Energy-efficient renovation of owner-occupied heritage dwellings: Insights from social practices

A thesis submitted in fulfilment of the requirements for the degree of Doctor of Philosophy

Ellis Paula Judson
BSc (Hons), GradDip Urban Planning, MSc

School of Property, Construction and Project Management
College of Design and Social Context
RMIT University
October 2013
I, Ellis Paula Judson, declare that:

a) except where due acknowledgement has been made, this work is that of myself alone;

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Signed: ..........................                  Date:  14 October 2013

Ellis P. Judson
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To my dearest

Keith, Tess and Baxter

and

my adopted family
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<td>ABS</td>
<td>Australian Bureau of Statistics</td>
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<td>ABARE</td>
<td>Australian Bureau of Agricultural and Resource Economics</td>
</tr>
<tr>
<td>ABCB</td>
<td>Australian Building Codes Board</td>
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<tr>
<td>ASBEC</td>
<td>Australian Sustainable Built Environment Council</td>
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<tr>
<td>BCA</td>
<td>Building Code of Australia</td>
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<tr>
<td>CO₂</td>
<td>Carbon dioxide</td>
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<tr>
<td>COAG</td>
<td>Council of Australian Governments</td>
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<tr>
<td>CSIRO</td>
<td>Commonwealth Scientific and Industrial Research Organisation</td>
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<tr>
<td>DCCEE</td>
<td>Department of Climate Change and Energy Efficiency</td>
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<tr>
<td>DEWHA</td>
<td>Department of the Environment, Water, Heritage and the Arts</td>
</tr>
<tr>
<td>DPCD</td>
<td>Department of Planning and Community Development (Victoria)</td>
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<tr>
<td>DTS</td>
<td>Deemed to Satisfy</td>
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<tr>
<td>EU</td>
<td>European Union</td>
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<td>HERS</td>
<td>House Energy Rating Schemes</td>
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<td>HIP</td>
<td>Home Insulation Programme</td>
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<tr>
<td>IPCC</td>
<td>Intergovernmental Panel on Climate Change</td>
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<tr>
<td>kWh</td>
<td>kilowatt hour</td>
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<tr>
<td>MEPS</td>
<td>Minimum Energy Performance Standards</td>
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<tr>
<td>m²</td>
<td>square metres</td>
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<tr>
<td>MJ</td>
<td>mega joule</td>
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<tr>
<td>NABERS</td>
<td>National Australian Built Environment Rating System</td>
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<td>NatHERS</td>
<td>Nationwide House Energy Rating Scheme</td>
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<td>NFEE</td>
<td>National Framework for Energy Efficiency</td>
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<tr>
<td>OECD</td>
<td>Organisation for Economic Co-operation and Development</td>
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<tr>
<td>PJ</td>
<td>peta joule</td>
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<tr>
<td>RBS</td>
<td>Registered Building Surveyor</td>
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<tr>
<td>UK</td>
<td>United Kingdom</td>
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<tr>
<td>VCAT</td>
<td>Victorian Civil and Administrative Tribunals</td>
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<td>VEET</td>
<td>Victorian Energy Efficiency Target</td>
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Abstract

Improving energy and environmental performance in the built environment has become an increasingly important objective for governments around the world in efforts to achieve sustainability, and to transition to a low-carbon future in response to prevailing concerns about global climate change. Attention has recently turned to the existing building stock, which offers potential for reducing energy use and greenhouse gas emissions but also presents significant challenges. Although renovation of existing dwellings, including retrofitting, has become a key strand of policy, little attention has been given to how this is achieved in practice, and with this, the implications for buildings with cultural heritage significance.

Previous studies have largely concentrated on technical aspects relating to energy efficiency and thermal performance of the building envelope and mechanical systems, and factors influencing occupants’ behaviours. These approaches have limitations as they tend to overlook the social and cultural aspects of housing improvement, which are increasingly recognised as being important in energy use.

This thesis investigates home-renovation practices in heritage housing and the alignment or otherwise of built heritage and energy efficiency ambitions of owner occupiers seeking to renovate their heritage dwellings. Drawing on theories of social practice for the analytical framework, the study examines the mechanisms shaping renovation activities and how these intersect in heritage dwellings.

Using an ethnographic case study approach, the research draws on qualitative interviews and walk-through home tours with home-renovators in Victoria, Australia who have embarked on a process to improve environmental performance. In exploring the experience of homeowners, attention is given to the common understandings, competences and material infrastructures that influence renovation of heritage dwellings. The study discusses how householders balance emerging requirements for energy performance with retaining heritage significance, and other needs and aspirations.
The findings provide insight into the importance of understandings and meanings of heritage in shaping renovation practice. Renovation practice is significantly affected by household expectations and conventions relating to comfort, cleanliness and convenience, and may only be tangentially related to environmental objectives. In conclusion, the thesis highlights the need to understand homeowner renovation practices as this has repercussions for both environmental performance and heritage significance. Implications for policy are discussed.
Chapter 1

‘How do we cope with this heritage, which at the same time sustains and constrains us?’

David Lowenthal, 1985

1 Introduction and overview

1.1 Background to the research

Improving the environmental performance of the existing built stock is a difficult problem that is far from resolved. Worldwide the building industry and the built environment are some of the largest contributors to energy and material use. The urban environment accounts for over two thirds of the world’s energy and over 70 per cent of the world’s CO₂ emissions (International Energy Agency, 2008). Energy used in residential, commercial and public buildings accounts for 35 per cent of total global energy consumption (International Energy Agency, 2006). In Australia, 42 per cent of energy use can be attributed to buildings. The operation of buildings accounts for over 27 per cent of national greenhouse gas emissions, and when combined with emissions embodied in the materials used throughout the building’s lifecycle, the impact is estimated to be between 32 and 40 per cent of national emissions (Australian Greenhouse Office and Department of the Environment and Water Resources, 2006). There is widespread concern about the need to reduce resource consumption and mitigate adverse impacts related to energy use in the built environment.

As new development accounts for a small proportion of the building stock in Australia, it follows that a large section of the current building stock will be in existence and continue to be used for many decades to come. Consequently, adaptation of existing buildings is seen as an important strategy for improving
performance with regards to environmental sustainability (Bullen, 2007; 2009; Department of the Environment and Heritage, 2004; Douglas, 2006; Meijer et al., 2009; Kohler and Yang, 2007; Wilkinson et al., 2009).

Interest in reducing energy and attendant CO₂ emissions is driven by climate change, concerns over depletion of fossil fuel resources globally, rising fuel costs, and fears over energy security (Urge-Vorsatz et al., 2007; Geller et al., 2006; Wienand et al., 2008; Falk and Settle, 2011). The existing building stock is expected to contribute to targets for reducing energy consumption and associated CO₂ emissions. Although government policy has prioritised energy efficiency in the residential stock through renovation and retrofitting, there is a lack of information, in particular on older dwellings that were constructed prior to the introduction of regulations to improve energy efficiency (Australian Greenhouse Office and Department of the Environment and Water Resources, 2007: 4), together with little evaluation of measures on energy use. With an estimated 57 per cent of dwellings in Australia over 20 years old (Australian Greenhouse Office and Department of the Environment and Water Resources, 2007), there is a pressing need to understand the composition and dynamics of the residential sector, including changes over time, and energy use, to be able to evaluate whether strategies can achieve the results envisaged (Wyatt, 2013).

Many buildings are registered for their heritage significance; in Australia, the most recent published estimates suggest that there are 14,148 historic-listed places at the state and territory level, and more than 76,000 individual historic places and an estimated 160,000 buildings in 1,770 historic heritage areas at the local level (Productivity Commission, 2006). Older buildings are perceived as operating very inefficiently with poor energy performance (Australian Greenhouse Office, 2000; Clarke et al., 2009; Department of Sustainability and Environment, 2006; Pearce, 2003). On the other hand, it is argued that conserving heritage buildings has significant environmental and other
advantages which include minimising use of resources. Adapting and extending lifespans of existing buildings offsets the need to use virgin materials, with savings in embodied energy (energy used in their manufacture and construction). They also represent social and cultural value for the community (Amoeda and Pinheiro, 2007; Avrami et al., 2000; Balderstone, 2004; Brooks et al., 1997; Cassar, 2009; Nijkamp and Riganti, 2008; Rodwell, 2007).

Different views exist on how to address the tension between environmental aspirations and cultural heritage conservation. Boardman (2007) focuses on the construction of new dwellings and demolition of the older residential stock that do not perform efficiently to achieve a 60 per cent reduction in carbon emissions in the UK housing stock by 2050 (Boardman, 2007). This approach has been criticised by others, for example by Lowe (2007) and Power (2008), for failing to take into account the positive attributes of the existing dwelling stock, and for unsupported assumptions regarding the performance of new dwellings. An alternative strategy, focusing on upgrading the existing dwelling stock is advocated by Lowe and others, including Itard (2007), Plimmer et al. (2008) and Kohler and Yang (2007). In comparing different strategies over extended periods of time, Kohler & Yang (2007) claim that regular renovation strategies are preferable to demolition and redevelopment, thus supporting Lowe’s approach. It would appear that there is potential to make a substantial contribution to the reduction of environmental impacts through renovation (Meijer et al., 2009; Urge-Vorsatz et al., 2007). However, as noted by Lomas (2010), strategies for reducing energy and related emissions in building stocks are not without issues, and need to be examined closely.

Previous research in this domain has predominantly focused on the environmental performance of new build (for example, Clune et al., 2012; Moore, 2012; Saman et al., 2011), the types of energy saving behaviours engaged in by householders (Oliphant, 1999), their attitudes and opinions
towards the environment (Fielding et al., 2009) and strategies for demand management (Red Jelly, 2008; Strengers, 2009). Previous studies on renovation of the dwelling stock take a quantitative approach, focusing on the types of interventions and products used in home renovations (for example, BIS-Shrapnel and Commonwealth Dept. of Housing and Regional Development, 1994; Sustainability Victoria, 2010). Little qualitative research has been conducted on home-renovation activities, and how this relates to everyday household practices and energy consumption. Further, previous research does not address the empirical gap that exists between environmental performance and conservation of heritage significance.

In seeking to address how the objectives of environmental performance can be achieved alongside conservation of heritage significance, this research explores home-renovation through the eyes of the homeowner to analyse how these competing objectives are accomplished.

1.2 Research question

The principal research question is:

In what ways is cultural heritage significance in contention with objectives for environmental performance and other changing priorities for home improvements, and how are these potentially conflicting objectives reconciled through home-renovation practice?

Based upon empirical research directly relevant to Victoria, Australia, the primary benefit of this inquiry is to development of policy in Victoria. However, the outcomes may reasonably be expected to be relevant to other states and territories in Australia, and may be applicable more widely to those jurisdictions that have an established residential stock with a large proportion of older heritage dwellings, and are seeking to reduce energy and environmental impacts. This thesis identifies critical issues for future policy
development in optimising energy performance of heritage housing within the Australian context. Furthermore the critical application of social practice theory (SPT) in this research contributes to the emerging field of SPT.

1.3 Aims and scope of the research

This aims of this research are to:

- examine the potential of current strategies for home-renovation for effecting positive changes in household energy consumption and associated environmental performance;
- investigate homeowner renovation practices in existing dwellings with heritage significance and how these are related to environmental concerns, household energy use, and other priorities for home improvements;
- analyse how home-renovation practices are shaped, and the implications for environmental performance and heritage significance.

1.4 Definitions and context

The focus of this research is on the potential for improving energy performance of existing dwellings through renovation. Despite having somewhat different definitions in heritage management (see further discussion in section 3.3.1), the terms refurbishment, retrofitting and renovation are generally used interchangeably in the built environment literature (Mansfield, 2002) and by organisations involved in reducing the energy use and carbon emissions of the existing housing stock. Douglas (2006: 1) observes that ‘in the world of building the terms “rehabilitation”, “conversion”, “remodeling” “restoration”, “reinstatement” and so forth are unhappily confused’. Essentially, the differences between the various terms relate to both the extent and the nature of the change and intervention they describe. In the model posited by Douglas (2006) reproduced in section 3.3.4 of this thesis, rehabilitation and
renovation involve more extensive work than refurbishment, which is seen as more superficial (i.e. a facelift or makeover). The term rehabilitation is interpreted as modernisation elsewhere (Douglas, 2006; Feilden, 2003). Refurbishment is also accepted as a proxy for rehabilitation to describe work to modify an existing building (Mansfield, 2002). Mansfield discusses the scope of refurbishment which is more often applied within the context of commercial buildings, and defined as ‘the extensive repair, renewal and modification of a building to meet economic and/or functional criteria equivalent to those required of a new building for the same purpose’ (Royal Institution of Chartered Surveyors (RICS), 1996). In comparison, renovation usually encompasses an element of upgrading or improvement in order to meet current standards and regulations; and may involve the introduction of new elements or partial demolition to remove elements which are unsafe, functionally redundant, create maintenance problems, outdated, or limit a viable use (RICS, 1996). Simple renovation is equated with insulating walls or replacing single glazing with double-glazing (Itard and Klunder, 2007), although can be extensive.

Elsewhere, the term retrofitting is used to describe undertaking modifications to the exterior envelope; equipment, lighting, appliances; management and control systems to improve the performance of buildings (Nilsson, 1996; Urge-Vorsatz et al., 2007). Whilst retrofitting incorporates new technology to meet new requirements or to provide performance not foreseen in the original design (Iselin and Lemer, 1993), or components that were not available at the time of the original construction (Ashworth, 1997) such as installation of solar hot water, solar electricity, heating and cooling systems, or grey water recycling systems. Accordingly, retrofitting is considered as part of broader renovation activities (Bernier et al., 2010; Itard, 2007). Given the wide usage and to avoid misunderstanding, for the purposes of this study the umbrella term renovation is used to describe those activities involving altering or modifying a dwelling to improve some aspect of environmental performance, and may also incorporate some element of upgrading, internal reconfiguration
or extension, and retrofitting new devices or systems. Thus renovation covers modernisation, retrofitting, refurbishment, rehabilitation, and other activities that go beyond maintenance.

The context for this research is the State of Victoria, Australia. The Victorian government was the first state to enact heritage legislation in Australia, and a well-established framework exists for heritage protection at state and municipal government levels (Pearson and Sullivan, 1995). Within the state of Victoria, there are over 2,200 individual historic heritage places registered at the state level, and an estimated 160,000 places at local government level. The building regulation system in Victoria, developed during the 1990’s into a leading model for other Australian States and Territories (Productivity Commission, 2004), is at the forefront of policy to improve energy performance of buildings in Australia.

This research concentrates on residential dwellings for a number of reasons: there are currently over 2.1 million dwellings in Victoria (Australian Bureau of Statistics, 2012c) and these form the largest proportion of the building stock in Victoria, in terms of numbers; in terms of energy consumption, residential buildings are significant consumers of energy in Australia (Energy Efficient Strategies and Department of the Environment Heritage and the Arts, 2008; Bureau of Resources and Energy Economics, 2013); and until 2010, the building regulations for energy performance were focused almost exclusively on residential development. Major government initiatives seeking to reduce energy and CO₂ emissions such as the Green Loans programme have been directed at the general residential building stock, with the intent to improve environmental performance through upgrading and retrofitting.

Although building performance is wide ranging in scope (Hartkopf et al., 1986), it generally relates to the ability to fulfill both functional and technical requirements under intended use conditions (International Organization for
Standardization, 2008: 3.16). The term *environmental performance* is broadly defined as being related to environmental impacts and environmental aspects (International Organization for Standardization, 2008). In this thesis, the term *environmental performance* refers to specified objectives of environmental quality and resource use efficiency, namely energy and associated CO$_2$ emissions, as this is the focus of policy.

This study is primarily concerned with those dwellings that are formally recognised by heritage designation, where the significance is documented and values are specified. However, it is acknowledged that significance may include appreciation by a community where the heritage values associated with a particular place are not officially established. In accordance with the definition adopted by the ICOMOS Burra Charter (Marquis-Kyle and Walker, 2004), and Douglas (2006), active conservation of the built environment is interpreted in a broad sense to include not only repair, but also adaptation to meet contemporary standards, changing user requirements, and to suit new environmental conditions, economic or functional criteria that would be equivalent to those required of a new building for the same purpose.

Where appropriate, this thesis draws on literature from other jurisdictions and contexts outside Australia, including studies from countries within Europe, such as the UK. The UK housing system is dominated by home ownership and experiences significant reinvestment through renovation, as in Australia. Energy performance of housing has been a policy objective for some time, linked to the European Energy Performance Building Directive (Directive 2002/91/EC, EPBD) introduced in 2003 to improve the energy efficiency of the housing stock (Sunikka, 2006), and recast in 2010 (Directive 2010/31/EU).

The UK government is pursuing a low carbon strategy and announced proposals for all UK homes to have ‘almost zero’ carbon emissions by 2050 (Jha, 2009) as part of a broader target of an 80 per cent reduction in carbon
emissions by 2050, compared to 1990 levels (Committee on Climate Change, 2013). Following the Heat and Energy Savings Strategy (Department of Energy and Climate Change, 2009) the UK Government's strategy for saving energy and ‘decarbonising’ heating, the flagship Green Deal programme was launched in 2012 to implement energy efficiency improvements to the existing housing stock (Hickman, 2013; Department of Energy and Climate Change, 2010). The UK government is currently grappling with the issue of reducing energy use in existing dwellings. Of the 22.8 million domestic buildings in England, an estimated 22 per cent were built before 1919 (Department for Communities and Local Government, 2012), including over 500,000 heritage-listed buildings (Boardman, 2007; Boardman et al., 2005; Lowe, 2007; Shorrock et al., 2005) and, therefore, provides an interesting reference point.

1.4 Research strategy and methods

The research strategy can be conceptualised as a ‘methodological chain’ (Richards and Morse, 2007: 33) linking research purpose, research question, choice of method for data gathering, and the type of data needed. To address the research problems highlighted in this chapter, and based upon identified gaps discussed in more detail in Chapters 2–4 of this thesis, the following second-level questions guide the research:

(i) What is the meaning and significance of cultural heritage as applied to dwellings, and how does this relate to homeowner renovation practices?

(ii) By what means does current policy seek to improve environmental performance of existing buildings in Victoria?

(iii) What are the renovation practices of homeowners undertaking improvements in the context of heritage significance, environmental performance, and other motivations and aspirations?
The research strategy comprises several steps: first, an overview of the current state of knowledge relating to the residential dwelling stock in Victoria, energy use and renovation activities, based on existing sources of data. This provides the starting point for the research as well as informing the collection of data for the research. Next, prior to data collection, a review of academic and policy literature relevant to this subject is undertaken to identify key factors affecting energy consumption, and critical evaluation of current approaches to improving environmental performance of existing dwellings. From this, a conceptual framework is developed for analysing renovation practices in heritage dwellings, framed using a social practices theoretical approach grounded in the socio-technical tradition. The primary data collection involves in-depth analysis of a selected number of individual ethnographic case studies to understand homeowner renovation practices. Qualitative semi-structured interviews and home tours are employed to gain insight into home-renovation and obtain the views and experiences of homeowners seeking to improve energy efficiency and other aspects of environmental performance of their heritage dwellings. This method is appropriate for collecting in-depth data on homeowners’ experiences of renovation and understanding homeowners’ motives, practices, structural and other factors influencing the outcome.

