Energy and Buildings 70 (2014) 463–471

Contents lists available at ScienceDirect

Energy and Buildings

journal homepage: www.elsevier.com/locate/enbuild

Modelling the through-life costs and benefits of detached zero (net) energy housing in Melbourne, Australia

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ARTICLE INFO

Article history:
Received 27 August 2013
Received in revised form
22 November 2013
Accepted 28 November 2013

Keywords:
Zero (net) energy housing
Cost–benefit analysis
Affordability
Renewable energy

ABSTRACT

Zero (or low) energy housing standards are being implemented in several developed countries and represent international best practice for minimum performance outcomes for new dwellings. However, the debate in Australia regarding housing energy performance continues to revolve around 'sustainability' versus 'affordability', with affordability typically prioritised as the more pressing short-term policy challenge. There is limited analysis informing this debate, particularly regarding higher energy efficiency requirements *and* the integration of renewable energy technologies to achieve a zero (net) energy house (ZEH) outcome. This paper aims to address the limited empirical evidence regarding costs and benefits of ZEH in Australia. A cost–benefit analysis focusing on new detached housing in Victoria, Australia was undertaken to determine upfront and through-life costs and benefits of ZEH performance. Results show that ZEH is a least cost scenario, in terms of capital and through-life operational energy costs, compared to a business as usual approach or improving the thermal performance of the building envelope only. The research highlights that ZEH standards are economical in Australia and that sustainability assists with affordability when a through-life perspective is applied.

1. Introduction

The setting of minimum building energy performance standards has arguably had the greatest affect in addressing energy use in the residential sector [1]. Such standards invariably aim to address a market failure preventing improved environmental sustainability in housing. Minimum energy performance standards in many developed countries, including Australia, have typically targeted improving heating and cooling energy requirements in new housing [2].

Jurisdictions such as the United Kingdom (UK), European Union and California have recently developed pathways to achieve ZEH (or near zero) standards drawing upon wider considerations in an attempt to more holistically account for environmental, economic and social elements [3,4]. As a result ZEH standards have recently become international best practice.

The development of these policies has occurred against a backdrop of increasing research and practical development of ZEH [5–8]. These examples of both built and modelled ZEH aim to advance the debate regarding the costs, benefits and feasibility of building ZEH standard dwellings. In most cases, the projects found that ZEH is a feasible minimum standard.

1.1. The Australian context

In Australia, the residential sector accounts for 12% of Australia's total final energy consumption and 13% of Australia's greenhouse gas emissions [9,10]. Total residential energy demand in Australia increased by 88% between 1973 and 2009 [9], while the total population has increased by only 60% across the same time-horizon [11]. Analysis by the Department of Environment, Water, Heritage and the Arts [12] projected total residential energy demand in Australia to increase by another 16% between 2008 and 2020, influenced by increasing numbers of housing stock and increased numbers and use of appliances and heating/cooling equipment.

In Australia there has been some form of minimum housing energy performance requirements in place since 1993. From 2004, new dwellings in Australia had their energy performance rated against a 'star' rating band which is primarily a thermal energy rating. The current star band ranges from 1 star (least natural thermal performance) to 10 star (best natural thermal performance, requires virtually no mechanical heating and cooling). As of May 2011, the minimum requirement for new dwellings in Australia is 6 star. The Nationwide House Energy Rating Scheme (NatHERS) sets the thermal energy load requirements for each star band for each of the defined climate zones in Australia. This is meant to allow for fair comparisons of dwellings taking into account regional variability in climatic conditions across Australia. Fig. 1 presents the thermal energy load for each star band for climate zone 60, which is the climate zone applied in the analysis in this paper [13].

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http://dx.doi.org/10.1016/j.enbuild.2013.11.084

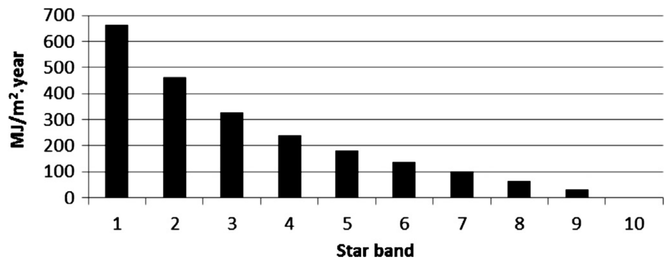

Fig. 1. Thermal energy load for each star band for climate zone 60.

