Energy Policy 54 (2013) 148–159

Contents lists available at SciVerse ScienceDirect

Energy Policy

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

Cost-benefit assessment of energy efficiency investments: Accounting for future resources, savings and risks in the Australian residential sector

J. Morrissey [a,b,*], B. Meyrick [c], D. Sivaraman [b], R.E. Horne [b], M. Berry [c]

[a] Geography Department, University of Otago, 364 Leith Walk, Dunedin 9016, New Zealand
[b] Centre for Design, RMIT University, GPO Box 2476 V, Melbourne VIC 3001, Australia
[c] Australian Housing and Urban Research Institute, RMIT University, GPO Box 2476 V, Melbourne, VIC 3001, Australia

HIGHLIGHTS

- ▶ High thermal efficiency is a key strategy to limit energy use in buildings.
- ▶ Integrated thermal modeling—life-cycle costing methods are applied to dominant house designs.
- ▶ The discounting framework is the primary driver of difference in observed costs.
- ▶ The selection of optimal performance investment options depends on the discount rate.
- ▶ Application of a discount rate of 3.5% or lower favours energy saving projects.

ARTICLE INFO

Article history:
Received 3 December 2010
Accepted 2 November 2012
Available online 12 December 2012

Keywords:
Residential building
Thermal efficiency
Cost-benefit

ABSTRACT

This article focuses on the impact of the discount rate on cost-benefit assessment of investment options for residential building efficiency. An integrated thermal modeling, life cycle costing approach is applied to an extensive sample of dominant house designs for Australian conditions. The relative significance of predicted thermal performance and the applied discount rate on the Present Value of energy savings from alternative investment scenarios is investigated. Costs and benefits are also evaluated at the economy-wide scale, including carbon pricing considerations, and for a test-case household faced with alternative investment options at the point of construction. The influence of the applied discount rate on produced cost-benefit calculations is investigated, as is the interaction between critical cost-benefit input parameters. Findings support that the discounting framework is the primary driver of difference in estimates about costs and benefits of higher standards of efficiency in the residential sector. Results demonstrate that agreement on a low discount rate based on sustainability principals would prioritise those projects with significant environmental benefits.

1. Introduction

Environmental policies frequently involve a trade-off between short-term costs and longer-term benefits. Investments in cleaner technologies and abatement equipment, for example, require up-front capital expenditure that leads to environmental improvements over time (Newell and Pizer, 2004). Residential energy efficiency provides a case in point. The potential for energy demand reduction via thermal efficiency of the building envelope is significant because of the energy savings possible and because of the relatively low cost of achieving these potentials (Jakob, 2006). The necessary capital investment in materials and labour at the construction stage ensures that the net cash flow of thermal efficiency investments have a distinctive time profile; that is, being initially negative and becoming positive only after the project has been completed and energy and associated operational cost savings have accrued over time (Campbell and Brown, 2003). Uncertainty over the nature of these costs, both capital and operational, as well as with appropriate costing methodologies, have contributed to difficulties in implementation of regulation for higher thermal performance standards for residential building envelopes in Australia (Horne et al., 2007), the UK (Pulselli et al., 2009) and in Norway (Ryghaug and Sørensen, 2009). The implications of higher capital costs on the overall lifecycle cost profile of

* Corresponding author at: Geography Department, University of Otago, 364 Leith Walk, Dunedin 9016, New Zealand. Tel.: +64 2102532862.
E-mail addresses: jem@geography.otago.ac.nz, john.morrissey@rmit.edu.au (J. Morrissey), Bronwyn.meyrick@rmit.edu.au (B. Meyrick), Deepak.sivaraman@rmit.edu.au (D. Sivaraman), Ralph.horne@rmit.edu.au (R.E. Horne), mike.berry@rmit.edu.au (M. Berry).

0301-4215/$ - see front matter © 2012 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.enpol.2012.11.005

housing has not been addressed in a sufficiently rigorous manner to allow clear quantification and appraisal of accrued benefits. Cost benefit analysis (CBA) is a policy tool which can be applied to ascertain the relative measures of different courses of action, and provide clear evidence for policy making (Le Dars and Loaec, 2007). Cost benefit analysis (CBA) and Life Cycle Costing (LCC) are therefore appropriate techniques to apply in this context.