Purposive sampling and snowballing (Robson, 2002) are used to recruit participants: homeowners are identified via various key organisations involved in housing and sustainability, namely local councils, state government, professional institutions and community groups, and invited to participate in an interview. Recruitment occurs until data saturation is reached (Richards & Morse, 2007). Interviews are conducted in home renovators’ dwellings and, where possible, carried out with a main interviewee and their life partner or spouse. Interviews include walk-through tours and photographs of the house, with agreement of homeowners. Walk-through home tours are recognised as a valuable mechanism for: (1) viewing the material infrastructures used in undertaking these practices; (2) prompting homeowners to elaborate further on their household practices in the context in which they are undertaken; and
(3) cross-checking, where possible, homeowners’ reported practices with evidence of their actual practices (Gram-Hanssen, 2010; Pink, 2005; Strengers & Maller, 2011). Home tours constitute an important prompting tool for discussion between the researchers and homeowners regarding renovation and other practices.

Interview questions prompt home renovators to provide details about: their dwellings (e.g. age of the dwelling, years of occupation, number of bedrooms, bathrooms, etc.); the renovation and retrofitting practices undertaken or planned, and why they were undertaken; strategies employed to improve efficiency; sources of information or advice; particular difficulties encountered; their ideas and concerns about the environment, energy use; and their other more routine practices in the home. Interviews are recorded with a digital voice recorder and transcribed verbatim. Transcripts are imported into qualitative data analysis software, together with other information relating to case studies including the researcher’s field notes, photographs, floor plans, magazine articles, planning reports and appeal decision notices, to facilitate analysis, and coded thematically to categorize: (1) the types of renovation practices homeowners engaged in; (2) the common understandings associated with renovation; (3) the ways in which materials (technologies, infrastructures) and social relationships moderate renovation; and (4) the ways in which household practices shape and are shaped by renovation. The analysis and interpretation of data is informed by social practice theory. Details of the research design and methods, together with reasoning for the choice of methods, are presented in Chapter 6.

1.5 Thesis outline

This thesis is organised into 10 chapters and these are briefly outlined in this section. As a starting point to the empirical enquiry, Chapter 2 provides an overview of the current state of knowledge of the existing residential building stock in Victoria, and renovation activity, focusing on the factors that influence
energy performance identified in the literature. Knowledge of the composition and dynamics of the existing dwelling stock and energy use is essential to understanding and optimising energy performance, and assists in informing the data collection and analysis. **Chapters 3, 4 and 5** provide the theoretical basis for the research by reviewing the relevant scholarly literature and previous studies relating to the research topic. The role of cultural heritage conservation in contemporary society is reviewed in **Chapter 3**. This chapter provides an understanding of the complex meaning of heritage, and the rationale for conservation of heritage buildings before going on to explore pertinent issues associated with the performance of the older building stock. A number of key theoretical concepts relating to the renovation of heritage buildings are presented. This is followed in **Chapter 4** by an outline of the policy context in Victoria, and critical evaluation of current approaches used to assess the environmental performance of existing buildings, and their relevance to buildings with heritage significance. Having discussed the limitations associated with existing technical and behavioural approaches, **Chapter 5** explores social practice theory (SPT) as an alternative approach to understanding home-renovation practices in heritage dwellings, and a conceptual framework is developed from key features identified in the international literature.

The methodological approach for addressing the knowledge gaps identified in the preceding chapters is explained in **Chapter 6**, which sets out the different steps of the research to achieve the research aims and answer the research question. In this research, qualitative research methods are employed, centred on interviews with homeowners: this allows for an in-depth study of homeowners’ renovation practices in a domestic setting from the homeowner’s perspective, and how this activity is implicated in heritage and environmental outcomes. In the conceptual framework thus developed, home-renovation is interpreted as a complex social practice, comprising loosely bounded entities constituted and reproduced through a series of components, these being: common understandings associated with renovation of heritage dwellings;
competences, including knowledge and know-how regarding what makes sense for someone to do; together with configurations of material infrastructures or ‘things’, such as the existing building, technologies, resources and systems of provision; and rules and procedures.

Taking an ethnographic case study approach, twenty-six homeowners undertaking renovations to twenty dwellings with heritage significance were selected for in-depth study. Primary data obtained from interviews with homeowners in Victoria are analysed and the findings are presented in Chapters 7 and 8. Drawing on the empirical findings from interviews with homeowners, the thesis examines how renovation in heritage buildings is currently composed and reproduced, and how renovation can be understood through the components of practice. Chapter 7 explores the different understandings associated with home-renovation, and how renovation practices intersect with daily household practices and homeowner aspirations. The focus is on those renovation practices that have implications for energy use, in particular the provision of services such as space heating and cooling to achieve comfort, hot water for bathing and household tasks, and integration of electrical appliances for cooking, laundering and other requirements. Chapter 8 analyses the different forms of knowledge and skills that are brought together in renovation, and how material components intermediate in renovation. The findings from this analysis are critical in understanding the key areas of interest around more efficient energy use and the part of renovation in achieving policy objectives. This detailed analysis also helps to identify areas of contention, together with opportunities for synergy. Having analysed how renovation is configured and reproduced, this thesis presents a case for social practices as an effective conceptual base for understanding home-renovation practices. The study reveals that the configuration of practice components influences energy performance and heritage outcomes.
The discussion in Chapter 9 responds to the second-level research questions, summarising the main arguments and discussing the key findings from the analysis of home-renovation practices in Chapters 7 and 8. The conclusions are presented in Chapter 10, together with the limitations of the research, the contribution to knowledge, and implications for policy, followed by opportunities for further research.

All tables and figures are produced by the author, unless indicated otherwise.
‘All buildings are predictions. All predictions are wrong.’

Stuart Brand, 1994 p. 178

2 The existing residential stock and renovations

To understand the nature of energy consumption and emissions associated with dwellings, it is asserted that better knowledge of the composition and dynamics of the existing building stock is critical to research in this domain (Kohler and Hassler, 2002; Wyatt, 2013). A review of the current state of knowledge on the existing dwelling stock and activities relating to energy
consumption is presented in this chapter, using data primarily drawn from the Australian Bureau of Statistics (ABS), and supplemented by other sources where available. This research focuses on permanent dwellings, and does not include temporary or other non-permanent structures such as caravans which are not subject to energy performance requirements laid down in the Building Code of Australia (BCA).

2.1 The challenge of the existing stock

Out of 8.6 million homes in Australia (Australian Bureau of Statistics, 2012d), it is estimated that a significant proportion will still be existence in 2050. Although new dwellings approvals have fluctuated in recent years, in 2010–11 the total number of dwelling unit approvals, added to the building stock was 163,052 (this includes new houses, new other residential dwellings and total dwellings) an annual increase of 1.9 per cent, and accounts for a relatively small proportion of the building stock in Australia (Australian Bureau of Statistics, 2013b). In common with other urbanised nations, the residential stock varies in age, condition and performance. Some 57 per cent of dwellings are more than 20 years old (Australian Greenhouse Office and Department of the Environment and Water Resources, 2007), constructed prior to the introduction of regulations to improve energy efficiency and without consideration of their environmental impact.

Of the 2.1 million dwellings in Victoria (Australian Bureau of Statistics, 2009c), based on property data collected in the statewide survey by the Valuer General of Victoria in 2008, an estimated 69 per cent of existing dwellings in Victoria were built before 1990, and 82 per cent before 2000. These existing homes are likely to remain in use for the next 50-80 years. According to the Victorian government, a high proportion of the existing housing stock hardly meets average energy efficiency standards; those built between 1994 and
2004 are estimated to have an energy rating of around 2 stars\(^1\), and those built prior to 1994 an energy rating somewhat less than this (Department of Sustainability and Environment, 2006). Many older buildings are perceived as being in poor condition and operating very inefficiently with high energy consumption (Clarke et al., 2009; Department of Sustainability and Environment, 2006; Pearce, 2003; Wilkinson and Reed, 2008). Therefore, government argues that many households in Australia may be ‘locked-in’ to poorly built and inefficient houses, with little control over the performance and energy emissions their homes produce.

According to official sources, the existing housing stock is responsible for 20 per cent of energy and an estimated 26 per cent of emissions in Australia (Department of Climate Change and Energy Efficiency, 2012a). By international standards Australia exhibits some of the highest levels of energy consumption per head of population (International Energy Agency, 2011). The household in its discrete dwelling setting has become a significant site for action and an important focus for policy makers in developing strategies to achieve improved environmental performance, driven by the climate change and sustainability agenda.

### 2.2 The residential stock and energy performance

Complexity arises from variations in physical form of the domestic stock, the location and climatic conditions to which it is subjected, previous upgrades, heating and cooling systems, appliance usage and the activities of the building occupants. Constructed over a period of time, there are many different building materials and techniques used, including stone and solid brick, timber and brick veneer wall construction which differ in their thermal performance. Within dwellings provision for space and water heating can vary widely in terms of

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\(^1\) The rating used to assess the energy performance of buildings is based on the energy used to heat and cool the house, and presented on a star rating scale from 1 to 10. A score of 6 stars or more indicates an energy-efficient home and a score of 10 stars is a highly efficient home.
types of systems, fuels used, and efficiency. Each building is subjected to local climatic conditions, including ambient air temperature and solar irradiation. In the technical literature household energy consumption is related to the design and construction of the building, in particular the floor area, the quality of the building envelope, the type and the efficiency of the heating and cooling systems, and the installed electrical appliances. As well as dwelling characteristics, the patterns of behaviour of occupants adds further complexity, with energy use dependent on the number of people in the household, their ages, income, occupancy patterns, and many other factors (Druckman and Jackson, 2008; Firth et al., 2010; Santamouris et al., 2006; Wyatt, 2013; Yohanis et al., 2008). Therefore, reliable information on the dwelling stock is important, together with an understanding of the nature of energy consumption activities of households.

As consumption of energy in the residential sector is deemed to be a significant contributor to Australia’s stationary energy and greenhouse gas emissions, it is imperative that development of response strategies is based on a well-informed understanding of energy consumption. Accordingly, a review of relevant information relating to the existing residential building stock and characteristics provides the starting point for this study.

### 2.3 Data sources on the existing housing stock

Data on the housing stock in Australia are distributed across various government surveys and national statistics. The Census provides basic information on the number and types of dwellings for states and territories and suburbs (Australian Bureau of Statistics, 2012d). The *Survey of Income and Housing* (SIH) includes information for Australian households on dwelling structure and condition (Australian Bureau of Statistics, 2009c). The *Australian Housing Survey* reports on the construction material and the building services provision for housing (Australian Bureau of Statistics, 1999). The
characteristics of Australian homes and implications for household energy use and greenhouse gas emissions are presented in *Energy in Focus; Energy Efficiency in Australian Homes* (Australian Bureau of Statistics, 2010d). Data on the quantum of work done in residential building, including alterations and additions, may be obtained from the quarterly *Building Activity Survey* (BAS) and *National Accounts*, both published by the Australian Bureau of Statistics (ABS). National statistics for energy consumption are available from the Australian government by fuel type at the national and state levels in *Energy Account* published by the ABS, and *Energy Update* published by Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES). Data in relation to how households use and conserve energy are available through *Environmental issues: Energy Use and Conservation Survey* (Australian Bureau of Statistics, 2008; 2011c) and to a more limited extent, through surveys such as the *Greenlight* survey of householders in Victoria (Sustainability Victoria, 2011).

As well as government sources this analysis is supplemented by published data from non-government sources including the Housing Industry Association (HIA). Data on the housing stock in Victoria is also drawn from the Valuer General of Victoria (VGV) unpublished dataset 2008, which is the most comprehensive survey available on the dwelling stock in Victoria and provided the most up to date property information available at the time. The next section considers the main sources of data and their limitations.

### 2.3.1 Census of Population and Housing

The Census of Population and Housing collects a range of demographic, social and economic information from all people and dwellings\(^2\) in Australia including the number of people, their key characteristics, and the dwellings in which they live. Conducted every five years, the most recent Census was conducted on 9 August 2011. Core demographic data items were released on

\(^2\) Excluding diplomatic personnel and dwellings.
21 June 2012 with other data requiring more detailed processing scheduled for release after this date. Whilst the census identifies numbers of dwellings in Victoria by type of structure (classified as separate house, semi-detached, unit or apartment, and other), and numbers of bedrooms, this does not provide detailed information about the age and construction of dwellings, which are important factors influencing energy performance (see section 2.4.2).

2.3.2 Australian Housing Survey

The most recent Australian Housing Survey was conducted between September and December 1999\(^3\) to report on the housing circumstances of Australians. Previous surveys covering similar material were known as National Housing Surveys, and were conducted in 1988 and 1994. Although these surveys collected information on dwelling characteristics including information on the physical characteristics and condition of dwellings, this is now dated, and many dwellings may have been upgraded or extended in the intervening period.

2.3.3 Building Activity Survey (BAS)

Statistical information on building activity is collected quarterly by state and territory for new residential buildings (houses and other residential), and alterations and additions to dwellings. Data series are shown in seasonally adjusted and trend terms, while the value of building work commenced and done is also shown in chain volume measures terms. The statistics are compiled using building approval details and returns collected from builders and other individuals and organisations engaged in building activity. However, the quarterly estimates only include residential building jobs valued at $10,000 or more. As the estimates for building activity (including alterations and additions) are based on a sample of approved building jobs, they are subject to sampling error; that is, they may differ from the figures that would have

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\(^3\) According to EES & DEWHA (2008) the last major survey of housing characteristics undertaken by the ABS (ABS 8212.0) was in 1986.
been obtained if information for all approved jobs for the relevant period had been included in the survey.

2.3.4 Australian National Accounts

A further important data series published by the ABS that can be used to observe the trend in alterations and additions is taken from the National Accounts measurement of Gross Fixed Capital Formation (GFCF) in dwellings where expenditure on fixed assets is broken down into two sub-categories: new and used dwellings, alterations and additions. The method used to calculate residential alterations and additions starts with the BAS. Since a significant proportion of alterations and additions are not captured in the BAS, it is used as a benchmark, which is then extended by use of estimates of expenditure on alterations and additions drawn from the Household Expenditure Survey (Dalton et al., 2008).

2.3.5 Rating Valuations Survey

The Valuer General of Victoria (VGV) oversees the collection of valuation data every two years by municipal authorities under the provisions of the Valuation of Land Act 1960 (as amended 15 December 2009). The statewide survey provides authoritative data on each individual rateable property in Victoria. As part of the valuation process, each property is surveyed and desk-based market valuations are undertaken. As part of the exercise, details about each building are recorded, including approximate date of construction, size, type of dwelling, construction materials and condition. Since this includes every residential dwelling and is based on a survey by a qualified valuer this data is likely to be more reliable than the ABS data. While the VGV 2008 dataset has a high level of coverage, it also has limitations. It does not include specific information on heritage status. The dataset contains millions of records with great variation in data formats, including inconsistencies in recording data. Analysis was undertaken as part of this study but not all records could be
successfully cleaned and classified, and there may be issues where records are not successfully reconciled. Nevertheless, analysis of this dataset has potential for providing an accurate and up to date profile of the composition and characteristics of built dwellings in Victoria.

2.4 Housing stock characteristics and energy performance

The impact of building characteristics on thermal performance and energy demand has been well studied, quantified and validated from building simulation and to a lesser extent, the monitoring of individual buildings. The literature on thermal performance and energy use identifies a relationship with the technical and architectural characteristics of a building (Table 2.1), notably size and type, age and construction of the building envelope, and related issues such as degree of insulation, infiltration, as well as heating, cooling and hot water systems and their use.
<table>
<thead>
<tr>
<th>Attribute affecting energy performance</th>
<th>Relevant research</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Building attribute</strong></td>
<td></td>
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<tr>
<td>Design of building envelope</td>
<td>Adalberth, 1997;</td>
</tr>
<tr>
<td></td>
<td>Beaumont, 2007;</td>
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<tr>
<td></td>
<td>Bell and Lowe, 2000; Catalina et al., 2008; Clune et al., 2012; Fay et al., 2000; Haas et al., 1998; Itard and Klunder, 2007; Lenzen et al., 2006; Meijer et al., 2009; Miller et al., 2012; Olofsson et al., 2009; Sardianou, 2008; Schuler et al., 2000; Summerfield et al., 2010; Yohanis et al., 2008</td>
</tr>
<tr>
<td>Construction Materials</td>
<td></td>
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<tr>
<td>Form/type</td>
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<tr>
<td>Dwelling size</td>
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<tr>
<td>Haapio and Viitaniemi, 2008; Meijer et al 2009; Building Research Establishment, 2007</td>
<td></td>
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<tr>
<td>Age of building/lifetime</td>
<td></td>
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<tr>
<td>Insulation</td>
<td>Guerra-Santin et al., 2009; Hens, 2010; Iyer-Raniga and Wong, 2012; Lowe et al., 2007; Mithraratne and Vale, 2004; Sanders and Phillipson, 2006; Sonderegger, 1978; Wyatt, 2013</td>
</tr>
<tr>
<td>Thermal bridging</td>
<td>Adalberth, 1997;</td>
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<td></td>
<td>Hong et al., 2006; Killip, 2011; Johnston et al., 2010; Bell &amp; Lowe, 2000</td>
</tr>
<tr>
<td>Infiltration/air tightness</td>
<td>Adalberth, 1997;</td>
</tr>
<tr>
<td>Ventilation</td>
<td>Banfill et al., 2012; Cavallo, 2005; Clarke et al., 2009; Liddament and Orme, 1998; Hubbard, 2011; Johnston et al., 2005; Kordjamshidi et al., 2006; Meijer et al., 2009; Shipworth, 2011</td>
</tr>
<tr>
<td>Space heating/cooling and hot water systems</td>
<td>Bell &amp; Lowe, 2000; Meijer et al., 2009; Hong et al., 2006</td>
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<tr>
<td>Lighting and appliances</td>
<td>Harrington et al., 2008; Hens 2010; Wall and Crosbie, 2009</td>
</tr>
<tr>
<td>Energy type</td>
<td>Peuportier, 2001; Lowe, 2007; Itard &amp; Klunder, 2007; Ortiz-Rodriguez et al., 2010; Harrington et al., 2008; Meijer et al., 2009</td>
</tr>
<tr>
<td>Occupants</td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td>Druckman and Jackson, 2008; Guerra Santin et al., 2009; Lenzen et al., 2006; Sardianou, 2008; Schuler et al., 2000; Wyatt, 2013</td>
</tr>
<tr>
<td>Household size</td>
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<td>Income</td>
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<td>Occupant behaviour</td>
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<td>Household practices</td>
<td></td>
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<tr>
<td>Other</td>
<td>Catalina et al., 2008; Haas et al., 1998</td>
</tr>
<tr>
<td>Climate</td>
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</tr>
</tbody>
</table>
2.4.1 Size and type

It is generally accepted that physical characteristics of dwellings influence household energy consumption. Empirical studies indicate that size of dwellings is strongly related to energy use for heating and cooling (Clune et al., 2012; Summerfield et al., 2010; Yohanis et al., 2008). Although Miller et al., (2012) argue that house size is not of itself an indicator of thermal performance (heating and cooling energy demand).