Reviews of the implementation of the star rating standard have found significant improvements to energy efficiency of new housing stock in Australia. The introduction of the Building Code of Australia minimum energy performance 5 star standards in Victoria (prior to the introduction of a 6 star standard in 2011) resulted in a reduction in greenhouse gas emissions of about 20% for new dwellings, compared to if the 5 star standards had not been introduced [14]. However, increasing house floor size and an increase in the number and use of appliances mean that actual greenhouse gas emissions increased by 6% compared to existing dwellings.

In Australia there is ongoing debate regarding the future direction of minimum energy performance standards. The debate centres on a perceived trade-off between affordability and sustainability, with affordability more frequently given priority [15]. The cost of housing has risen faster than incomes in Australia in recent years and any additional capital costs for improved sustainability outcomes is often cited as a concern for policy makers and home owners [8]. Most at risk from increasing housing costs are low income earners and first home owners. This is a point which is strongly argued by key building industry associations who are typically against changes which add to costs or which may hamper the sale of dwellings [16]. Sustainability features are seen as adding costs in this context.

The development of minimum energy performance standards for new housing by the Australian Building Codes Board, along with wider debates on affordability/sustainability have been informed by cost–benefit analysis (CBA). The role of CBA for ZEH policy development is highlighted by analysis undertaken in jurisdictions who have developed ZEH (or near ZEH) standards, such as the UK [17]. There has been limited analysis in the Australian context to date of ZEH. This is partly due to the fact that in Australia (as of 2013) ZEH is off the immediate or near term policy agenda.

The current public policy agenda for minimum housing standards in Australia is about maintaining the current 6 star standard. While the standards undergo a yearly review, this is more about fine tuning the standard rather than proposing any incremental or significant changes to minimum housing standards. The last change to the agenda was in the introduction of the 6 star standard which was first publically announced by the Council of Australian Governments in 2008 and took until May 2011 to become a mandatory minimum standard for new housing [18]. For a more detailed discussion of building standards in the Australian context refer to Moore [19].

While there is some emerging ZEH research in Australia, there remains a significant gap in analysis and a lack of empirical research into the lifecycle cost implications of increased energy efficiency at the household level, and an interpretation of the wider practical implications of this analysis in terms of a transition to a low carbon housing future. As Newton and Tucker [20] state:

> '. . .there is a market failure related to provision of the information necessary for informed policy or investment decisions. . .it is timely to question whether the scope of current building regulations is now sufficient in the face of 21st-century challenges relating to climate change'.

2. Aims and objectives

This paper aims to address this gap by presenting clear lifecycle cost–benefit information regarding ZEH standards for Melbourne, Australia. In doing so, the evidence developed can inform future policy development and the wider debate regarding ZEH standards in the Australian context.

Specifically this paper asks the following questions:

1. What are the through-life costs and benefits of ZEH performance standards for owner-occupied new home buyers?
2. How do these outcomes compare to a Business-as-Usual (BAU) approach or improving the building envelope thermal performance only?
3. What implications arise from through-life costs and benefits of ZEH for policy development and advancing the sustainable housing debate?

For the purposes of this analysis, ZEH is defined as a net balance of zero between renewable energy generation and total energy consumed by the occupying household across a year. The focus of this analysis is on energy and greenhouse gas emissions from the operational phase of the dwelling, which is responsible for 80–90% of energy impacts across the life of the dwelling [21]. It is acknowledged that embodied energy, which is not considered in this analysis, is also a consideration for sustainable housing outcomes as explored by others such as Pullen [21].

3. Method

A CBA was undertaken to determine the through-life costs and benefits of achieving a ZEH standard; an approach which is in line with the setting of previous minimum energy performance standards in Australia and internationally [3,22]. Analysis presented in this paper builds upon previous CBA application as well as methods, data and assumptions from previous research into energy efficiency in the residential sector in Australia [20] and internationally [6].

The research in this paper goes beyond emerging research in the Australian context for ZEH in terms of the level of detail and rigour of costs estimates reported in each scenario modelled, across a much larger sample of house designs than has previously been considered (Table 1).

3.1. Scenario development

For this paper, three scenarios are presented for comparison of capital and through-life costs and benefits of improved energy performance, which correlate to three methods steps:

- Step 1 – a BAU scenario (6 star building envelope),
- Step 2 – an improved building envelope scenario (8 star building envelope), and
- Step 3 – a ZEH scenario (8 star building envelope with 4.3 kW photovoltaics (PV) generating an average of 17.2kWh/day across an average year and a solar hot water (SHW) system).

The analysis required the calculation of addition capital costs for steps 2 and 3 and comparing these costs with operational energy savings and other benefits (such as environmental) across time. Fig. 2 provides a schematic overview of the applied approach.