Energy Policy 85 (2015) 12–21

Contents lists available at ScienceDirect

Energy Policy

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

Zero energy homes – Are they economically viable?

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HIGHLIGHTS

- The concept of net zero energy homes is examined for economic viability.
- Evidence is collected from a near net zero energy housing estate.
- Conservative results show that societal benefits outweigh costs.
- Significant additional benefits gained from net zero energy homes.

ARTICLE INFO

Article history:
Received 25 March 2015
Received in revised form
8 May 2015
Accepted 12 May 2015

Key words:
Building energy policy
Zero energy homes
Building monitoring
Energy economics

ABSTRACT

Whilst net zero energy homes are espoused in many policy circles, and many bespoke examples have been constructed to demonstrate their technical feasibility, there is a scarcity of evidence demonstrating such a standard would be economically rational, particularly for large scale housing development where orientation and aspect may not always be optimal. Drawing on energy monitoring evidence and construction economics associated with a nearly zero energy housing estate in Adelaide, Australia, this paper explores the economic feasibility of the net zero energy home policy in warm temperate climates. The results demonstrate that using economic tools and assumptions typically applied for building energy regulatory policy changes, net societal economic benefits significantly outweigh costs. The clear economic outcomes, combined with expected health and productivity benefits from improved levels of thermal comfort, should provide security to policy makers to progress home energy standards towards net zero energy performance.

1. Introduction

1.1. Background and research question

Zero energy and zero carbon homes are a hot topic of discussion in research and policy circles. Net zero energy case studies can be found in many countries, with the International Energy Agency's 'Towards Net Zero Energy Solar Buildings' project mapping almost 300 zero energy and energy-plus buildings worldwide (Research for Energy Optimized Building, 2013). Building energy policy is steadily moving towards regulatory levels approximating zero energy or zero carbon (Lovell, 2009; Kapsalaki and Leal, 2011; Moore et al., 2014). In the United Kingdom the regulatory target is set at zero carbon for new dwellings by 2016 (Department of Communities and Local Government, 2006); the European Union Directive on the Energy Performance of Buildings (European Commission, 2010) specifies that by the end of 2020 all new buildings shall be 'nearly zero energy buildings' (Sartori et al., 2012); and other nations have developed policy paths towards zero energy buildings (Department of Climate Change and Energy Efficiency, 2010; Sartori et al., 2012).

While much of the zero energy home literature has focussed on design strategies and technology application, little evidence has been presented demonstrating the economic viability of a net zero energy regulatory standard. Regulatory changes are typically subject to the analysis of a Regulation Impact Statement (RIS) and in particular, a net present value (NPV) calculation of the economic costs and benefits. For example, in Australia house energy standards (Australian Building Codes Board, 2002, 2006, 2009) have been tested using the RIS process defined by the Australian Government (Office of Best Practice Regulation, 2010, 2013), but these have been limited by the available evidence, and the quality of the building energy models. These economic tests have predominantly focused on expected increased construction costs and direct energy savings associated with the proposed higher performance level. Other impacts, such as savings in peak energy demand infrastructure, health or productivity benefits from improved

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http://dx.doi.org/10.1016/j.enpol.2015.05.009
0301-4215/

thermal comfort, or temporal cost reductions due to supply chain evolution, have not been quantified and incorporated into RIS calculations. This has meant that Australian building energy standards, like those of many nations, have not reflected the optimal environmental and economic outcome, and current limitations in the economic model would be unlikely to support a change to a zero energy housing standard.

This paper addresses this research gap by developing an economic model that builds upon NPV equations applied to energy efficiency changes in many nations, including those for the Building Code of Australia. This economic model is robustly developed through the incorporation of monitored energy performance collected from near zero energy homes at Lochiel Park in South Australia and local building cost data, and is combined with the evidence developed internationally in various economic studies to develop a more comprehensive model of the costs and benefits associated with increasing the minimum energy performance standard. Utilising the available evidence, this study investigates the research question: are net zero energy homes a net benefit or cost to society in warm temperate (Mediterranean) climates? With substantial populations in both Australia (i.e. Sydney, Perth and Adelaide) and internationally (i.e. Mediterranean cities, California) located in a similar climate, the results have wider policy application. By addressing this research question, this study will enable many policy makers to better understand the impacts associated with the application of net zero or near zero energy housing standards.

The paper is structured to: firstly, review the literature on net zero energy and near zero energy homes to identify the key factors that shape their economics. Secondly, the material and methods are outlined, identifying and describing the case study estate, Lochiel Park, and provide the functional detail of the proposed net zero energy standard. Thirdly, the economic model is detailed including key assumptions and factors, construction and equipment costs and savings, direct energy savings, and indirect impacts. The paper concludes with a discussion of the key findings from the case study and their implications to policy makers.