According to building approvals data, there has been a steady increase in the average floor area of residential dwellings in Australia. Over the period 1984-85 to 2008-09 the average floor area of all new residential dwellings increased from 149.7 to 218.9 sq. metres, an increase of 46 per cent. Data collected by the ABS indicates that the floor area of new houses has risen from 162.4 to 248.0 sq. metres (an increase of 53 per cent) (Australian Bureau of Statistics, 2010c), with new homes built in Victoria having an average floor area of 249.5 sq. metres, the third largest after New South Wales and Queensland (Australian Bureau of Statistics, 2009b), significantly exceeding that of the stock average, thereby driving up the average floor area of the stock of dwellings as a whole over time (Energy Efficient Strategies and Department of the Environment Heritage and the Arts, 2008). Further, this and a previous study by BIS-Shrapnel and Commonwealth Dept. of Housing and Regional Development (1994) also recognises that home-renovations are increasing the floor area of existing dwellings—particularly the older detached dwellings—with the average increase in floor area of 48.8 m² for additions in 1992 (51.4 m² in Victoria). Between 1975–76 and 2007–08, the average dwelling size increased from 2.8 to 3.1 bedrooms (Australian Bureau of Statistics, 2010a). In 2009–2010 31 per cent of households were living in a dwellings with four or more bedrooms, up from 15 per cent in 1971 (Australian Bureau of Statistics, 1995; 2012d). As noted by Petchey (2010) and others, the increase in the size of dwellings is one of the key determining factors identified as contributing to higher energy demand and environmental impacts. However, there remains a lack of detailed data on the characteristics of the older dwelling stock.
Dwelling type is often included in studies of energy consumption, and variation in dwelling type (detached, semi-detached or terraced house, or apartment, for example) has been shown to have a correlation with energy use (Guerra-Santin et al., 2009); and energy demand for heating is related to shape (i.e. the ratio between the heated volume of the building and the sum of all heat loss surfaces) Catalina et al., 2008). Druckman and Jackson (2008) claim that the type of dwelling is one of the major factors affecting the energy performance along with the level of energy-saving measures installed. Whilst others argue that dwelling type has a small influence on energy use (Hinnells et al., 2007; Johnston et al., 2005; Schipper et al., 1989). However, there are associations between dwelling type and size (Yohanis et al., 2008), and the amount of heat-loss surface area available to a building (Hong et al., 2006; Schuler et al., 2000), as well as reflecting income and household size (Lutzenhiser and Bender, 2008; Poulsen and Forrest, 1988), which have been shown to influence energy use.

Detached dwellings remain the predominant dwelling type in Australia. Of the 5.7 million households that owned their own home in 2009–10, 88 per cent lived in separate houses (Australian Bureau of Statistics, 2012d). As well as having greater potential for thermal transmittance through external walls and roof (Shorrock and Uttley, 2003), detached dwellings are responsible for higher energy consumption relating to space heating and appliances (Firth et al., 2010; Shipworth et al., 2010), as they tend to be larger than other dwelling types. The observation is also made that the potential for extensions tends to be much greater in detached dwellings than in most other dwelling types. Thus contributing further to energy use.

2.4.2 Age and construction

Within the engineering disciplines research indicates that thermal performance of dwellings, and energy used for heating and cooling, is related to its physical
characteristics including age and construction. Data on the age and typology of the stock are considered as essential factors with regard to the energy performance of dwellings and energy-saving potential (Meijer et al., 2009). Thus performance also depends on the extent to which these dwellings have been renovated, for example through installation of insulation. The extent and nature of renovation activity is discussed further in section 2.7.

The total number of private dwellings in Victoria is 2,191,431 including unoccupied dwellings (Australian Bureau of Statistics, 2012d), with 1.51 million located within Melbourne Major Statistical Region (Metropolitan Melbourne) and the remaining 590,000 households in Balance of Victoria Major Statistical Region (regional Victoria). An estimated 96 per cent of dwellings are more than 2 years old (Australian Bureau of Statistics, 2009c). The Household Water, Energy Use, and Conservation Survey (ABS, 2009) subdivides the residential dwelling stock into age groups of 2 years old or less, and more than 2 years old, and does not provide further detailed breakdown. Since there does not appear to be any recent published survey data on the age of the dwelling stock, a breakdown of the age distribution for the state of Victoria was derived from the VGV 2008 dataset and this is shown in Figure 2.2. Analysis of property data collected by the Valuer General of Victoria in 2008 reveals that the earliest dwellings in the state date from the 1830s, with around 1.5 million (69 per cent) built before 1990 and the introduction of regulations for insulation to improve thermal efficiency in 1991. An estimated 82 per cent of the building stock was built before 2000, prior to the introduction of increased standards for energy performance in the Building Code of Australia.
Figure 2.2 Age distribution of dwellings in Victoria

Source: derived from the Valuer General of Victoria dataset, 2008

Notes:
(a) As 53,971 dwellings were not classified by age, these are not included in the above totals.
(b) Drawing on the property valuations database, the total existing housing stock in Melbourne as at 2008 consisted of just over 1.5 million (1,507,521) dwellings. Differences between this figure and the 2011 Census figure on households in private dwellings include the coverage of all dwellings—a larger figure than occupied private dwellings in the Census, and including vacant and non-private dwellings—and the difference in timing of the valuations data (2008 compared to 2011) with increase in the intervening period.

There is a lack of reliable data for construction types used for dwellings in Victoria. The most detailed breakdown of dwelling structure provided by the ABS is contained in the Environmental Issues: Energy use and conservation, Mar 2008 (Australian Bureau of Statistics, 2008) based on survey data from 12,965 households, and the data for Victoria is reproduced in Table 2.2.
Table 2.2 Dwelling structure, Victoria: Main material of outside walls

<table>
<thead>
<tr>
<th>Construction Type</th>
<th>Capital city ('000)</th>
<th>Balance of state ('000)</th>
<th>Total state ('000)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brick</td>
<td>957.6</td>
<td>299.8</td>
<td>1,257.4</td>
</tr>
<tr>
<td>Brick veneer</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Reverse brick veneer</td>
<td>210.5</td>
<td>42.8</td>
<td>253.3</td>
</tr>
<tr>
<td>Double brick</td>
<td>4.6</td>
<td>14.9</td>
<td>19.5</td>
</tr>
<tr>
<td>Stone</td>
<td>182.0</td>
<td>141.6</td>
<td>323.6</td>
</tr>
<tr>
<td>Fibre cement</td>
<td>66.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Concrete/besser blocks</td>
<td>45.2</td>
<td>6.3</td>
<td>51.5</td>
</tr>
<tr>
<td>Steel/aluminium</td>
<td>5.5</td>
<td>13.2</td>
<td>18.7</td>
</tr>
<tr>
<td>Aerated concrete</td>
<td>0.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>15.8</td>
<td>10.2</td>
<td>26.0</td>
</tr>
<tr>
<td>Did not know</td>
<td>11.0</td>
<td>5.5</td>
<td>16.4</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>1,456.2</td>
<td>600.3</td>
<td>2,056.5</td>
</tr>
</tbody>
</table>

Proportion (per cent)

<table>
<thead>
<tr>
<th>Construction Type</th>
<th>Capital city (%)</th>
<th>Balance of state (%)</th>
<th>Total state (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brick</td>
<td>65.8</td>
<td>49.9</td>
<td>61.1</td>
</tr>
<tr>
<td>Brick veneer</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Reverse brick veneer</td>
<td>14.5</td>
<td>7.1</td>
<td>12.3</td>
</tr>
<tr>
<td>Double brick</td>
<td>0.3</td>
<td>2.5</td>
<td>0.9</td>
</tr>
<tr>
<td>Stone</td>
<td>12.5</td>
<td>23.6</td>
<td>15.7</td>
</tr>
<tr>
<td>Fibre cement</td>
<td>11.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Concrete/besser blocks</td>
<td>3.1</td>
<td>1.1</td>
<td>2.5</td>
</tr>
<tr>
<td>Steel/aluminium</td>
<td>0.4</td>
<td>2.2</td>
<td>0.9</td>
</tr>
<tr>
<td>Aerated concrete</td>
<td>0.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>1.1</td>
<td>1.7</td>
<td>1.3</td>
</tr>
<tr>
<td>Did not know</td>
<td>0.8</td>
<td>0.9</td>
<td>0.8</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
</tr>
</tbody>
</table>


Notes:

Figures highlighted have a relative standard error of 25 to 50 per cent and therefore should be treated with caution.

The main construction types for dwellings in Victoria is brick veneer (61 per cent), double brick (12 per cent), and timber (16 per cent). The construction types associated with older, heritage dwellings are double brick, timber, stone and fibro cement which account for around 34 per cent of the dwelling stock. The trend over time has been towards greater use of brick veneer which
became the most common wall construction after the Second World War (Lewis, 1999). Later (Mar 2011) ABS data available on dwelling construction categories are simplified into just five main construction materials: brick (brick veneer, double brick and other); timber; fibro cement; concrete and other. Stone (which represents about 1 per cent or 19,500 dwellings) is not listed in the 2011 data, and steel, aluminium and aerated concrete are included within Other. The shares are similar to 2008, with the composition of Victorian dwellings about 73 per cent brick, 17 per cent timber (mainly weatherboard), and 4 per cent fibro cement (Australian Bureau of Statistics, 2011c).

Inconsistency is noted in recording and analysis of dwelling construction characteristics between the different data sources. The simplified classification used by ABS of five predominant wall construction types varies from the coding adopted for the building shells employed in the study by Energy Efficient Strategies and Department of the Environment Heritage and the Arts (2008); this housing stock model uses combinations of various construction types to match known variants within the stock to estimate residential energy consumption, where wall construction types are categorised as: lightweight (including construction in fibre cement, timber aluminium, steel or curtain glass); heavyweight (double brick); and brick veneer, and floor types are subdivided into: timber and concrete. Dwelling construction in the VGV dataset is recorded variously by surveyors, and represented by over 60 different combinations and multiple codes. Analysis of dwelling construction in the VGV dataset would be assisted by a more standard classification of materials (similar to that used in the Australian Bureau of Statistics, 2008), and more consistent coding.

Insulation is generally regarded as an important element of energy efficient buildings. Although statistical data is available on the share of dwellings in Australian states and territories with insulation (Australian Bureau of Statistics, 2008; 2009c; 2011c; 2012c), there is limited information on the nature and
degree of insulation. The proportion of Australian households with insulation has reportedly increased from 61 per cent in 2008 to 69 per cent in 2011, and in Victoria, this figure rose from 72 to 76.5 per cent (Australian Bureau of Statistics, 2011c). The most recent data released by the ABS indicates that 75 per cent of households in Victoria have insulation installed and, of these, 99 per cent (1.4 million) had insulation in the roof, 34 per cent (474,400) had insulation in the walls and 2 per cent (33,500) had insulation in the floors. However, insulation varies depending on the age, dwelling type and tenure (Australian Bureau of Statistics, 2012c). Data collected in the *Energy Use and Conservation Survey* conducted throughout Australia in March 2011 is an estimate based on survey of 12,841 households collected by either a face-to-face or telephone interview, not an inspection. The most recent ABS data is analysed from 4,624 households in Victoria collected over a two-week period during October 2011. Both surveys are subject to sampling and non-sampling errors. The increase in insulation is partly attributed to take up of incentive programmes such as the Commonwealth Government’s *Energy Efficient Homes Package*, which commenced in 2009. This scheme, which provided subsidies for the installation of ceiling insulation and solar and heat pump hot water systems to replace electric storage systems, was terminated prematurely in 2010 due to concerns about safety and standards of workmanship in installation. Although an estimated 11 per cent of Australian households indicated they installed insulation because of the rebate that was offered, 70 per cent indicated that their main reason for doing so was to 'achieve comfort' (Australian Bureau of Statistics, 2011c). The reasons given by householders in Victoria for installing insulation are shown in Figure 2.3. These are, for comfort, building regulations, and to save on energy bills, although the significance varies depending on household characteristics (Australian Bureau of Statistics, 2012c).
2.5 Residential energy consumption: trends and key issues

Having presented above an overview from the data on the physical characteristics of the existing residential stock, we now turn to energy consumption data and key issues relating to residential energy use.

Energy use is an important physical indicator in ascertaining the use of resources and reducing environmental impacts (Lenzen et al., 2004), and has become the focus of policy for reducing emissions associated with buildings. Therefore, for this study, energy is considered a suitable indicator in the environmental assessment of buildings due to the relationship between energy demand and other environmental indicators (Szalay, 2007).
The following section examines the trends in residential energy consumption, mainly from published data, where this relates to household practices including renovation activities.

2.5.1 Trends in energy consumption

Energy consumption in Australian residential buildings has been increasing over the last two decades. In 1989-90 household energy use accounted for 313 PJ (Akmal and Riwoe, 2005; Sandu and Petchey, 2009). Household energy use increased from 997 PJ in 2008-09 to 1,015 PJ in 2009-10, a rise of 2 per cent (Australian Bureau of Statistics, 2011b). Households accounted for 26 per cent of domestic energy use in 2009-10 (Australian Bureau of Statistics, 2011b). The evidence collated by ABARES using the Australian Energy Statistics (AES) database, indicates that Australia’s total final energy consumption is estimated to have increased by 1.4 per cent to 3,703 petajoules in 2009–10 (Schultz and Petchey, 2011). The difference is due to variations in how energy consumption data is estimated.

In Australian households, space heating and cooling represents 40 per cent and domestic water heating almost 26 per cent of the energy demand of residential buildings; household appliances such as refrigerators, separate freezers and dishwashers account for almost 20 per cent of household electricity usage. As indicated in Figure 2.4 the largest growth has been in standby power, space cooling, lighting and appliances (Petchey, 2010).
Energy efficiency in Australian households is examined in the release *Energy in focus* (Australian Bureau of Statistics, 2010d) using data from the *Energy Account 2009-10* (Australian Bureau of Statistics, 2011b) and environmental household survey published in *Environmental Issues: Energy Use and Conservation*, (Australian Bureau of Statistics, 2008; 2011c), as well as data from the *Australian Demographic Statistics*, (Australian Bureau of Statistics, 2013a) and *Household and Family Projections, Australia* (Australian Bureau of Statistics, 2004; 2010e). This release outlines the following key factors in energy use: the size and characteristics of Australian homes (focusing on number of bedrooms, main construction materials of outside walls, existence of insulation, and window treatments), heating and cooling, lighting, and use of household appliances. It also discusses the use of renewable and green energy sources, and the measures commonly adopted by households to, such as the presence of installation, or double-glazing. The report notes that, despite efforts to improve energy efficiency, household electricity use per person rose 19 per cent throughout the period 2001–02 to 2006–07. This increase is attributed to structural and activity effects including larger dwelling...
sizes, decreasing average household size, more appliances and IT equipment per household as well as the increased use of heaters and coolers.

More recently, *Environmental Issues: Energy Use and Conservation survey* (Australian Bureau of Statistics, 2011c) collected a range of information from 12,841 households using either face-to-face or telephone interviews on factors which can affect how much energy a household consumes including dwelling type, the type of insulation a dwelling has and the number and types of electrical appliances within the household (including computers), and the sources of energy used by households. However, some estimates derived from this survey are subject to large sampling and non-sampling errors and therefore are unreliable. Neither of these publications specifically addresses the renovation of dwellings and impact on energy consumption.

Despite improvements in energy efficiency, overall end use energy consumption in the residential sector continues to rise. In analysing energy consumption in the Australian residential sector, Petchey (2010) identifies key factors underlying the trends in energy consumption by disaggregating changes in energy consumption into three components: a structural effect, an activity effect, and an efficiency effect. The structural effect refers to changes in the number and size of households (dwelling floor area per person) in terms of changes in household occupancy for lighting; changes in appliance ownership for various appliances, including space heating and cooling; and other end uses. The level of activity in the residential sector reflects population growth in the number of households and a reduction in average household occupancy from 2.8 people per household in 1989–90 to 2.6 people per household in 2007–08 has resulted in an average increase in household energy consumption of 21 petajoules. The efficiency effect refers to the energy intensity for each end use, defined as either energy use per appliance, energy use per unit of floor area or energy use per household, and is used as an indicator of energy efficiency. The decline in energy intensity in the residential
sector is attributed to efficiency improvements related to technological advances and fuel switching, resulting in a reduction in energy use of 0.2 per cent a year in the residential sector between 1989–90 and 2007–08, leading to energy savings of 17 petajoules. Most of these savings were made in water heating, refrigerators and the use of more efficient major electrical appliances, but were partially offset by increases in energy intensity in various electrical appliances and standby power. Factors considered to influence energy intensity trends are household income, adoption and increased penetration of new technology, energy prices and government policies (Petchey, 2010).

Despite improvements in ‘efficiency’, overall energy consumption in the residential sector grew by 36 per cent from 1989–90 to 2007–08, increasing at an average annual rate of 1.7 per cent between 1989–90 and 2007–08, and is currently increasing moderately at 1.2 per cent per year (Schultz and Petchey, 2011). Sections 2.5.2 – 2.5.4 consider the key issues for energy consumption in relation to renovation of existing dwellings.

2.5.2 Size v. efficiency

As indicated in section 2.4.1 and 2.5.1 the size of dwellings has increased with implications for energy demand. Despite the introduction of minimum performance standards in all jurisdictions to improve thermal performance of the building envelope and reduce energy demand for heating and hot water, improvements in efficiency have been outpaced by the rate of increase in average floor area of dwellings. Given the large size of Australian dwellings, which have increased in floor area from 160 sq. metres in 1985 to 243 sq. metres in 2009 (James, 2009), it is perhaps unsurprising that Australian households exhibit some of the highest levels of energy consumption by international standards (International Energy Agency, 2011; Vasek, 2009). Energy consumption is linked not only to the construction of new, larger dwellings, but also adding extra floor space to existing dwellings (Energy
Efficient Strategies and Department of the Environment Heritage and the Arts, 2008; James, 2009; Wright, 2008).

Industry data confirms that home renovation or improvement activity has risen rapidly over the last two decades and is widespread (Dalton et al., 2008; Housing Industry Association (HIA) Economics Group, 2011), with additions and internal alterations accounting for around 36 and 23 per cent respectively of renovations activity by value (BIS, 1994). As part of the strategy to reduce energy demand within the residential sector, regulations for minimum standards of energy performance were introduced for alterations to existing dwellings in 2008. These relate to the thermal transmittance of the envelope and efficiency of heating and hot water systems. The trend for renovation activity is likely to be assisted by Australian Government-sponsored policy work for significant improvement to energy efficiency of dwellings (Dalton et al., 2011). Even so, additions and internal alterations are likely to have implications for energy consumption.

