy Rating Scheme (NatHERS) approved software AccuRate, was used in order to estimate the total energy requirement of selected house plans.
AccuRate simulation models were applied to model thermal house performance of all designs at the following levels of energy efficiency rating performance:

- 5 stars
- 7 stars

Modelling orientation

The orientation of each model was varied across 4 cardinal points and four inter-cardinal points. These points referred to the azimuth of the wall of the main living space, and included:

- North
- North-East
- East
- South-East
- South
- South-West
- West
- North-West

Simulations produced heating and cooling loads for all 81 sample plans, for both 5 stars and 7 stars thermal performance scenarios and across the 8 orientation points. A total of 1296 simulations were conducted. For all models, it was assumed that the house as a whole was rotated, so that glazing areas or other external features were not adjusted, to reflect standard practice of the volume build industry.

Statistical analyses were conducted on these data, together with plan characteristic data such as floor area, external wall area, wall to floor ratio and glazing to wall ratio.

Findings

Results show that smaller houses had significantly lower ranges of thermal performance rating across eight orientations, in comparison to larger houses. This indicates that it is more difficult to get larger residential houses to perform to a consistent standard in terms of thermal efficiency, at either 5 stars or 7 stars performance standards.

Larger houses, with a floor size of greater than 250 m², showed higher ranges and higher standard deviation of mean ratings across the 8 orientation points.

In addition, statistically significant differences between 5 stars and 7 stars thermal performance scenarios were found. 7 stars rated buildings showed a significantly lower range of star ratings across the 8 orientations than 5 star rated buildings.

Results suggest that smaller houses and those of higher thermal performance are more adaptable to orientation change than larger houses and houses at the current regulatory standard thermal performance of 5 stars.
Policy and Practice Implications

Buildings are durable, and building decisions have long-term consequences. In view of current poor energy performance levels of residential buildings and trends of upwards household consumption and increasing house size, building design decisions have a critical role to play in the effective management of future energy requirements. The potential for intervening at the design stage in order to improve building energy efficiency is substantial, whereby relatively basic measures can deliver significant improvements.

Responding to the need to reduce emissions and energy consumption, Government has introduced energy efficiency standards via building regulations and codes. These regulations have proved controversial, and to date the debate has been framed by an expectation of high additional costs involved for 7 stars and 8 stars options compared with standard 5 star rated houses. This expectation is based on an assumption of material based interventions to achieve higher performance. In this context, there is a strong case to examine the benefits of low cost passive design approaches.

Results show that higher thermal performance standards are more difficult to meet for larger houses (>250 m² floor area), while smaller houses are more flexible in terms of performance, and can more easily adjusted to perform to higher thermal performance standards.

In addition, better performing designs exhibit greater flexibility and adaptability. Moreover, energy efficient houses can be built at a range of orientations, requiring fewer design variations from the building industry.

The research indicates passive solar energy efficiency design can provide an important and low cost step towards reducing environmental impacts.

The following further recommendations and investigations are proposed:

1. House size is a critical factor in performance, and furthermore, better performing designs require less adjustment across different orientations
2. Building standards regulation could be used to further drive energy efficiency standards without undermining affordability.
3. More compact designs with passive solar features are more adaptable and can potentially be provided at lower cost than bespoke alternatives.
4. Investigate broader cost implications of volume built designs with improved passive design performance.
5. Apply the method to other climate zones across Australia (this study is based on Melbourne climate).

Recommended Reading


Acknowledgements

This research was supported under Australian Research Council’s Linkage Projects funding scheme (project LPO776834). The authors wish to acknowledge the contribution of project partner's the Building Commission, Land Management Corporation and VicUrban, Adjunct Professor Alan Pears, RMIT University and Dr. Deepak Sivaraman, RMIT University and for their contribution to this work.

Disclaimer

The views expressed herein are those of the authors and are not necessarily those of the Australian Research Council, or of the project partners.

Contact

Centre for Design, RMIT University
Building 15, Level 2, Room 11
124 La Trobe St, Melbourne 3001 Victoria, Australia
Ph: +61 3 9925 3484 Fax: +61 3 9639 3412.
Further reports and papers from this project can be found on the Lifetime Affordable Housing website:
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