1.2. The economics of near zero energy homes

Most recently, concern over anthropogenic greenhouse gas emissions and rising energy costs have meant that governments have sought to address the energy and carbon impact of buildings (Koeppel and Ürge-Vorsatz, 2007; Intergovernmental Panel on Climate Change, 2014), and, at least at the micro-economic level, the new drivers of housing economics have become higher energy efficiency standards and the domestic application of renewable energy technologies.

Political debates about house energy standards have often been framed as a choice between housing affordability and higher energy efficiency, yet once many of the direct and indirect costs and benefits are considered, it can be demonstrated that the overall cost of housing may fall with improved energy standards (Horne et al., 2008; Morrissey and Horne, 2011; Moore, 2014). The link between housing affordability and energy efficiency requires further investigation, particularly the literature examining the economics of net zero energy homes.

1.2.1. Higher construction and lower operating costs

Low energy use homes, such as net zero energy or zero carbon homes, have been associated with higher construction and lower energy use costs (Anderson et al., 2006; Audenaert et al., 2008; Moore, 2010; Leckner and Zmeureanu, 2011; Carrilho da Graça et al., 2012). For example: Anderson, Christensen and Horowitz (2006) found that a zero energy standard would require a net investment above building code requirements of between USD $8432 and USD$15,166 depending on geographic location. Audenaert et al. (2008) estimated the additional cost of the ‘Passivhaus’ standard in Belgium to be EUR€37,330, and would need a 9% annual energy price growth before the standard provides a benefit within a 20 year mortgage life. Leckner and Zmeureanu (2011) found that zero energy homes would need energy prices to increase by 13% annually or technology prices fall by an equivalent amount or a combination of the two before the standard became cost effective over the prescribed life. Carrilho da Graça et al. (2012) found in Lisbon for an 11% initial cost increase, a net zero energy home had a simple payback of between 11 and 18 years. Moore (2010) found that the average increase in construction cost from a 5 NatHERS Star to a 7 Star home in Melbourne was AUD $4226. NatHERS thermal simulation ratings are based on annual sum of the heat energy required to be added or removed to maintain thermal comfort due to design and construction characteristics, the local climate and standardised user behaviour patterns. Further detail on NatHERS is available at NatHERS National Administrator (2010).

Other research has found that improving climate sensitive design, therefore reducing heating and cooling demand and the associated plant, can lead to a net lower construction cost (Elberling and Bourne, 1996; Vale and Vale, 2000; Energy Efficient Strategies, 2001; Sustainability House, 2012a, 2012b; Ambrose et al., 2013). In Australia, for example: Sustainability House (2012b) demonstrated that improving home design from 5 to 7 NatHERS Stars could be achieved by improved climate responsive design practise without increasing net construction costs.

Compliance and construction costs are dynamic and respond to regulatory changes, with performance-based standards a key driver of innovation (Gann et al., 1998; Beerepoot and Beerepoot, 2007; Meacham, 2009). Research has identified that performance-based standards can lead to improvements in industry skills and knowledge, product and supply chain development, and increased production volumes, leading to material housing cost reduction. From one perspective regulation may drive some costs higher in the immediate term, but simultaneously regulation creates the market transformation that drives the cost of housing lower over the medium and long term.

Research into building product experience curves has demonstrated that over time, through processes of market transformation, energy performance characteristics have increased whilst real costs have decreased (Jakob and Madlener, 2003; Harvey, 2009). Experience curves for building products and energy technologies have been calculated by many researchers (Grübler et al., 1999; International Energy Agency, 2000; Iwafune, 2000; Jakob and Madlener, 2003, 2004; Nemet, 2006; Papineau, 2006; Pan and Köhler, 2007; Weiss et al., 2010; de La Tour et al., 2013). Typically savings for building fabric technologies fall in the range of 9–27% per doubling of cumulative production, with 18% being average. Photovoltaics have averaged a learning rate of over 20% per each doubling of cumulative production over a 30 year period (de La Tour et al., 2013). In the UK, early industry construction to the Code for Sustainable Homes points to cost reductions associated with industry learning and increased production quantity (Department of Communities and Local Government, 2011; Element Energy and Davis Langdon, 2013).

The housing market may also recognise the benefits of improved energy performance through higher resale value. There is a body of evidence that demonstrates housing markets in USA, UK, Europe and Australia value energy efficiency, thermal comfort and lower utility bills (Laquatra, 1986; Dinan and Miranowski, 1989; Gilmer, 1989; Nevin and Watson, 1998; Jakob, 2006; Banfi et al., 2008; Department of the Environment Water Heritage and the Arts, 2008; Brounen and Kok, 2011; Fuerst et al., 2013; Hyland et al., 2013). For example, in Australia, hedonic modelling found a