2.5.3 Heating, cooling and hot water

Energy used for space heating is a significant factor in the energy performance of the dwelling stock. Space heating demand is related to heat transmission losses, ventilation and air infiltration (determined by the building fabric and build quality, and ventilation system), and by the efficiency of the heating system used (Clarke, 2001). However, energy use for space heating is also increasingly recognised as influenced by the actions of householders (for example, Guerra Santin et al., 2009; Gram-Hanssen, 2010; Guerra Santin & Itard, 2010; Hens, 2010; Hong et al., 2006; Shipworth et al., 2010; Sonderegger, 1978; Steemers & Yun, 2009).
Electricity continues to be the main source of energy for space heating for 37 per cent of households in Victoria, followed by gas (32 per cent) and wood (10 per cent). While wood and gas has decreased slightly as the main source of energy, use of electricity increased between 2005 and 2011 (up from 32 per cent) (Australian Bureau of Statistics, 2012c). Households in rural areas that are not on the gas network are reliant on electricity for space and water heating. The main reason for choice of heater across all forms of heating is ‘comfort/convenience’ (reported by 42 per cent of Australian households). Cost/price, savings in energy bills and energy efficiency were also important. Environmental reasons were cited by just 1.2 per cent of households (Australian Bureau of Statistics, 2012c). The desire for comfort is reflected in the increasing share of dwellings with heating and cooling (Australian Bureau of Statistics, 2011c). In winter, 19 per cent of Victorian households heat the entire house, not just rooms that are in use, with 28 per cent of households setting the heating thermostat above 20°C. In summer, 36 per cent of..
households use a cooling system setting of 25°C or less (Sustainability Victoria, 2011). The extensive use of energy for space heating and the higher heating load from the cooler climate is the major contributor to Victoria having the highest energy consumption of any state in Australia (Energy Efficient Strategies and Department of the Environment Heritage and the Arts, 2008). Accompanying this desire for thermal comfort, the share of dwellings with space cooling has risen significantly. In just over 40 years, residential air-conditioning penetration in Victorian households has grown from virtually nothing to 64 per cent, with rapid growth from 1999 (Energy Efficient Strategies, 2006). The existence of insulation does not appear to have a significant impact on air conditioner usage during the summer months.

As noted in section 2.5.1, water heating is the second largest use of energy out of all household end uses. The main source of fuel for water heating in Victoria is gas (66 per cent), followed by mains electricity (28 per cent), solar (3.8 per cent) and wood (1.8 per cent) (Australian Bureau of Statistics, 2012c). Solar hot water systems tend to be installed in new dwellings, with 17.5 per cent of dwellings less than 2 years old having solar hot water compared to 3.8 per cent of households across the older dwelling stock (Australian Bureau of Statistics, 2009c). According to the most recent data, 4.8 per cent of older dwellings have solar hot water (Australian Bureau of Statistics, 2012c).
2.5.4 Electrical appliances

Together with heating and cooling and hot water, appliances constitute the majority of the energy and greenhouse gas emissions from Victorian households’ energy use (Department of Sustainability and Environment, 2006). Relevant sources pointing to trends in energy consumption by major end use indicate that electrical appliances dominate total energy consumption, with rising electricity consumption linked to an increase in appliance ownership (Australian Bureau of Statistics, 2011c; Energy Efficient Strategies and Department of the Environment Heritage and the Arts, 2008; Petchey, 2010). Refrigeration is a major energy use in households (George Wilkenfield & Associates, 2008), along with ICT (International Energy Agency, 2009). In 2009 26 per cent of households in Victoria reported having two or more refrigerators (Australian Bureau of Statistics, 2009c). In a survey of 2,160 Victorians in 2010, almost half (49 per cent) reported using more than one fridge or stand-alone freezer. The largest growth is in ICT and entertainment and 62 per cent of households in Victoria have more than one television set,
with a marked increase in plasma and LCD screens between 2008-2010. The number of computers per household is higher in 2010 than in 2009, with 19 per cent having three or more, compared to 15 per cent in 2009 (Sustainability Victoria, 2011). Although there is much data on numbers and distribution of household appliances, this does not explain the underlying reasons for acquirement and use.

Mandatory energy efficiency labelling has been implemented for a variety of electrical appliances including refrigerators, washing machines, dishwashers, and air conditioners, and energy star rating was a factor considered by over half of households purchasing refrigerators, dishwashers and clothes dryers in the year ending March 2011. In comparison, only one-third of households purchasing a heater or an air conditioner considered energy star ratings (Australian Bureau of Statistics, 2012d), which suggests that other considerations take priority. Even though household appliances are a significant and growing contributor to energy demand, energy for cooking and electricity consumption for household electrical appliances (other than space heating) is excluded from energy performance ratings of dwellings. However, some models predicting energy and emissions do include use of appliances.

2.6 Housing environmental performance: predictive models

Housing stock models are used widely to predict energy consumption and associated emissions based on various building and demographic variables (for example, Firth et al., 2010; Hinnells et al., 2007; Johnston et al., 2005; Mata et al., 2010; Meijer et al., 2009; Nemry et al., 2010; Peacock et al., 2008; Shorrocks et al., 2005). Swan and Ugursal (2009) identify two distinct methodological approaches for modeling residential sector energy consumption by: a top-down approach utilizes historic aggregate energy values and regresses the energy consumption of the housing stock as a function of top-level variables such as macroeconomic indicators, energy price, and general climate; and a bottom-up approach extrapolates the
estimated energy consumption based on a representative set of individual houses to regional and national levels, and consists of two distinct methodologies: the statistical method and the engineering method. Each technique relies on different levels of input information, varies in the calculation or simulation techniques used, and provides results with different applicability.

A bottom-up end use model was used to estimate energy consumption in the Australian residential sector (Energy Efficient Strategies and Department of the Environment Heritage and the Arts, 2008) employs. This study draws upon available data to establish a profile of housing in Australia to estimate energy consumption at a state level from 1986 to 2005 with projections to 2020. The model separately tracked four main categories of end use: space conditioning, water heating, cooking and appliances. In addition, the four main fuel types of electricity, mains (natural) gas, LPG and wood were also tracked. Attention is given to the interaction of the thermal performance of the building shell, heating and cooling regimes and the product type, fuel mix and energy efficiency of space heating and cooling equipment together with climate data. To achieve this, the model uses selected combinations of various dwelling types and construction to match known variants within the stock. Modelling of space conditioning load was conducted on a range of selected sample dwelling types selected as representative of the building stock as a whole. This study, which provides one of the most detailed assessments of residential end use energy consumption ever undertaken in Australia, nevertheless identifies significant gaps in the knowledge base that underpins the estimates in the report, with a need for more end-use data for residential energy use in Australia, including the drivers behind householders’ energy consumption. The main findings of the study are summarised below:

a) A forecast increase in the number of occupied residential households from six million to almost ten million between 1990 and 2020, with rise in residential floor area from 685 to 1,682 million square metres.
b) The study predicts a 56 per cent increase in residential sector energy consumption over the period 1990 to 2020 under the current trends, with an increased proportion of the total residential energy demand being met by electricity.

c) Projecting forward to 2020, a 6 per cent decline in energy consumption per household compared to 1990 levels is predicted, despite expected increases in service delivery to households, and trends previously outlined in sections 2.5 and 2.6 in house size, space conditioning equipment and appliances, and increase in standby energy consumption. The forecast decline per household is ascribed to existing and planned energy efficiency programmes.

d) An increase in per capita energy consumption from 17 gigajoules (GJ) per person in 1990 to 20 GJ in 2020, or approximately a 20 per cent increase over the study period, driven partly by a decline in the number of persons per household. Lower than ABARES official data in which residential energy use per person increased from 18.3 GJ in 1989-90 to 19.9 GJ in 2006-07 (Sandu and Petchey, 2009), the divergence is attributed to uncertainties in national energy consumption data based on top-down methodology, and assumptions used.

Benefits of housing stock models include: reducing the requirement for time-consuming measurements for large numbers of dwellings; estimating savings based on current/predicted information; and providing information on hard-to-measure quantities, such as heat loss coefficients or ventilation rates of buildings. Bottom–up engineering models have high requirements for detailed data and computational intensity (Swan and Ugursal, 2009). Where models are used to identify optimum energy and CO₂ reduction strategies by employing a variety of scenarios, and varying the input parameters to the scenarios, it is argued that the model must accurately describe the complexities of the housing stock including the physical, climatic, and household behavioural aspects, for such results to be of value in policy
formation. Further, any model must be thoroughly validated against existing data sets and the uncertainties within the model fully quantified. Without rigorous testing, predictions will lack credibility. In particular, as inputs to a housing stock model will be inferred or estimated values (due to the size and complexity of the built environment, the limited data available, and the difficulty in making many of the necessary measurements), the model should clearly demonstrate the effect of the uncertainty in the model inputs on the model predictions (Firth et al., 2010). Although used for scenario planning to estimate the effects of technologies, policies, and future climates on overall energy consumption and CO₂ emissions, the ability of models to identify the effectiveness of specific policy measures is regarded as ‘highly limited’ by Summerfield et al. (2009). For ascertaining the effectiveness of renovation as a strategy, it is vital to look beyond such models and to investigate dwellings and occupants.

Renovation, including retrofitting, is widely promoted for reducing energy and associated emissions in residential dwellings, and the next section examines data available on home-renovation to further understand the extent and nature of activities.

2.7 Extent and nature of home-renovation

Opportunities exist to make a substantial contribution to the reduction of environmental impacts through renovation (Meijer et al., 2009; Urge-Vorsatz et al., 2007). However, such activities need to be considered together with changes to how dwellings are inhabited (Maller and Horne, 2011). In other words, renovation can contribute to the energy performance of residential stock (Dalton et al., 2007; Meijer et al., 2009; Ouyang et al., 2011; Wright, 2008) but as renovation activity within Australia is not extensively documented, there is considerable uncertainty about the actual effects on energy performance. In the absence of empirical evidence, estimations of the thermal performance and the potential for energy saving in the residential building
stock associated with renovation and domestic practices may be based on little more than guesswork.

As noted in section 2.3 above, the ABS Building Activity Survey (BAS) and the Australian National Accounts are two important data series that may be used to describe trends in the quantum of work within this residential alterations and additions. However, the value of work done drawn from the BAS and National Accounts data present significantly different pictures of the investment in existing stock. The only reliable trend data on renovation activity is ‘alterations and additions’ published by the ABS, which defines alterations and additions as:

_Building activity carried out on existing buildings. Includes alterations and additions to floor area, the structural design of a building, and affixing rigid components which are integral to the functioning of the building._ (Australian Bureau of Statistics, 2013b, Glossary)

However, the only published data currently available is for work valued over $10,000 and which requires Council approval. As small alterations and additions that do not involve structural changes to a building are not included in the survey, the ABS definition of alterations and additions does not capture all home-improvement, leading to under-reporting of renovation activity.

2.7.1 Renovation activity

The extent of home-renovation activity can be appreciated by the value of work done on existing dwellings. Alterations and additions account for around half of all investment spending on dwellings (Battellino, 2009). The Commonwealth Bank estimates that alterations and additions to dwellings accounted for $31 billion or 43 per cent of the $71 billion total residential investment, in the year to September 2011. Of this, about $6.6bn or just 21 per cent of estimated spending on renovations, is on Council-approved
renovations (Workman, 2012). Figure 2.7 shows the value of residential work done for alterations and additions for the period 1998–2010 based on the BAS data. In 2010–11, the estimated value of alterations and additions increased to $7.4 billion (Table 2.3).

**Figure 2.7 Value of alterations and additions**

![Graph showing the value of alterations and additions](image)


**Table 2.3 Value of residential work done**

<table>
<thead>
<tr>
<th>Year</th>
<th>New houses</th>
<th>New other residential</th>
<th>Total new residential</th>
<th>Alterations and additions</th>
<th>Total residential</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$m</td>
<td>$m</td>
<td>$m</td>
<td>$m</td>
<td>$m</td>
</tr>
<tr>
<td>2009–10</td>
<td>27,823</td>
<td>11,374</td>
<td>39,197</td>
<td>6,878</td>
<td>46,075</td>
</tr>
<tr>
<td>2010–11</td>
<td>27,372</td>
<td>13,576</td>
<td>40,948</td>
<td>7,393</td>
<td>48,341</td>
</tr>
</tbody>
</table>


Notes:
(a) Value based on 2011 prices.
(b) Building activity carried out on existing buildings. Includes adding to or diminishing floor area, altering the structural design of a building and affixing rigid components which are integral to the functioning of the building.
Dalton et al. (2011) document the extent of renovation activity in Australia using the National Accounts measurement of Gross Fixed Capital Formation (GFCF) in dwellings, a measure of the value of alterations and additions and used to observe the trend in alterations and additions to existing dwellings. According to the National Accounts published in December 2001, Australians spent $14.3 billion on alterations and additions to residential dwellings (Australian Bureau of Statistics, 2001). In the National Accounts methodology, alterations and additions are more significant than the values reported through the BAS alone, which does not capture a significant proportion of alterations and additions. Dalton et al. (2011) argue that the GFCF data indicates that alterations and additions form a more significant proportion of total residential activity than suggested by the BAS value of work data, between 38 per cent and 49 per cent since the mid-1980s. Similarly, data on State final demand for Victoria drawn from the Australian National Accounts shows that annual investment in renovations in Victoria is significant, rising from is $4.2 billion in 2004 to $6.5 billion in 2012 (Australian Bureau of Statistics, 2012a). This is significantly higher than BAS data released by ABS in December 2011 which shows an increase in the value of additions and alterations in Victoria from $1.2 to 2.15 billion during the period 2001 to 2011 (Australian Bureau of Statistics, 2013b; Housing Industry Association (HIA) Economics Group, 2011).

Although the GFCF National Account measure is considered to be the more accurate of the two measures, Dalton et al. (2011) argue that both data series under-report alterations and additions work carried out on existing dwellings due to the narrow classifications used. In their survey of building materials and fittings. BIS Shrapnel (1994) use the term home improvements to encompass a broader range of projects including additions, renovations, alterations, refurbishments and general dwelling improvement projects (BIS Shrapnel, 1994: 6). This report provides insight into the nature of the home-renovation work. The broader definition used by BIS Shrapnel incorporates ground and upper floor additions; kitchens, bathrooms and laundries; dwelling envelope
improvements; garages and carports; swimming pools and spas; and external improvements including fences, paving, patios and decks. Survey data on expenditure includes all projects costing less than $10,000, and those for which householders did not receive council approval. However, this data is only available for 1992. Whilst efforts were made to obtain more recent data from BIS Shrapnel who conduct regular surveys of building renovation activity as well as other commissioned surveys, results are only available through subscription (P. Giles, Senior Manager BIS Shrapnel, pers comm., 21 March 2012), and the prohibitive cost put it beyond the means of this research. Thus the 1994 BIS Shrapnel report is the most recent study of the home improvement sector available.

BIS Shrapnel estimate that Australian households spent $8.8 billion on improving their homes in 1992. Figure 2.8 shows the shares in investment and the number of projects, with additions to the main dwelling attracting the largest share of investment. This is followed by investment in the utility areas of dwellings, kitchens, bathrooms and laundries; external improvements; building envelope improvements, which includes roofs, walls, windows and claddings; garages and carports; and swimming pools and spas. The distribution of projects across these six categories differ, reflecting significant variation in share and the average value of projects. As this study is concerned with reducing energy use and associated emissions relating to existing dwellings, the focus is on additions, internal modifications, and dwelling envelope improvements e.g. installing insulation, new windows. The survey data collected by BIS Shrapnel in the 1994 report does not separately identify green renovations such as installation of renewable energy systems.
The report by BIS Shrapnel (1994) does, however, provide some further insight into the nature of home-renovation activity, which varies depending on the type of the project. Additions activity was highest for households who are living in dwellings aged over 51 years, householders who are married with children and have lived in their dwelling for 3-7 years, respondents aged between 35-44 years (at 4.6 per cent this category was significantly higher than the national average of 2.5 per cent). Further, activity was highest amongst respondents who were married with children aged over 17 years. Internal renovations projects are mostly undertaken on dwellings aged 31 years and over. For the dwelling envelope improvements sub-group activity was highest amongst respondents living in dwellings aged 31 years and over. Activity was greatest for households who have lived in the dwelling for 4 to 7 years, married in the 35-44 age range, and have children who are less than 5 years. Additions and improvements activity is greatest for higher income households.
Victoria accounted for 826,700 projects or 29 per cent of the 2.84 million separate home improvement projects in 1992 (BIS Shrapnel 1994: 2). Amongst the most common projects were re-guttering, kitchen renovations, bathroom renovations, ground floor additions, and window replacement. Additions, kitchen and bathroom renovations accounted for $4.94 million (ibid; 1994: 3). The largest growth in activity was in ceiling insulation, kitchen renovations, re-guttering, laundry and bathroom renovations.

The survey report by BIS Shrapnel (1994) found in 1992 that a total of 1.7 million households, or 30 per cent of total households in Australia, undertook some form of home improvement. In the Australian Housing Survey (1999), 58 per cent of owner-occupiers stated that some renovations had been carried out on their current dwelling in the previous 10 years (a total of 2.9 million dwellings), while 27 per cent stated that renovations had been carried out on the dwelling in the previous two years (1.3 million dwellings). The most common renovations were kitchens, bathrooms and internal alterations (Australian Bureau of Statistics, 1999).

Recent research indicates that renovations projects in the home are becoming an increasingly prevalent activity. A study of green renovation projects by homeowners across six Australian states found that the number of improvements undertaken per household varied from one to seven, with most describing from two to five in the last 12 months, more than might be expected of ‘typical’ Australian homeowners. Improvement projects ranged from modest changes such as draught proofing and changing light fittings, to more major renovations; purchasing and installing new appliances for the kitchen or bathroom, installing insulation (ceiling or sub-floor), fitting window blinds or curtains or installing a low-flow shower head being the most frequently reported activities. Other home improvements mentioned less frequently were draught proofing, painting, repair of the dwelling structure, adding or modifying windows, adding additional storage, installation of external shading, fitting new
taps, and installing air conditioning (Maller and Home, 2011). Although a small sample size, smaller scale studies such as this are of value as they can provide fine-grained description of the many complex factors that influence household activities (Shipworth et al., 2010).