For residential energy efficiency in the Australian context, the debate on increased stringency of thermal performance standards has typically focused on narrowly defined aspects of the cost-benefit equation. On the costs side, the debate has focused on the upfront costs of implementing improved thermal performance standards at the construction stage, and on the implications on affordability of purchase of these added costs (Morrissey and Horne, 2011). On the benefits side, there has been a dearth of information on the through-life operating cost savings implications of improved thermal performance standards (all other factors being equal) (Horne and Hayles, 2008). In addition, links between micro-level cost-benefit equations and macro-level cost benefit equations have not been made in the Australian context to date. While the applied parameters of CBA are critical to the results obtained, CBA methods have largely been omitted from the policy debate. Discounting procedures are fundamental to the theory and practice of CBA, for instance (Awerbuch and Deehan, 1995). The discount rate, inherited from financial mathematics and interest theory, is used to evaluate future cash flows at their current value. Discounting techniques permit the consideration of the value of time in economic analysis (Le Dars and Loaec, 2007). The discount rate therefore represents a critical parameter of the investment decision (Corum and O'Neal, 1982) and in policy analysis which applies CBA. The applied discount rate is widely recognised as having significant effects on cash flows (Awerbuch and Deehan, 1995). From an Australian policy perspective, critical energy policy questions concerning the CBA of improved thermal performance standards and the applied discount rate include:

I. What is the impact of the discount rate on cost-benefit calculations for improved thermal performance standards at the building level?
II. What impacts do discount rates have on the assessment of benefits of improved thermal performance at the economy-wide scale?
III. From a policy prioritisation perspective, how do discount rates affect the predicted benefits of instruments such as carbon pricing
IV. At the household level, how do applied discount rates affect Net Present Value and Risk Adjusted Present Value calculations for investments under Australian conditions?

As part of a wider study on the through life costs of housing provision in Australia, this article focuses on the impact of the discount rate on LCC of thermal efficiency investment options for the new build residential sector. Four thermal performance standards, including a 'business as usual' baseline and three higher efficiency standards, are applied to an extensive sample of dominant house designs, selected to be representative of the new build volume housing market. Building cost databases, residential energy demand simulations, and current and projected statewide average utility rates are applied to determine the Present Value (PV) of energy savings for the three enhanced performance standards, compared with the baseline standard. Costs and benefits are also evaluated at the economy-wide scale, including carbon pricing considerations, and for a test-case household faced with alternative investment scenarios of the three improved thermal performance standards. The influence of the applied discount rate on produced cost-benefit calculations is investigated, as is the interaction between critical cost-benefit equation input parameters. Statistical tests are applied as appropriate.

2. Theoretical perspectives on the discount rate

Discounting arises in cost-benefit analysis as a way of converting costs and benefits that accrue at different points in time into comparable present-value units (Howarth, 1996). The choice of discount rates to use in a CBA is a key issue in the analysis of long-term societal issues, in particular environmental issues such as climate change. There is a large and growing body of literature on the subject, addressing conceptual, ethical and practical elements of the argument, the scope of which prevent a detailed discussion here. A brief overview is therefore provided.

For a discussion on conceptual issues involved with discounting see Howarth (1996), Neumayer (1999), Padilla (2002), Frederick (2006), Baum (2009). Padilla (2002) for example, discusses the limitations of conventional economic analysis of intergenerational problems and examines some alternative conceptual solutions. Heal et al. (2005) explore the conceptual underpinnings of inter-temporal welfare economics and the environment.

Simpson and Walker (1987), Sáez and Requena (2007) and Pickin (2008) discuss methodological issues of integrating environmental and sustainability concerns within standard CBA methodologies. Newell and Pizer (2004) discuss the magnitude of the effect of discount rate uncertainty and the flaws within current discounting techniques. Tonn (2002) approaches the problem from an ethical perspective and proposes an integrated framework for environmental policy and ethics that encompasses epochal time frames. The ethical dimension and significance of values to the debate is also addressed by Wong et al. (2008) and Baum (2009). Seminal papers by Weitzman (1994), Rabl (1996), Azar and Sterner (1996), Weitzman (1998) and Abrahamse and Steg (2009), argue for the conception and application of discounting techniques which are more conducive to intergenerational equity. In application, Guo et al. (2006) suggest hyperbolic discounting with declining discount rates as one means of achieving equitable inter-generational accounting. The argument, further articulated by Hepburn et al. (2009), is that declining discount rates increase the weight placed upon future impacts, reducing the apparent tension between intergenerational equity and efficiency. Counter arguments to hyperbolic discounting are provided by Philibert (1999), Winkler (2006) and Horowitz (1996) who highlight particular issues with declining discount rates, chief of which includes the problem of time-inconsistency. Conceptually, the debate on whether to use declining discount rates or not is linked to arguments on weak versus strong sustainability and the measurement and accounting techniques appropriate to these opposed axioms, after, Cabeza GutÈs (1996), Victor (2005), Dietz and Neumayer (2007) and Gasparatos et al. (2008).

Thompson (1997) suggests that a more appropriate incorporation of risk into discounting procedures used to evaluate energy efficiency projects would yield higher net benefits to such projects than standard evaluation techniques. This is also explored in key publications from Howarth (1996, 2003, 2004).

In view of these debates, Clinch and Healy (2001) attest that there is no consensus on which discount rate is appropriate and that in practice, the discount rate used to evaluate public projects is chosen via the political system. The variation of discount rates applied across jurisdictions tends to support this assertion. Even among intrastate government agencies, there is heterogeneity in the discount rates used to assess policy interventions.