2.7.2 Reasons for renovation

Although the extent and nature of renovation activity is not well documented, evidence suggests that key factors affecting alterations and additions include ageing of dwelling stock, together with population growth, changes in demographic structure, economic conditions, property market conditions, and government policies (BIS Shrapnel, 1994). As noted above, the ageing of the dwelling stock is likely to increase home renovation activity, in particular internal renovations, and improvements. The older stock of dwellings in Victoria provides increased opportunity for home improvements activity in comparison to other states and territories with a comparatively younger dwelling stock. A period of rising house values and access to flexible low cost finance for homeowners have together been associated with renovation as an activity becoming more widespread (Housing Industry Association (HIA) Economics Group, 2008). Home renovation is linked to the dynamics of the property market with activity traditionally occurring in the first few years following a house move (BIS Shrapnel, 1994). As an alternative to moving house, homeowners may decide to stay and make changes to an existing dwelling (Baum and Hassan, 1999). General economic management policies impact on household renovation activities. Research by the HIA indicates that a rise in interest rates has a negative effect on renovation activity (Johanson, 2011). Specific government policy measures such as financial incentives for householders to improve the energy efficiency of existing appliances may also make certain activities more attractive. Between 2007-2012, the federal government funded over 255,000 rebates in excess of $323 million for ‘climate friendly hot water systems’ (Department of Climate Change and Energy Efficiency, 2012a). According to ABS survey data, 602,700 households (66,200 in Victoria) used solar energy for heating water in 2011, or 8.5 per
cent of households (3.8 per cent in Victoria) (Australian Bureau of Statistics, 2011c). This amounts to a rise of 4.1 per cent nationally (2.8 per cent increase in Victoria) since 2005.

Previous studies indicate that householders are guided by multiple motivations to renovate (for example, Baum and Hassan, 1999; Crosbie and Guy, 2008; Dalton et al., 2007; Maller and Horne, 2011; Wilk and Wilhite, 1985), including meeting lifestyle aspirations and family needs (Baum and Hassan, 1999; Kintrea, 2007). The survey by BIS Shrapnel suggests that renovation activity is more prevalent amongst households with dependents. Issues with affordability in Australian cities and the trend for adult children to stay at home longer could have a positive impact on home improvements activity, as families undertake additions to increase floorspace or add facilities. Further, the ageing population may result in adult children extending their homes to accommodate ageing parents or in-laws to live with them. Additionally, renovation activity may reflect the design, tastes and innovations promoted by media marketing. The increasing interest in home renovation may also be attributed to reality TV series such as *The Renovators*, *Grand Designs* and *The Block* (Johanson, 2011; Housing Industry Association (HIA) Economics Group, 2010) as well numerous lifestyle magazines.

The academic literature highlights several significant impulses associated with home renovation. Within the sociological literature, renovation is bound up in the process of making a home (Blunt and Dowling, 2006). In a study into the experiences of UK householders’ who had extended or significantly remodelled their home, spatial changes are linked to acquisition of new technologies and goods and to daily practices, which support particular images of domestic life (Hand et al., 2007). Motivation for renovation is strongly linked to the importance people place on their homes as a site of comfort and the locus of family life (Munro and Leather, 2000). The trend towards internal reconfiguration to create an open-plan domestic interior is
based around ideals of family life (Dowling and Mee, 2007). Coolen and Meesters (2012) and Dowling and Power (2012) relate satisfaction with the spatial and temporal affordances of a dwelling, whether in terms of environment, functions or features offered, for example, the size and layout may not be adequate to afford all the functions desired, or privacy for inhabitants. The decision to make modifications to the home is seen as an outcome of a given level of housing dissatisfaction that is indicative of a gap between the actual and desired level of residential environment attributes (Baum and Hassan, 1999). A variety of factors, some of which are endogenous to the household, commonly changes to the household structure or socio-economic position, may result in changes in residential environment satisfaction. Changes to housing prices and mortgage interest rates, as well as changes to public policy, are exogenous to the household—all of which may influence housing demand and satisfaction. Included within the assessment are not only financial costs of undertaking renovations but also any disruption caused by the renovation procedure. Cost benefits are not a significant motivator in green renovations, but rather a variety of linked and negotiated motivations including environmental concerns, cost and desire to achieve standards of comfort (Dalton et al., 2008).

In the more technical-based literature associated with building science and construction, the focus is on building obsolescence as reason for renovation, related to the physical characteristics of a building structure, the statutory and regulatory framework, and more subjective, aesthetic issues (Douglas, 2006; Kintrea, 2007; Mansfield, 2009). However, the expectation of occupants operate alongside physical, social and contextual influences (Thomsen and van der Flier, 2011b). Building performance and obsolescence is the subject of further discussion in Chapter 3.
2.8 Digest: the existing residential stock and renovation

The existing dwelling stock provides a starting point for the theoretical and empirical investigation into the renovation of dwellings with heritage significance in this thesis. Drawing together information from various sources, this chapter has investigated current knowledge on the composition of the residential stock and dynamics in terms of energy performance. Obtaining coherent information on the performance of the dwelling stock for Victoria has proved difficult, as there remains a lack of reliable data on older buildings that were constructed prior to the introduction of regulations to improve energy efficiency; information on renovation of dwellings is also fragmented. This is regarded as a significant information gap.

Whilst sources generally confirm that renovation is a widespread activity, little is known about the nature of home-renovations, the reasons behind renovation activity or the effects on energy consumption. The lack of coherent and up to date published data is a concern; although increasingly pursued as a pathway to reduce energy and associated emissions, the effectiveness of home-renovation in achieving environmental objectives is uncertain. Despite appreciable efforts to improve efficiency, the indications are that residential energy demand continues to trend upwards.

Within existing datasets on energy performance in buildings, the emphasis is on technical efficiency. General knowledge about households’ approaches to energy renovation is poor, and further research is needed to fill the information gap, to inform the development of successful strategies and policies for managing energy use and environmental performance. Household composition and dwelling characteristics go some way to explaining differences in energy consumption. However, the available measured data is insufficient for understanding energy use and how this relates to renovation of the existing housing stock.
Having identified the key issues relating to energy performance in the existing dwelling stock, attention turns in the next chapter to the significance of the built heritage.
‘We need to remind ourselves so as to persuade others that consciously informed use of heritage is essential to civilized life.’

David Lowenthal, 2008 p. 10

3 The relevance of cultural heritage conservation

This chapter first outlines concepts underlying cultural heritage conservation, then explores the role of heritage buildings in contemporary society, including how and why heritage is valued, and how the concept of significance intersects with emerging concerns about sustainability and environmental priorities. Drawing on building concepts, contentions between cultural heritage conservation and renovation are discussed. The policy and regulatory framework for the protection and management of heritage buildings in Victoria is outlined, and this is followed by an account of the salient issues relating to strategy to improve environmental performance of heritage buildings through renovation.

3.1 Conservation theory: concepts, criteria and definitions

Prior to considering the theoretical principles underlying conservation it is necessary to understand the various terms and concepts used, and how these are applied in the context of building conservation to frame the discussion that follows.

3.1.1 Cultural heritage: concept

Cultural heritage has acquired a wide usage to include not only inherited customs, beliefs, and institutions held in common by a nation or community, but more recently, it has been applied to landscapes, buildings and
environments held in trust for future generations (ICOMOS, 1982; Jokilehto, 2005; Schapper, 1994). There is no single, generally agreed definition of cultural heritage (Blake, 2000). In the Convention Concerning the Protection of the World Cultural and Natural Heritage (UNESCO, 1972) cultural heritage refers to monuments (including architectural works), groups of buildings, and sites. This definition, is enlarged to encompass:

‘the entire corpus of material signs - either artistic or symbolic - handed on by the past to each culture and, therefore, to the whole of humankind.’
(UNESCO, 1989 Article 227)

The UNESCO Draft Medium Term Plan 2000-2005 continues:

‘The idea of the heritage has now been broadened to include both the human and the natural environment, both architectural complexes and archaeological sites, not only the rural heritage and the countryside but also the urban, technical or industrial heritage, industrial design and street furniture.

‘Furthermore, the preservation of the cultural heritage now covers the non-physical cultural heritage, which includes the signs and symbols passed on by oral transmission, artistic and literary forms of expression, languages, ways of life, myths, beliefs and rituals, value systems and traditional knowledge and know-how.’ (UNESCO, 1989 Article 229 and 230)

The idea of the cultural heritage is indeed broad, having been enlarged to incorporate both the human and the natural environment, areas as well as individual buildings, and physical and non-physical forms.

3.1.2 Cultural built heritage: denoted

The cultural built heritage is generally differentiated from the natural heritage as being derived from the activities of humankind, and represented by the ‘products of material culture’ (Avrami et al., 2000: 7; UNESCO, 1989). In
Australia a distinction is made between natural, indigenous and historic heritage, and is designated according to world, national, state or local significance (Department of the Environment, 2011). In keeping with this understanding, the term heritage is used in this thesis to refer to the historic built heritage i.e. the physical remains of the past in the form of buildings erected following settlement by European and other migrants and, more specifically, dwellings with designated cultural or heritage significance as defined in the Burra Charter (Australia ICOMOS, 1999). Built heritage encompasses a wide range of different buildings, and is not confined to the grand or outstanding (Aplin, 2004). This is particularly relevant in Australia, which lacks the richness of historic structures found in Europe. Early colonist and botanist–clergyman William Woolls remarked in the 1830s that, ‘we cannot boast of the massive structures which have been raised by the piety of our forefathers, and which are now the sacred storehouses of our predecessors, and guardians of their bones; we cannot pride ourselves upon the triumphal arch, the high-raised battlement, the moated tower, and the mouldered grandeur of times gone by’ (Davison et al., 1998). Even modest buildings may be recognised for their heritage significance, as noted in the Charter on Vernacular Built Heritage (ICOMOS, 1999). Modest buildings may be considered worthy of protection for their aesthetic, historic, scientific, social or other special significance to the local area. For example, the ramshackle timber cottage in Kelly Street, Beveridge⁴, a settlement just north of Melbourne, dating from 1869 is registered for its historical and architectural significance, as an example of an early vernacular dwelling, and valued by many Australians for its association with the outlaw, Ned Kelly. The pioneer’s cottage represents something important in terms of the local and even the national history or culture. Not only does it provide an insight into ordinary everyday life in the past, it also expresses Australian identity.

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Widely understood as those monuments and buildings forming the physical remains of the past that are valued and considered worthy of preserving for present and future generations, in keeping with a contemporary interpretation the definition of cultural heritage encompasses not only *material objects* but also the *meanings* of heritage items to people (Aplin, 2004). Cultural heritage is often articulated as either tangible or intangible: tangible refers to the fabric or physical material of the place including buildings, objects, artifacts, and the intangible refers to the non-physical component including traditions, social practices, skills, and memory (UNESCO, 2003). According to Smith (2006), the tangible aspects of heritage are being challenged by alternative conceptions of heritage which establish and develop themes of identity, memory, performance, intangibility, dissonance and place.

This thesis is essentially concerned with the physical remains of the past as represented in buildings and associated infrastructure, however, it also recognises that intangible heritage provides meanings, values and context to places and objects, and the two are inextricably linked and indivisible (ICOMOS, 2003). As noted by Johnston (1992), intangible values such as social significance can be inherent in buildings but may not be obvious in the fabric or apparent to a disinterested observer.

Although cultural heritage is not limited to the built heritage, structures and buildings are amongst the most common type of cultural heritage assets (Worthing and Bond, 2008) and are the focus of this thesis. The next section is concerned with the place of built heritage in contemporary society, and the reasons why it is valued.

### 3.2 The contemporary role of heritage

There has long been a tension between the present and the past. In his seminal work *The Past is a Foreign Country*, Lowenthal (1985) argues that the
past in general, and its interpretation as history and heritage in particular, confers social benefits and costs. He identifies four reasons why the past is valued (which can be taken as synonymous with the built heritage in this respect): for antiquity; continuity; termination; and sequence. Lowenthal goes on to discuss seven benefits of the past which he sees as providing familiarity; reaffirmation and validity; identity; guidance, enrichment; and escape. He also considers the burdens of the past, and the on-going conflict between tradition and innovation:

“Stability and change are alike essential. We cannot function without familiar environments and links with a recognizable past, but we are paralyzed unless we transform or replace inherited relics... Yet to cope amidst change we also need considerable continuity with the past. The cultural legacy, too, is conservative and innovative: survival requires an inheritable culture, but it must be maleable as well as stable.” (Lowenthal, 1985: p 69)

Heritage is considered important for many reasons. Fundamentally, cultural and heritage diversity is seen as an essential aspect of human development (ICOMOS, 1994). Heritage has a key role in supporting and maintaining the cultural life and vitality of human civilization (Throsby, 2000). A source of memory and inspiration, heritage contributes to national and local community identity, which is fundamental to ‘sense of place’ (Pereira Roders and van Oers, 2011; Spennemann, 2006). The role of heritage buildings for contemporary society is encapsulated in the following excerpt from the Australia ICOMOS Burra Charter:

Places of cultural significance enrich people’s lives, often providing a deep and inspirational sense of connection to community and landscape, to the past and to lived experiences. They are historical records that are important as tangible expressions of Australian identity and experience. Places of cultural significance reflect the diversity of our communities, telling us about who we are and the past that has formed us and the Australian landscape. They are irreplaceable and precious. (Australia ICOMOS, 1999 sub. 122).
3.2.1 Significance, fundamental and incidental values

Heritage performs different, often multiple roles in different circumstances, and this can be expressed in terms of value (Pendlebury, 2009: 203). The Macquarie Dictionary definition of value is ‘worth, merit, or importance’, and the Oxford Dictionaries online refer to the importance, worth, or usefulness of something—but not limited to financial worth. To value something is to consider something to be important or beneficial in the present age (Graham, 2002). Referring to the contemporary use of heritage, Pendlebury (2009) distinguishes between fundamental and incidental values, to clarify why we seek to conserve a building, and how we should aim to conserve it. In his Contemporary Theory of Conservation, Muñoz Viñas (2005) equates value with a functional view in considering the importance or usefulness of the cultural built heritage. In terms of its usefulness, the Framework Convention on the Value of Cultural Heritage for Society (Council of Europe, 2005) acknowledges that cultural heritage is valuable for its own sake and also for the contribution it can make to other policies. In the report of the World Commission on Culture and Development Our Creative Diversity, cultural heritage is recognised for its value as a resource for human development, as part of sustainable development (World Commission on Culture and Development, 1996).

The values attributed to heritage buildings outlined in Table 3.1 have been compiled from various principal heritage organisations involved with policy and practice. The cultural heritage significance of a place or building emerges as a composite of intersecting values brought together under the notion of significance also enables assessment of the relative importance of different aspects of the building.

Essentially, heritage buildings are considered important not only for their cultural value but also for their incidental values. Adopting the classification
used by Pendlebury (2009) above, *fundamental* value relates directly to the heritage place for example, aesthetic qualities, historical significance. *Incidental* value refers to the social, economic and other use benefits derived from heritage property. The multiple ways historic built heritage supports and contributes to the economy, society and daily life are well-documented elsewhere in the literature and are not discussed in detail here (see Clark, 2006; de la Torre and Mason, 1999; Department of the Environment and Heritage, 2004; Maeer and Fawcett, 2011; Productivity Commission, 2006; Rypkema, 2009; Allen Consulting Group, 2005; Throsby, 2007). As observed by Worthing and Bond (2008), the values represented by the cultural built heritage are diverse and complex, with different parts of the cultural heritage resource having different, often multiple values with different levels of significance. Consequently, there is no one single approach to measure the benefits, and methods used to quantify benefits have limitations (Wills and Eves, 2006). Focus on a single dimension, for example, economic appraisal, cannot produce an adequate analysis of the value of cultural heritage (Mason, 2005; Throsby, 2007).

Although often difficult to quantify due to the multifaceted nature of heritage (MacDonald, 2007), it is evident that cultural built heritage fulfills many important socio-economic functions in contemporary society including a source of revenue, a historic-cultural resource related to the memory of the past, an object for education and scientific study, as well as being a source of inspiration, an object of historical pride, or an asset with a high artistic value (Nijkamp and Riganti, 2008). One of the principal reasons why built heritage is valued is for its contribution to local identity and ‘sense of place’ (Graham et al., 2000; Pendlebury, 2009). The ‘heritage aesthetic’ has become a key factor in ensuring local distinctiveness as globalisation takes effect, and where this underpins local economic vitality (in terms of tourism or other economic benefits) then its status is enhanced (Strange, 1999). The contemporary role of ‘the heritage of the conserved built environment, and culture more widely’ is
also regarded for its contribution to other objectives such as sustainability (Rodwell, 2007: 209).

### Table 3.1 Values attributed to heritage buildings

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### 3.2.2 Environmental benefits

Although cultural heritage is generally acknowledged as the source of a wide range of important benefits to society, it is only relatively recently that the environmental benefits of heritage buildings have become part of the discussion. Probably the first explicit link between heritage conservation and environmental sustainability is expressed in the *UN Conference on Human*
Settlements (Habitat II) (United Nations, 1996) which builds on the concept of sustainable development in the World Commission on Environment and Development, Our Common Future (Brundtland and World Commission on Environment and Development, 1987). It is asserted that there are environmental benefits to be achieved through the conservation of heritage buildings, which represent a major investment in natural and human resources. In the context of environmental sustainability, Rodwell (2007: 206-207) describes the built heritage as a ‘functional, material and cultural resource’ and ‘heritage buildings and areas represent a non-renewable capital resource—of materials, energy and financial investment—as well as a cultural one’. Others assert that adapting and re-using existing buildings capitalises on the embodied energy invested in the original structures, consumes less materials and energy than new construction, and reduces the amount of waste going to landfill (Balderstone, 2012; Douglas, 2006; Elefante, 2007; Godwin, 2011; Rodwell, 2009; Wilkinson, 2012). Bullen (2007) argues that adaptation supports the key concepts of sustainability by reducing materials, transport, energy consumption and pollution. These claims are supported by a number of empirical studies, (for example Bell and Lowe, 2000; Itard and Klunder, 2007; and Ireland, 2008). Even so, the value of heritage conservation to environmental sustainability is not widely recognised, and its scientific basis has not been explored. The discussion document Sustaining the historic environment: new perspectives on the future (English Heritage, 1997) includes 'resource values' in the list of heritage values (Table 3.1). The recent policy document Conservation Principles: Policies and Guidance for the Sustainable Management of the Historic Environment (English Heritage, 2008a) makes reference to the energy and resources embodied in heritage buildings. This document also mentions durability and performance of building materials and buildings in terms of the energy needed in production and in use but does not elaborate further. Recent research by Menzies (2010), on behalf of Historic Scotland, examines the embodied energy of retrofit glazing options for historic buildings. Despite parties to the World Heritage Convention (UNESCO, 1972) being encouraged to develop scientific and technical studies and research and to work out operating methods capable of counteracting the dangers that
threaten the cultural or natural heritage, little research has been conducted on heritage buildings, in comparison to the studies on new buildings or the general building stock. It is asserted that this lack of empirical evidence has resulted in ecological and environmental values being undervalued and under-represented (Worthing & Bond, 2008).

3.3 Conservation and change: contentions

Buildings protected for their cultural significance are inevitably shaped by other needs and wants—this is particularly valid when considering heritage dwellings which are a living part of the community. As observed by Brand (2004), in use, a building has to tolerate the continuous alterations that accompany normal life. In exploring the areas of contention that commonly arise in seeking to make material changes to heritage dwellings, including efforts to improve environmental performance, it is necessary first to explain what is meant by the term conservation and its scope in the context of buildings.

3.3.1 The extent of conservation

The generally accepted broad view, developed from the principles set down in charters and other standards, is that conservation refers to the whole subject of the care and treatment of valuable artefacts, both movable and immovable (Jokilehto, 1999), and encompasses a range of processes of looking after a place or object so as to retain its cultural significance (ICOMOS, 1999). The Victorian Heritage Act 1995 further elaborates the purpose and scope of conservation as:

*the retention of the cultural heritage significance of a place or object; and any maintenance, preservation, restoration, reconstruction or sustainable use of a place or object* (s.3, Heritage Act 1995).
This definition recognises the range of activities involved in conservation of a building, including the term ‘preservation’ which requires some clarification. Although preservation is often used interchangeably with conservation, there is an important difference. Generally understood as a more limited notion than conservation (Muñoz Viñas, 2005), preservation is maintaining [the original] in an unchanged state, keeping something as it is. This view is consistent with the Burra Charter (Marquis-Kyle and Walker, 2004) which defines preservation as ‘maintaining the fabric of a place in its existing state and retarding deterioration’. Whereas conservation means, or has come to mean, ‘preserving purposefully: giving not mere continued existence, which often implies retaining or restoring the traditional appearance of buildings, singly or in groups, but adapting the interior to modern uses.’ (Burke, 1976: 117). As suggested by Burke, conservation is more dynamic, embracing elements of change, and even enhancement (Cullingworth and Nadin, 2002). The subject of heated exchanges (Smith, 2012; Williams, 2010), some argue that conservation means preserving, not altering and destroying (Petzet, 2009), whilst others contend that preservation has no place in the management of the historic built environment in the twenty first century, only conservation as a process of managing change (Rodwell, 2011).

Taking a closer look at conservation as management, this activity is not restricted only to protection, maintenance and, where necessary, stabilisation of existing fabric (Schapper, 1994) but can involve adapting a building to accommodate a different use or to meet modern standards. Loulanski (2006) applies the term purposeful preservation to describe the adaptive reuse of heritage buildings, combining preservation with upgrading of a building and economic rejuvenation: subject to the use being sustainable and, as a prerequisite, protection of the core values of heritage. Thus a central principle of conservation is established that whilst upgrading and adaptation is permissible, even advantageous, the essential heritage values of a building should be retained.
Within the broad definition (Australia ICOMOS, 1999), it is asserted that conservation involves an action to secure the survival or presentation for the future of a building, or part of its fabric, structure or site (RICS, 1996). The pro-active nature of conservation is emphasised by Feilden in his authoritative work on the fundamental principles of conservation, *Conservation of Historic Buildings*, where conservation is further elucidated as ‘the action taken to prevent decay and manage change dynamically’ (Feilden, 2003). Feilden orders these actions into seven (ascending) ‘degrees of intervention’ and discusses the strengths and weaknesses of each: prevention of deterioration; preservation of the existing state; consolidation of the fabric; restoration; rehabilitation; reproduction; and reconstruction. There has been some debate over what these different terms mean and the scope of works involved. Essentially, the first three involve actions to arrest deterioration and retain a building in its present state, which includes consolidation or stabilisation of structural elements to ensure its continued durability or structural integrity.

Restoration and rehabilitation relate to management of change, as opposed to preservation of the existing; restoration is generally used to describe actions to reinstate a building to a former preferred state (Muñoz Viñaz, 2005) by re-introducing elements that are missing or are decayed, or removing later interventions. The term rehabilitation is suggestive of restoring to good condition or operation although it is also interpreted as modernisation (Mansfield, 2002); such intervention could involve adaptive alteration or different use (RICS, 1996) and may be the only way that historic and aesthetic values can be retained economically, and the building brought up to contemporary standards (Feilden, 2003). This thesis is mainly concerned with alteration to meet contemporary requirements i.e. refurbishment, retrofitting and renovation. These various terms fall under the category of adaptation in the Burra Charter, which refers to ‘modifying a place to suit the existing or proposed use’ (Australia ICOMOS, 1999 Article 1.9).

One of the chief aims of conservation is to safeguard buildings for future generations. Yet adaptation inevitably involves modifications that potentially
removes evidence, and diminishes significance. As observed by Salvador Muñoz Viñaz, ‘With the exception of preventative conservation, conservation is all about altering objects’ (Muñoz Viñaz in Richmond and Bracker, 2009: 53). Paradoxically, conservation involves securing the past whilst changing it.

By way of summary, although there are differing terms and views, it is generally accepted that conservation involves a combination of preservation and pro-active management which can encompass alteration of a building to a lesser or greater extent. However, the key criterion is whether the modifications to achieve the level of environmental performance required would affect the cultural heritage significance, which relates to the physical fabric and other values and meanings. Critical to the extent of conservation and change is the issue of authenticity, which is discussed in the next section.

3.3.2 Re-negotiating authenticity

The conservation principle of authenticity arose out of the great nineteenth century restoration debate (Jokilehto, 1999), and is expounded in John Ruskin’s leading work The Seven Lamps of Architecture (Ruskin, 1849), and the Society for the Protection of Ancient Buildings (SPAB) Manifesto published in 1877, and emerged as one of the cornerstones of conservation philosophy and practice (Bell, 1997; Rodwell, 2007). Not an easy concept to grasp, according to Bell (1997: 16), it is elaborated by Feilden and Jokilehto (1993) who observe that ‘[a]uthenticity is ascribed to a heritage resource that is materially original or genuine and as it has aged and changed in time’. Incorporated into conservation charters and guidance as the benchmarks for establishing and conserving significance of buildings (for example, English Heritage, 2008a; ICOMOS, 1964), the need to preserve the integrity and authenticity is mentioned in the preamble of the Venice Charter, one of the most influential documents in the international conservation movement—being widely adopted and the starting point for many other internationally agreed standards and practice. Although the term authenticity is not defined further,
the emphasis in the remainder of the document is on the material fabric—thus, the tacit understanding is that authenticity is related to the physical elements. However, more recently, the concept of authenticity has been further developed in *The Nara Document on Authenticity* (ICOMOS, 1994). An important document of modern conservation theory, The Nara Document explicitly includes the intangible values of cultural heritage, and effectively challenges the doctrinal foundation inherent in the various charters, and long-held understandings that focus on material authenticity.

In his influential book *The Conservation Plan*, Kerr (2013) considers the relationship between conservation and development. The seventh (partly revised) edition contains the following explanation of authenticity,

‘authenticity’ suggesting genuineness ... *Authenticity may reside in the fabric itself, with its evidence of workmanship and age, or in the design and layout of a place (the latter can make a decision on the reconstruction of fabric of minor importance). It can also repose in the setting or in a combination of all three* (Kerr, 2013: 32)

The term authenticity does not appear in the *Burra Charter*. However, throughout the Charter the emphasis is strongly towards retaining original fabric. Although not specifically stated, Rowney (2004) argues that the avoidance of the term rather than the concept seems to be the intention, and hence authenticity is tacitly perceived to be residing in the original fabric. The notion of authenticity is considered relevant in relation to alterations to an existing building, and tensions that arise between conservation and development, as illustrated in the following example:

*There are limits, however, beyond which loss of inherited fabric compromises the authenticity and integrity of a place. At the extreme, a proposal to retain no more than the façade of an historic building attached to a modern structure must be considered in the light of an assessment of the existing values of the*
This excerpt describes façadism, the removal of all the internal elements of a building, leaving only the front or exterior walls whilst reconstructing the interior, in order to retain the image and prestige of a historic façade combined with functional performance. A radical intervention, this practice is highly contentious, as it conflicts with traditional conservation tenets (Araoz, 2011; Pendlebury, 2009), and is considered to be the antithesis of a sustainable approach (Rodwell, 2007), whilst it is viewed by others as a workable solution to balance historic character with function. The debate around the degree of intervention and practicalities of use continues.

For Pendlebury (2009) from a modern conservation perspective, the lack of regard for the notion of authenticity is troubling. Pendlebury (2009: 9) asserts that people place greater value on the retaining the image and perceived prestige associated with a heritage building, rather than the principles of authenticity and integrity endorsed by orthodox conservation. Bell (1997: 3) argues that authenticity runs through all strands of the conservation debate, including the concepts of cultural diversity and national identity which together with the ecological benefits of re-using scarce resources, have ‘become widely acknowledged as significant factors in the value of older buildings’. However, the following extract from The Getty Conservation Institute research sheds some light on why the concept of authenticity is seen as out of date in the contemporary debate:

‘Artefacts are not static embodiments of culture but are, rather a medium through which identity, power, and society are produced and re-produced. Objects, collections, buildings, and places become recognised as “heritage” through conscious decisions and unspoken values of particular people and
institutions—and for reasons that are strongly shaped by social contexts and processes. Thus the meaning of heritage can no longer be thought of as fixed, as the traditional notions of intrinsic value and authenticity suggest.’ (Avrami et al., 2000: 6)

Contemporary conservation theory contends that the importance of cultural heritage arises from the meanings attributed to the objects by the subjects and not from something inherent to the asset or material. Thus conservation is no longer an action of conserving material truth, but rather of the meanings of cultural assets. Muñoz Viñaz, (2005) asserts that there may be ‘many truths’ in one object; therefore, deciding which truth and which goal must prevail in each case is essential and is a preliminary stage in the decision-making process for conservation. In this process of establishing meaning, the function and use of the cultural asset are also seen as being relevant. ‘The greatest value of any site for society is rarely just the fabric itself. Its true worth nearly always lies in the site’s less tangible qualities, its “cultural significance”.’ (Bell, 1997: 27). The main aim, argues Bell, is not the maintenance of the fabric per se but should be to safeguard the cultural significance by maintaining the fabric, to find a way of conserving the physical fabric which does the least damage to the qualities that are protected. Thus, there has been a re-negotiation of established concepts, criteria and values in heritage which, argues Rodwell, runs parallel to the emergence of global agendas about sustainable development (Rodwell, 2011). The broadening of perceptions and accumulation of parallel agendas signals a move from traditional approaches involving the conservation of manifestations of tangible cultural heritage for their architectural and historic interest, to a more complex world where cultural heritage is engaged in meeting the broad needs and demands of society.

3.3.3 Obsolescence: theoretical understandings

The concept of obsolescence is held to be a decline the overall performance of a building over time, leading to a decrease in the capability of any building
to fulfil its original function or purpose time (Douglas, 2006). Thus obsolescence, from a technical perspective, is ‘a process of declining performance resulting in the end of service life’ (Thomsen and van der Flier, 2011a: 353). Obsolescence is generally linked to the physical, functional and technical characteristics of a building structure, the particular site the property occupies and the surrounding area, the statutory and regulatory framework and more subjective, aesthetic issues (Mansfield, 2009; Kohler & Yang, 2007). However, for Kohler and Hassler, obsolescence is determined by human factors: ‘[t]he idea that the life span of a building has an end, is rather new. There is no relationship between the age of a building and the probability that it will be demolished. The real reasons for demolition are complex ... In general, buildings are not demolished because they are old or in a bad state; they are in a bad state because their owners want to demolish them’ (Kohler and Hassler, 2002: 232). The relationship between physical, human and contextual variables is further discussed by Thomsen and van der Flier who also suggest that obsolescence is a function of human action or disregard (Thomsen and van der Flyer, 2011).

In terms of the resources offered by housing, Nutt et al. (1976) argue that obsolescence occurs when a dwelling no longer satisfies the following requirements: physical resources, such as space, services and fabric condition; use resources, that is, the uses to which a building can be put, including its capacity for adaptation for new uses; financial resources, i.e. the capacity to generate financial returns through, for example, letting or capital appreciation; and locational resources, such as access to services, jobs etc. (Nutt et al., 1976). Kintrea (2007) develops this a further, adding cultural resource, which is associated with the design and the meaning of the dwelling. This is analogous with social obsolescence (Douglas, 2006) which includes demographic shifts, and changes in expectancy levels as well as changes in taste and style. Several forms of obsolescence and their influences have been identified, and these are characterised in Table 3.2 as: physical, functional,
economic, social, legal (regulatory requirements), and aesthetic (including architectural) (Barras and Clark, 1996; Douglas, 2006).

Table 3.2 Types of obsolescence

<table>
<thead>
<tr>
<th>Type of obsolescence</th>
<th>Criteria</th>
<th>Factors</th>
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</thead>
<tbody>
<tr>
<td><strong>Economic</strong></td>
<td>Cost-effectiveness</td>
<td>Rental income levels</td>
</tr>
<tr>
<td>(including Financial)</td>
<td>Rate of return</td>
<td>Capital value versus redevelopment value</td>
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<td></td>
<td>Depreciation</td>
<td>Oversupply or drop in demand</td>
</tr>
<tr>
<td><strong>Functional</strong></td>
<td>Fulfilment of purpose</td>
<td>Decreased utility</td>
</tr>
<tr>
<td>(including Locational)</td>
<td>Degree of use</td>
<td>Inadequacy</td>
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<tr>
<td></td>
<td>Technological adequacy</td>
<td>Incapacity</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Errors/omissions in layout or form</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Technical advances</td>
</tr>
<tr>
<td><strong>Physical</strong></td>
<td>Structural stability</td>
<td>Structural failure</td>
</tr>
<tr>
<td>(including Environmental)</td>
<td>Weather tightness</td>
<td>Physical deterioration</td>
</tr>
<tr>
<td></td>
<td>Overall performance</td>
<td>Dilapidation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Urban blight</td>
</tr>
<tr>
<td><strong>Social</strong></td>
<td>Satisfaction of human needs</td>
<td>Demographic trends and shifts</td>
</tr>
<tr>
<td>(including Cultural)</td>
<td>Cultural requirements</td>
<td>Changes in taste and style</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Changes in expectancy levels</td>
</tr>
<tr>
<td><strong>Legal</strong></td>
<td>Compliance with statutory requirements</td>
<td>Changes in legislation or regulations</td>
</tr>
<tr>
<td>(including Control)</td>
<td></td>
<td>Changes in planning policies</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Existing adverse legislation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Nuisances and hazards – dangerous buildings</td>
</tr>
<tr>
<td><strong>Aesthetic</strong></td>
<td>Style of architecture no longer fashionable</td>
<td>e.g. office building designs of the 1960s</td>
</tr>
<tr>
<td>(including Architectural)</td>
<td></td>
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</tr>
</tbody>
</table>

Source: Douglas, 2006

In their conceptual model, Thomsen and van der Flyer, (2011) reconfigure this categorisation, condensing the major variables and their relations which are presented as a matrix of physical and human, and endogenous and exogenous, the latter referring to the context.
Obsolescence is referred to as a deficiency in utility or function relative to the conditions prevailing in the population of similar building stock (Kintrea, 2007; Nutt et al., 1976; Wilkinson, 2011). The suggestion is that obsolescence develops as the result of a variety of processes, ranging from physical weathering to changing levels of income or changing expectations about lifestyles, which are related to the building itself, and to the specific geographical, social, political or economic context (Figure 3.1).

Kintrea (2007) relates housing obsolescence to the increasing expectations of households about what is acceptable housing and normal standards, and to government policy. Thomsen and van der Flyer (2011: 11) describe the process of obsolescence as ‘the growing divergence between the declining performance of buildings and the rising expectations of users and proprietors’.

**Figure 3.1 Conceptual model of obsolescence**

Source: Thomsen and van der Flyer, 2011.
This understanding thus combines individual, social and contextual influences. The criteria that determine the obsolescence of buildings are many and diverse (Barras and Clark, 1996; Thomsen and van der Flyer, 2011), and are interrelated (Golton, 1997). This interrelation can be demonstrated using the example of the environmental challenge of energy performance which, on the one hand is influenced by the quality of the physical design and construction as assessed in the building regulations, but on the other hand, also depends on the occupants' patterns of behaviour or use. A low energy performance rating and high energy bills may stimulate improvement through renovation or retrofitting. On the one hand, improving energy performance has become a rationale for additional investment in structural improvement of dwellings. Alternatively, where this results in low demand and weaker market position, chances for improvements may be reduced, leading to proposals for demolition on a large scale (Office of the Deputy Prime Minister, 2003; Plimmer et al., 2008; Power, 2008; Sustainable Development Commission, 2006). Efforts to improve energy performance thus poses threats as well as opportunities for the existing older built stock (Power, 2008; Thomsen and van der Flier, 2011a).

Although comparatively little is known about the detailed dynamics of obsolescence and renovation, Shove and Pantzar (2005) apply the concept of ‘social fossilisation’ whereby domestic practices change or fall out of use making certain objects redundant, thus linking obsolescence to the discontinuance or transformation of ideas and skills, and evolution of technology (Shove and Pantzar, 2005b). An illustration is provided by chimneys which have become redundant. The practice of making an open fire in a hearth has been superseded by central heating which is seen as cleaner, more convenient and more effective at providing warmth.
3.3.4 The nature of adaptation

According to a technical view, when a certain level of obsolescence is reached a building may be adapted. Research on obsolescence of buildings in construction, property and real estate indicates that one way of deferring obsolescence is by adaptation either within the existing use or though a change of use (Kincaid, 2002; Wilkinson, 2011), with the level of intervention depending on the nature and extent of obsolescence. The traditional linear lifecycle thinking for a building is initial construction followed by use (the length depends on the construction and context), and at the end of the service life the building is renovated to produce another service life, or demolished (Erlandsson and Borg, 2003). According to the model put forward by Preiser, adaptation takes place at the end of the useful building life or at the point where continued current use is no longer perceived to be economically viable (Preiser and Vischer, 2005), although they also acknowledge that building interiors are changing constantly throughout the lifetime of a building. Thomsen and van der Flyer (2011) and Kohler and Yang (2007) see alteration and adaptation as a means of extending the longevity and usefulness of buildings. Douglas (2006) suggests that adaptation may occur at any time during the life, and is a more realistic view of what occurs in practice, as dwellings are often modified numerous times to suit the requirements of occupants during their life, or different households, with minor adaptations initially giving way to more major adaptations. Whereas, Brand (1994) argues that changes occur within and throughout building lifecycles—with buildings constantly refined and reshaped by their occupants, adapted to accommodate changes in society, financial prosperity, advances in technology, new regulatory standards and fashion. As the needs of building occupants are constantly evolving, older heritage buildings may fall short of current needs (Bullen and Love, 2010), or performance requirements. It is submitted that upgrading, through some degree of building adaptation, can overcome obsolescence (Thomsen and van der Flier, 2011), and is seen as a critical aspect of improving sustainability of the built environment (Cooper, 2001).
Adaptation is a term that is widely used, but has different connotations. Douglas (2006: 2) uses the term *adaptation* to describe any interventions to a building over and above maintenance to change its capacity, function or performance. As noted previously, it is widely recognised that adaptation is a valid method of conservation (Australia ICOMOS, 1999; Department of the Environment and Heritage, 2004; English Heritage, 2006). According to the Burra Charter *adaptation* means modifying a heritage place to suit the existing use or a proposed use (Marquis-Kyle and Walker, 2004). Although the precept of minimal intervention is questioned by Muñoz Viñas (2005), the established approach is to retain as much as possible of the original building [fabric], so as not to reduce the *authenticity* of a historic building or its cultural significance, while upgrading the performance to suit modern standards and changing user requirements (Heritage Council of Victoria and Heritage Victoria, 2009 Latham, 2000; Matero, 1993). Adaptation to meet current expectations of performance may involve interventions at various levels (Douglas, 2006; Feilden, 2003; Matero, 1993) and demand for changes to accommodate higher expectations of functional performance; the tension between functional requirements and cultural values is referred to in section 3.3.2, and illustrated by façadism.

In recent years, increasing environmental performance through energy efficiency has become ever more important, and this is recognised in the definition posited by Douglas (2006), where *adaptation* is interpreted in a broad sense, and taken to include any work to a building over and above maintenance to change its capacity, function (use) or performance i.e. any intervention to adjust, reuse or upgrade a building to suit new conditions or requirements. He identifies eight levels of intervention, from basic preservation works at one end of the spectrum to almost complete reconstruction at the other depending on the extent of dilapidation and deficiencies in performance of the building. In Douglas’ model, in common with the earlier discussion in section 3.3.1 of this thesis, a distinction is made between preservation and conservation—where the former implies maintaining a building in its existing
state. Conservation (termed *purposeful preservation*) is included in this model but its scope is limited to maintenance and stabilisation, towards the lower end of the scale of interventions (and equivalent to levels 1-3 of Feilden's degrees of intervention). In its narrowest sense, conservation is carried out through maintenance and repair activities, to arrest or slow down the rate of decay. However, conservation is more complex and, as discussed earlier, in its widest interpretation, can include a range or combination of actions. The test is whether the actions result in the retention of the cultural heritage significance of a place or object. Although the greater the degree of intervention, the more likely the impact on cultural heritage significance, as indicated by Figure 3.2. Typically, improving the energy performance of a building will involve modernisation, upgrading and improvement, and even partial demolition (such as the removal of internal plaster or timber floors to install insulation).
3.4 Framework for protection and management

This section outlines the regulatory and policy framework for the protection and management of heritage buildings in Australia and Victoria, including renovation.
3.4.1 National context

Australia is a signatory to several international conventions and recommendations that provide the context for the Australian regulatory framework and policies for managing the built heritage. (Pearson and Sullivan, 1995). The Australian Government’s central piece of environmental legislation is the *Environment Protection and Biodiversity Conservation Act 1999 (Cwth)*. Responsibility for heritage protection and management is organised according to thresholds for differing levels of cultural significance—national, state and territory, or local. Whilst the Australian Government is responsible for environment and heritage of national and world significance, responsibility for matters of state and local significance are assigned to the appropriate level of government. Different systems of decision making occur across the three levels of government and across local governments (Productivity Commission, 2006). Responsibility for heritage is organised according to thresholds for differing levels of cultural heritage significance – national, State or local.

3.4.2 Policy framework for renovation

Within the State of Victoria, the context for this study, heritage protection and management is divided between the two levels of government. The principal legislative instruments for protection of heritage buildings are the *Heritage Act 1995*, and the *Planning and Environment Act 1987 (Cwth)*. The *Planning and Environment Act 1987* provides the statutory framework for integrating controls in land use, development planning and environment protection, and also conserving buildings of cultural heritage significance. The *Building Act 1993* also influences conservation and management of buildings by virtue of building codes and standards, since the adoption of a uniform national approach through the *Building Code of Australia* (Australian Building Codes Board, 2013).
Victoria was the first state to introduce legislation for the protection of heritage buildings in Australia in 1975 (Davison et al., 1998). Since that time, all State and Territory governments have adopted legislation for the protection of historic heritage places (Davison et al., 1991), and conservation of built heritage has become a cornerstone of mainstream planning, at state and local (municipal) level. The number of protected places on statutory lists in Australia is estimated to be in the region of 160,000 (Productivity Commission, 2006), however, the absence of comprehensive data on heritage places (State of the Environment Committee, 2011) means that this is likely to be an underestimate. Within the State of Victoria alone, the number of individual historic heritage places currently registered as being of State significance is 2,262 and the number of properties subject to heritage controls at local government level is estimated to be 160,000 (Chris Benham and Geoff Austin, Heritage Victoria, pers comm. December 2011). Buildings of local heritage significance, which form the vast majority of heritage places, are covered by the Heritage Overlay provisions in Clause 43.01 within all Victorian Planning Schemes (Department of Transport Planning and Local Infrastructure, 2013a). Planning controls generally apply to changes to the exterior only. A planning permit is required from the local council for works that would alter the appearance, including: demolition or partial demolition of a building; externally alterations; construction or works to a heritage building. In some instances, internal alteration controls may also apply (Department of Transport Planning and Local Infrastructure, 2010). Works or alterations to a registered heritage place that affect the cultural heritage significance require a heritage permit (Heritage Council of Victoria et al., 2007).

The Burra Charter (Marquis-Kyle and Walker, 2004) provides the philosophical framework for conservation of cultural built heritage. The values-centred approach developed in the Burra Charter underlies the theory and practice of conservation in Australia, and has been adopted in Victoria. Although the notion of value itself has undergone a series of transformations, as noted previously, value remains at the very centre of heritage conservation practice
(Clark, 2006; Jokilehto, 1999: 18). Understanding the heritage significance and values of a place is the basis for making decisions about its management (Mason, 2002 Mason, 2002). The Burra Charter recognises that all places and their components change over time at varying rates, requiring intervention. The overarching philosophy is that the least amount of change is better, as change, in whatever form, is undesirable where it reduces cultural significance. The Charter discusses adaptation, (Article 21), which may be related to use as well as to modifications to the material aspects, or new services resulting from a new use. Adaptation is the most commonly employed form of conservation action according to Rowney (2004), and invariably involves alterations to the fabric. Both the significance of use as well as fabric are recognised by the Burra Charter. In the articles relating to adaptation and new uses, Articles 7.2 and 21.2 both refer to adaptation and minimal change to the fabric which could be interpreted as the fabric being significant, and that new uses associated with adaptation should respect this significance. Articles 7.1 and 23 refer to the cultural significance of use, and in the case of Article 23 the use may be continued, modified or reinstated. Such actions, it is stated, may even constitute preferred forms of conservation. The accompanying explanatory note to Article 23 elaborates: 'these may require changes to significant fabric but they should be minimised. In some cases, continuing a significant use or practice may involve substantial new work' [authors’ emphasis]. This could be interpreted either as a recognition of the use being more significant than the fabric, or a caution that, given the significance of the fabric, continuing the use no matter how significant, may result in unacceptable changes. There is some ambiguity in the Burra Charter over which should take priority—whether fabric or use. In addressing changes to built heritage, fabric or use, the Charter makes reference to compatible use, defined as ‘a use which respects the cultural significance of a place’ (Article 1.11) and which ‘involves no, or minimal, impact on cultural significance’. The inference here is that continuing existing uses that involve changes to significance are unacceptable. The use and adaptation of protected buildings in the light of the needs of contemporary life is encouraged—but with due regard to heritage significance. Rodwell (2007) argues that this involves
making best use, including enhancement and conservative development. However, there can be tension between heritage values and functional requirements, as noted by a recent roundtable discussion exploring the conflicts between places of historic significance that are also home, which determined that cultural significance can increase or decrease depending on society’s more pressing needs and aspirations (International Institute for the Conservation of Historic and Artistic Works (IIC), 2010). In discussing the tension between functional requirements and fabric, Muñoz Viñas uses a pertinent example of installing modern services into a historic building:

‘if a modern air-conditioning system is installed during its restoration, [but] this can require the alteration of some original parts of the building – or the installation of insulated pipes might be visible in some places. Under these circumstances, the building’s usefulness as historical evidence (its ability to function as historical evidence, its historical value, its historical meaning) is decreased, although its usefulness as convenient housing (its ability to function as convenient housing, its functional meaning, its functional value) are improved.’ (2005: 181)

Thus some functions or values are increased, often at the expense of decreasing others, and illustrating the dilemma in reconciling conflicting demands in renovation.

The next section outlines the emerging issues relating to renovation of heritage dwellings to improve environmental performance.

3.5 Renovation of heritage dwellings: issues

As discussed earlier in section 1.1, there is broad support for strategy to improve the environmental performance of existing dwellings, and the literature suggests that adaptation and renovation offers considerable opportunities for improvement, however, there are drawbacks associated with
the implementation of policies and extensive programmes focusing on reducing operational energy use through renovation.

3.5.1 Renovating existing buildings is complex

There is convergence among researchers that increasing the life of a building through adaptation can make a significant contribution to the sustainability of existing buildings, including lower material, transport and energy consumption and pollution (Bullen and Love, 2010). However, there are ‘challenges associated with retrofitting older building stock’ to improve energy-related performance (Marsden Jacob Associates and Department of Sustainability and Environment, 2009: 18). Bullen and Love highlight a number of broad issues in relation to adapting existing commercial buildings and improving performance, including on-going maintenance costs associated with an older building, technical problems associated with adaptation such as condition of the existing structure, services and fabric, and existence of hazardous materials, and difficulties in meeting regulatory standards for health and safety, and environmental performance which are also relevant to older residential buildings. Douglas (2006) and Latham (2000) further elaborate on the complexities of adapting heritage buildings which may be summarised as: technical difficulties associated with the building or systems; deficiencies in technical knowledge or skills; competency in procedures; capability to deliver on objectives whilst working within policy constraints; inadequate understanding of the existing building and its significance. Several technical publications in the form of ‘how to’ guides and case studies, have been produced; this guidance, aimed at homeowners and practitioners, seeks to achieve better energy performance whilst protecting those features that contribute to heritage significance (for example, Changeworks, 2008; Energy Saving Trust, 2005; English Heritage, 2008b; 2011; Heritage Council of Victoria, 2009; Historic Scotland, 2010; Prince’s Regeneration Trust, 2010).
3.5.2 Different understandings of sustainability

Within the built environment sustainability has become synonymous with ‘green’ design or systems to reduce energy and CO₂ emissions, and using environmentally friendly materials in buildings. For historic tangible resources such as buildings, Matero and Teutonio (2003) argue that the aim is notably different, as the physical resource is finite and cannot be easily reproduced. In this context, sustainability means ensuring the continuing contribution of heritage to the present through the thoughtful management of change responsive to the historic environment and to the social and cultural processes that created it. This different understanding of sustainability leads to a focus on different aspects: in the former, a preoccupation with improving efficiency through introduction of technical systems, and the latter with avoiding unnecessary interventions into the physical fabric, or that would otherwise reduce cultural heritage significance into the future. Thus a contention emerges from the two understandings.

To overcome conflicts amongst different interests and values, Pereira, (2007) proposes a further understanding, termed cultural sustainability. The notion of cultural sustainability reflects the objectives of conservation and sustainability i.e. to use for present needs and to transmit the maximum significance for future generations. This has similarities with the approach of sustainable conservation advocated by Muñoz Viñas (2005: 183) who regards sustainability as a ‘crucial notion’ underlying contemporary conservation, contends that the objective should be ‘maximum benefit’ to present users whilst not reducing meaning to future users. However, as discussed previously in section 3.2, the benefits of conservation are not easy to measure. Both of these precepts require that the present generation may use and adapt the cultural asset only to the point where future generations will not be reduced in their capacity of understanding and their multiple meanings and values. Whilst having merit, this raises issues over how to ensure that present use will not reduce significance of cultural heritage for the future, and how to predict future generations’ values.
3.5.3 What takes precedence—environmental performance or heritage?

As attention has turned to reducing energy use and related emissions from buildings, there is suggestion that heritage conservation has become displaced by other objectives such as environmental sustainability (State of the Environment Committee, 2011). In its report into the economic and environmental potential offered by energy efficiency, the Productivity Commission (2005: 236) noted that important issues such as the consequences of diversity among individuals and buildings, and the loss of building features that individuals value more than energy efficiency, had been largely overlooked by policy-makers, noting that ‘Some home buyers may prefer to have a less energy-efficient home if that is what is required to obtain certain highly-valued characteristics’. Furthermore, higher levels of energy efficiency may only be sustained through trading-off other features that occupants’ value.

There is a perception amongst other groups, as noted by the recent independent report presented to the Australian Government Minister for Sustainability, Environment, Water, Population and Communities (State of the Environment Committee, 2011), that heritage is expendable, and at risk at being over-ridden by the green building agenda, with current sustainability policies and guidelines biased towards removing historic buildings and fabric and replacement with recycled materials and new energy-efficient structures, and modifications to the building envelope and significant investment in efficient systems or innovative technologies are required to satisfy current approaches. In the face of overwhelming pressure for heritage buildings to meet new environmental and energy performance requirements, May Cassar (2009: 8, 10) has observed that, in borrowing cultural assets from future generations, ‘If we are to lose original features in order to make historic buildings more energy efficient or to increase options for reuse, we must quantify and compare the performance of old and new measures ... Since the
measures that we take will increasingly affect the integrity and therefore the meaning of historic buildings, we need evidence to justify the inevitable changes in significance and value to the public that major interventions to reduce and improve energy use entail’.

3.5.4 Household expectations

As discussed in section 3.3.2 and 3.3.3 environmental, legal, as well as functional and social factors contribute to obsolescence of the existing dwelling stock, and also influence the level of intervention. There is a suggestion that the extent of renovation activity is an indication that the older housing stock is failing to meet the (increasing) expectations of households (Kintrea, 2007). In examining the relationship between obsolescence and housing aspirations, Kintrea contends that some elements of the housing stock will inevitably become obsolete with improvements in functionality. In this scenario, the physical resource, such as space, services and condition of the physical fabric, and capacity for adaptation, in conjunction with the cultural resource (Nutt et al., 1976; Kintrea, 2007), are weighed against the expectations of households about what housing should provide, with different weightings on attributes depending on a household’s needs and aspirations. Kintrea observes that in some instances the physical resources of traditional dwellings can be mitigated by the ‘cultural resources of their high quality and attractive townscape settings’ (Kintrea, 2007: 332). However, depending on cultural preferences, changes in households’ needs associated with changing household arrangements; demands for internal space driven by the complex social life of households; and the accumulation of goods associated with activities necessary for contemporary living may over-ride other considerations. Both Shove (2003) and Kintrea (2007) note a general shift upwards in expectations of ‘comfort, cleanliness and convenience’; technical innovations such as indoor plumbing and central heating, have ‘implications for what people expect and for how they conceptualise what is normal and necessary’ (Shove and Hand, 2005: 11). Kintrea argues that public policy also plays a significant role in promoting new and higher standards, leading to an
‘upward leverage of expectations for all households, therefore, contributing to the process of obsolescence’ (Kintrea, 2007: 323). Whilst demand for older housing with high cultural resources may continue, Kintrea contends that there is an ‘attributes gap’ between older housing and new housing that can offer more features, including en suite shower rooms in addition to family bathrooms; utility rooms; patio doors opening up into outdoor living spaces; large dining kitchens; a second toilet; and off-street parking. Features such as central heating and double-glazing, although once luxury items are now seen as increasingly ‘normal’. The incorporation of ‘environmentally-friendly’ features in new housing, often absent from older housing, is also rising in importance.

Taking a cultural approach to obsolescence and renovation, Shove and Hand (2005) recognise the link between elements of the home and the kinds of activities and ways of life that can be pursued or imagined within the home. Images of normality are influential as consumers attempt to match possession with desired performance that is, how they see themselves living. A question therefore emerges over whether existing dwellings can accommodate the changing images of domestic life identified by Shove (2003) and Shove and Hand (2005) and which are themselves shaped by available forms and designs. Where new, or more desirable products are available, there is also a risk that the gap between existing and desired performance for residents of older housing will widen. If this cannot be bridged by renovation to provide new amenities owing to physical, cost and other constraints, the long term desirability of some forms of older housing may be in doubt. The obsolescence of older properties is inadvertently encouraged by government policy to improve the quality and sustainability of new homes; one of the most notable differences between new and older homes is the ability to meet standards for energy efficiency.
3.5.5 Performance of older buildings

As noted earlier, the environmental performance of traditionally constructed buildings is imperfectly understood. A lack of reliable data to inform decisions to upgrade these buildings to meet regulatory obligations driven by the climate change agenda, and to meet homeowner aspirations, is a concern expressed by Swallow (2011). This issue is illustrated in an empirical study by Hubbard (2011) in the UK which challenges the accepted standard adopted for air permeability incorporated into the approved software for assessing energy performance of existing buildings. Further, a recent study of thermal transmittance through building fabric (Rye, 2011) indicates that performance of traditional buildings is somewhat better than previously assumed using standard assessment methods. Initiatives which seek to improve aspects of environmental performance, if not proven, can irreversibly alter the significance, whether architectural, historic or other significance, without achieving the improved performance being forecast—a point which is eloquently made by Cassar (2009).

3.5.6 Regulatory standards and compliance

Existing buildings in Victoria are subject to increasing performance requirements relating to energy efficiency through the Building Act 1993 and associated regulations and standards. As from 2008, any new building work (which includes alterations and additions to a heritage building) must comply with the Regulations. In some instances, where the building work exceeds 50 per cent of the volume of the existing building, the existing building may also need to be brought into compliance\(^5\). Further, existing Class 1 dwellings are required to meet the same standard as for new dwellings. Generally, the Regulations provide the Relevant Building Surveyor with discretion as to how these requirements are applied. Heritage dwellings are not exempted from the requirements for energy performance, which have the potential to adversely impact on the cultural significance of the heritage building (Balderstone, 2012).

\(^5\) The Building Regulations 2006 (s.608).
As noted in Chapter 2, the majority of existing dwellings in Victoria were built prior to the introduction of standards for energy performance, and many older dwellings do not meet contemporary standards for environmental performance; their physical characteristics may present difficulties for achieving standards as required by the building regulations. The inability to insulate walls, under floors, or to add to the roof area, where this would adversely impact on heritage values, could affect the ability of heritage structures to meet contemporary energy requirements as determined by standard assessment methods. Currently there is no data available on how many heritage buildings may be affected, and the impacts. Research by Woods et al. (2009) demonstrates that benign improvements such as the use of shutters, heavy curtains and secondary glazing can significantly improve thermal performance and comfort, and draught stripping can reduce leakage or drafts by 85 per cent. However, modest measures such as these are unlikely to be sufficient to meet the standards for thermal performance and energy efficiency (Wong et al., 2011), and more drastic interventions would be necessary for compliance. Whilst many small adjustments can be made to accommodate the changing needs of inhabitants without detriment to the cultural heritage significance, making a functional change can result in the historic evidence being compromised, often to an unacceptable extent. As observed by Rowney (2004) considerable change to the internal fabric often occurs during adaptation, even though the exterior of the building may experience little change. Changes may also affect intangible values linked to the use of the place, including associations, and meanings.

### 3.6 Digest: the relevance of cultural heritage conservation

Having first considered the theoretical principles underlying cultural heritage conservation from the literature, this chapter then explored the role of heritage buildings in contemporary society. Protection and management of cultural heritage is embedded within the policy and regulatory framework in Australia.
However, the conservation of built heritage has undergone a ‘tectonic’ shift, with heritage buildings and conservation having to play an increasing part in a wider strategy to meet social and other objectives. In doing so, long-held tenets that underpin conservation of historic built heritage are losing ground to other goals and understandings including sustainability, and demands for conservation objectives to be counterbalanced with contemporary use requirements.

This chapter has explored how adaptation and renovation of heritage buildings intersects with concerns about environmental performance and other priorities. A review of the literature on improving the environmental performance of existing dwellings indicates that renovation as a strategy can contribute to objectives for improving environmental performance of the existing building stock. However, strategies for reducing energy and related emissions in building stocks are not without issues, and need to be examined closely. In this era of environmental concern, heritage buildings face significant challenges. The environmental performance of buildings is still an area of emerging understanding, and the environmental value of heritage buildings is not well understood—due to little research having been undertaken in this field. There remains a deficit of information relating to the performance of the older stock of dwellings, and limited empirical research relating to energy use and renovation of heritage dwellings.

The next chapter examines the current approaches and strategies that are used to improve the performance of existing dwellings as a means of strengthening environmental sustainability in the built environment.
Chapter 4

‘No technological project is technological first and foremost’

Bruno Latour, 1996 p. 32

4 Environmental performance in existing dwellings: current approaches

Having explored the rationale for the conservation of built heritage, this chapter considers various ‘technologies of government’ put in place to govern the environmental performance of existing dwellings in Victoria, as a prelude to investigating how these objectives are reconciled. Whilst Rose (1999, following Foucault) uses this term to describe government schemes, programmes, techniques and devices that seek to shape conduct in certain ways so as to achieve certain objectives, contemporary forms of life are, in addition, significantly shaped by a range of material technologies and technological systems (Healy, 2008; Soufoulis, 2005).

In discussing how policy is put into effect, this chapter examines current technical and behavioural approaches, and their limited contribution to the overall goal of reduced energy consumption and associated emissions in the built environment. Where examples are used, these are drawn primarily from thermal performance and energy use, as these form the focus of attention in government policy, having become closely associated with measures to reduce environmental impacts.
4.1 Policy context

As discussed in Chapter 1, reducing energy use from existing buildings features prominently in policy and programmes at all levels of government, driven increasing by an worldwide focus on sustainability and climate change (Elliott and Thomas, 2009; Gorse and Highfield, 2009; Greene and Pears, 2003). Current policy in Australia has emerged from the international policy agenda process, in response to global environmental concerns.

Whilst building-related environmental impacts have become increasingly important due to concerns about climate change and the sustainable consumption of resources, and also because of the link to building obsolescence (section 3.3.3), there is debate on the exact meaning of performance (Larsson, 2004). Some clarification is provided by international technical specifications and standards which set out the principles and methods for assessing environmental performance, broadly defined as being related to environmental impacts and environmental aspects (International Organization for Standardization, 2008). In identifying and describing issues to be taken into account in the development and use of methods in assessing the environmental performance of both new and existing buildings, International standard ISO 21931-1:2010, *Sustainability in building construction – Framework for methods of assessment of the environmental performance of construction works – Part 1: Buildings*, the focus is on reducing energy and CO₂ emissions, and resource use, with a component referring to human health (International Organization for Standardization, 2010).

This section provides an overview of current strategy and the policy framework at national and State levels relating to the reduction of energy and CO₂ emissions from existing dwellings in Victoria.
1.6 Current policy targeting dwellings

A central component of government policy at the time of writing (2013) is the *National Strategy for Energy Efficiency* (NSEE), (Council of Australian Governments, 2009; 2011; Department of Climate Change and Energy Efficiency, 2012b), a partnership agreement setting out a ten year work plan between the Australian, state and territory governments to address energy consumption and greenhouse concerns. The Strategy aims to provide a nationally consistent and coordinated approach and proposes to substantially improve minimum standards for energy efficiency through regulation, as well as financial incentives and information and accelerate the uptake of new energy-efficient products and technologies. Amongst the key themes included in this strategy is making the built stock more energy efficient, with measures directed to the regulation of minimum energy performance requirements for new residential buildings and major renovation of existing dwellings through the *Building Code of Australia* (measure 3.3.1), and the mandatory disclosure of residential building energy and greenhouse performance at the time of sale or lease, commencing with energy efficiency (3.3.2). Other measures include providing incentives for residential building owners to undertake energy efficiency improvements (3.3.3) and information on energy efficient housing options (3.3.6). The Strategy also refers to the need for improved understanding of the energy efficiency of Australia’s existing housing stock (3.3.7).

At state level, the most recent policy document, *The Energy Efficiency for Victoria Action Plan* (Department of Sustainability and Environment, 2006), published by the former Government of Victoria, aims to drive improvements in energy efficiency and greenhouse gas abatement, through a combination of minimum standards for energy efficiency and disclosure of building energy performance. The plan identifies one of the main challenges as improving the energy efficiency of the existing housing stock (p. 17), with policies and programmes aimed at households grouped under the following main headings: improving the performance of the built environment, information and behaviour
change, rebates and incentives, and providing clear signals to encourage energy conservation. Following a change in government in November 2010, the policy programme of the current Liberal National Coalition government does not appear to diverge from the path set out by the previous Labor government; as well as a commitment to ‘support the transition of all existing housing stock to meet an average of 5 star energy rating as soon as possible’ (The Liberal National Coalition, 2010: 6), it is continuing with programmes introduced under the previous administration, including the Victorian Energy Saver Incentive/ Victorian Energy Efficiency Target (VEET), and the roll out of ‘smart meters’ to residential properties in Victoria. The Energy Saver Incentive scheme has been extended to include subsidies for in-home energy displays to provide households with data on energy consumption collected from Smart Meters (Department of Primary Industries, 2012). The focus continues to be on energy efficiency, with measures directed at influencing behaviours towards upgrading existing homes and the uptake of particular products, technologies or services aimed at reducing energy derived from brown coal. The Department of Primary Industries introduced the Victorian Renewable Energy Target (VRET) scheme as a market based measure aimed at increasing the share of electricity consumption in Victoria from renewable energy sources. The VRET scheme was announced in June 2006 with a target of 10 per cent renewable electricity by 2016 (ABS, 2012 Australian Bureau of Statistics, 2012c; Department of Primary Industries, 2012).

4.2.1 Linking energy efficiency and greenhouse gas emissions

Energy efficiency is broadly defined as the ratio of energy output of a process to energy input (Greene and Pears, 2003; Herring, 2006; Williamson et al., 2010). Using this physical definition, reducing energy input for a given level of end-use energy service will give an increase or improvement in energy efficiency or alternatively increases the end-use energy services delivered for a given energy input. The desired outcome of using less energy while maintaining expected standards is reflected the Building Code of Australia, which asserts,
Energy efficiency for housing means reducing the load on equipment that directly consumes energy (such as heating and cooling equipment) and the ways that heat flows into and out of the house through its enclosing fabric. ... Better fabric thermal performance can mean smaller equipment, running for less time', and also, 'houses with fabric that keeps conditions inside comfortable for the occupants ... will be less likely to use heating or cooling services, thereby reducing energy demand and greenhouse gas emissions’ (Australian Building Codes Board, 2010: 7-8).

Increasing energy efficiency through technical interventions to existing dwellings has become a key focus for policy and programme development at all levels of government (COAG, 2009; Prime Minister’s task Group on Energy Efficiency, 2010; Sunikka, 2006) within the policy agenda of climate change mitigation, and framed within broader concerns about sustainability. Interventions designed to improve the environmental performance of existing dwellings commonly include such options as retrofitting ceiling insulation, solar hot water, solar electricity, efficient heating systems, lighting and appliances.

Most programmes aimed at renovating and retrofitting involve rebates and other rationally based incentives to encourage uptake of more efficient or renewable technologies, and are promoted to households on the basis of saving energy, improved comfort and saving money (Maller and Horne, 2011; Sustainability Victoria, 2012). The pathways for improving energy-related building performance focus on technical interventions to improve energy efficiency and the use of renewable energy, and the need to adopt practical and cost effective technical solutions (Marsden Jacob Associates and Department of Sustainability and Environment, 2009). The principal instruments adopted by governments to implement policy are: regulation, financial incentives, and provision of information resources (Meijer et al., 2009), with the latter often in combination with the other approaches, to achieve desired outcomes. The building regulations are central to delivering
environmental performance objectives, and these are examined in the following section.

4.2.2 Building regulations: Part J ‘Energy Efficiency’

Regulations are at the forefront of the technical approach, and have a critical role in policy to reduce energy and associated emissions in Australia. Building regulations set the minimum standards for the design, construction, and performance of buildings, the goal being to ensure the achievement of health, safety, amenity and environmental standards. Together with the standards that underlie them, the building regulations define the minimum environmental performance requirements for buildings. The Australian government introduced provisions into the BCA in 2003 aimed at improving the environmental performance of new houses. Whereas previously the emphasis had been on efficiently using energy, added weight is now given to reducing greenhouse gas emissions in the Objective, Functional Statement and some Performance Requirements, the aim being to reduce greenhouse gas emissions through increased efficiency of the building envelope and services (Australian Building Codes Board, 2010); thereby reinforcing the combined objectives of energy efficiency and reducing emissions.

The building assessment process set out in the BCA offers a number of optional pathways to demonstrate compliance with performance requirements. The Deemed to Satisfy (DTS) approach or predictive modeling software is widely used to demonstrate compliance with Victorian housing standards (Australian Building Codes Board, 2010; Productivity Commission, 2005), and is the recommended method for compliance for alterations and additions to existing dwellings in the Practice Note 2011-55:

_in cases where the existing dwelling does not have a HER it would usually be more practical to use the DTS elemental provisions than HER software. However, if using HER software to assess an alteration or addition to an existing dwelling that has not previously been assessed using HER software it_
will be necessary to provide two HERs to the RBS. The first HER would assess the existing building as constructed to determine what star rating it currently meets and the second HER would use this first star rating and the required star rating for the new building work to determine the proposed star rating for the whole building design incorporating the proposed building work (Building Commission of Victoria, 2011b: 7)

Current DTS provisions for housing include insulation of roof, walls, floors; external glazing, including shading, in order to avoid or reduce the use of mechanical heating and cooling. The provisions also include sealing of buildings to reduce energy loss through air leakage; natural ventilation and internal air movement, where appropriate, to avoid or reduce the use of mechanical air-conditioning; insulation of piping and ductwork to hot water and heating appliances; and measures to reduce greenhouse gas emissions from electrical appliances.

The *Nationwide House Energy Rating Scheme* (NatHERS) provides the framework for House Energy Rating Software against which building performance is assessed, and focuses on the operational energy efficiency of the thermal envelope (Department of Industry, 2013). The estimated performance relates to the heating and cooling load (based on energy used per m$^2$ floor area) required to achieve a determined star rating in each of Australia’s climate zones. First introduced for new dwellings in 2005, the minimum performance of 5 stars or equivalent was subsequently extended to the alteration or extension of existing dwellings in Victoria in 2008, and increased to 6 Stars, or equivalent from May 2011. Heritage buildings are not exempted from the energy efficiency rating standard. Furthermore, the BCA incorporates consequential improvements; where new work, whether renovation or extension, exceeds 50 per cent of the original building volume, the entire building must comply with the minimum energy efficiency standard (*Building Regulations, 2006*: Regulation 608). At the time the fieldwork for this
study was undertaken (2011), renovations to dwellings in Victoria required a 5 star energy rating, or equivalent, for the building fabric, water saving taps and fittings, and the installation of either a rainwater tank for toilet flushing or a solar hot water service. The 5 star standard was promoted on the grounds of significant abatement of greenhouse gas emissions, and claims that the new standard would provide better quality, more comfortable homes that consume less energy, resulting in lower energy bills for households (Allen Consulting Group, 2002). However, considerable uncertainty exists about the effectiveness of these standards in reducing energy consumption, as they have not been subject to ex post evaluation (Productivity Commission, 2005: 205). The Australian Government commissioned CSIRO to undertake an evaluation of the 5 star energy efficiency standard in July 2011, and findings of the evaluation are expected to be available by end of 2012. At the time this thesis was submitted the review of Victoria’s five star standard had not been completed.

4.2.3 Tools to improve energy performance

The development and use of building assessment tools is a common strategy to promote a more efficient and sustainable built environment, with many countries either having adopted or in the process of developing their own assessment methods (Ding, 2008). There is a wide array of assessment methods and tools available (Building Research Establishment, 2006). The development of home energy rating tools in Australia is charted elsewhere (Kordjamshidi, 2010; Williamson et al., 2006). This section examines the methods that are mandated in Victoria and which are central to the improvement of the energy performance. In critically evaluating the use of assessment methods, information is drawn from various secondary sources including reviews, as well as material published by peak bodies and industry.

Section 1.0.9 of the Building Code of Australia (Australian Building Codes Board, 2010) lists the assessment methods that can be used to determine that
a building solution complies with the performance requirements. The Deemed to Satisfy (DTS) energy efficiency provisions for dwellings provide prescribed acceptable construction solutions, and for verification of performance using computer simulation software approved by the *Nationwide House Energy Rating Scheme* (NatHERS). The most commonly used approach amongst practitioners, the designer must show that the proposed building meets the performance requirements for the elements of the building. This prescriptive method of compliance is detailed within each part of the BCA. The other option is formulating an *Alternative Solution* that complies with the performance requirements or is shown to be at least equivalent to the Deemed to Satisfy provisions (Australian Building Codes Board, 2010; Building Commission of Victoria, 2011b). However, there is heavy reliance on the predictive *House Energy Rating Software* (HERS) to evaluate energy performance.

Three software packages accredited under NatHERS have been mandated for use in Victoria, Accurate, BERS Pro, and FirstRate (Building Commission of Victoria, 2011a). Verification through approved HERS software to obtain a NatHERS star rating based on a computer simulation of the dwelling, requires detailed information about construction, layout, shading, glazing and ventilation, while the software assumes other non-variable data, as specified by the NatHERS protocol, such as occupancy profiles, casual heat loads and appliance use. Changes made to any of the input or non-variable data will determine the star rating realized and ultimately whether or not compliance is achieved. To produce a NatHERS rating, the simulation uses a reference meteorological year of hourly weather data assumed to be the most appropriate to the location chosen from a database of climate zone files which form part of the scheme. In accordance with the location, determined by postcode, the dwelling is fixed to operate under a standard control regime. Standardised occupancy profiles are adopted within NatHERS, with number of occupants and associated casual loads determined as a function of the dwelling floor area. The star rating is derived from the sum of predicted heating and cooling energy loads normalized to floor area (expressed as
annual MJ/m$^2$ of conditioned floor area) (Table 4.1). An adjustment is made to the total load according to the floor area so that small houses are not too disadvantaged (Delsante, 2005; Williamson et al., 2010). Dwellings are rated using a 10 star band, with 0 stars being inefficient and 10 stars indicating the highest level of energy efficiency.

Table 4.1 Total thermal requirement [energy loads MJ/m$^2$ per annum] under NatHERs, for climate zones across 6 performance standards, Victoria

<table>
<thead>
<tr>
<th>Climate zone</th>
<th>5 Star (MJ/m$^2$)</th>
<th>6 Star (MJ/m$^2$)</th>
<th>7 Star (MJ/m$^2$)</th>
<th>8 Star (MJ/m$^2$)</th>
<th>9 Star (MJ/m$^2$)</th>
<th>10 Star (MJ/m$^2$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Melbourne</td>
<td>21</td>
<td>149</td>
<td>144</td>
<td>83</td>
<td>54</td>
<td>25</td>
</tr>
<tr>
<td>Tullamarine</td>
<td>60</td>
<td>182</td>
<td>138</td>
<td>100</td>
<td>64</td>
<td>30</td>
</tr>
<tr>
<td>Mildura</td>
<td>27</td>
<td>143</td>
<td>110</td>
<td>81</td>
<td>53</td>
<td>25</td>
</tr>
</tbody>
</table>


As noted above, the dominant approach to achieving environmental aspirations is based on a technical or engineering framing of the problem, which focuses on reducing energy and CO$_2$ emissions associated with existing buildings through physical interventions such as installation of high levels of insulation, energy efficient appliances, and low- and zero-carbon technologies, designed to improve the thermal efficiency of the housing stock and energy consuming services within domestic properties.

4.3. Policy targeting behaviour change

In addition to targeting efficiency of the building envelope and systems, a variety of other informational and economic initiatives have been introduced, aimed at influencing individual choices and changing behaviours relating to energy consumption. Large-scale schemes such as the *Energy Efficient Homes Package* administered by the Federal government, provided rebates
for the installation of home insulation and replacement of electric storage hot water heaters; the *Green Loans* programme provided home audits and offered financial incentives to householders to invest in solar and energy efficient technologies. In Victoria, the *Victorian Energy Saver Incentive/ Victorian Energy Efficiency Target* (VEET) established in 2007, aims to increase the uptake of energy efficient technology, through incentives to householders for selected energy efficiency upgrades including lighting, water and space heating and better insulation (Essential Services Commission, 2012; Department of Primary Industries, 2012). Other incentives included *ResourceSmart* rebates for retrofitting solar and gas hot water, and water-saving devices (Sustainability Victoria, 2012), and attractive feed-in tariffs for generation of renewable energy. At a local level, municipal councils and non-governmental organisations promote energy efficiency through advice, education, and other initiatives such as the *Moreland Solar City Project*. Other measures include the introduction of mandatory energy efficiency labeling of certain household appliances. A formidable array of information resources is available, including the development of sustainable building and renovating guides such as *Your Home – Technical Manual* (Department of Climate Change and Energy Efficiency, 2010). A scheme for mandatory disclosure of residential building energy, greenhouse and water performance at time of sale or lease is currently being developed (Department of Climate Change and Energy Efficiency, 2012c). Central to the strategy to reduce energy use, and shift to renewable energy technologies is the Carbon Tax, which came into effect in July 2012. Part of the Australian government’s *Clean Energy Plan* to reduce CO₂ emissions, the scheme applies to larger organisations which emit more than 25,000 tonnes CO₂ or equivalent per year, mainly energy companies and industry, who are required to purchase carbon units for their CO₂ emissions. The tax is estimated to increase household energy costs between 9 and 14 per cent (Australian Government, 2012). Although the overall impacts on the building and construction sector are uncertain, the cost of materials and other inputs used in building and construction are predicted to increase on the supply side, with changed investment activity on the demand
Demand for energy efficient buildings may be increased over the longer term (CIE, 2011).

Strategies in relation to environmental performance, including energy use, are divided between technical and behavioural solutions, with measures taking the form of either retrofitting, behavioural change programmes or a combination of both (Guy and Shove, 2000; Maller and Horne, 2011) to achieve goals. A review of more than 100 programmes by Moloney et al. (2010) aiming to reduce energy or resource use primarily in the residential sector in Australia, including Victoria, identified a range of approaches; these typically involve incentives to encourage retrofitting, replacement of inefficient appliances or infrastructure projects (e.g. shifting from coal-fired to solar or other renewable energy), providing information, or education (e.g. auditing). Initiatives framed around behaviour change have become an increasingly popular means to achieve social change (Maller and Horne, 2011), and widely adopted by government and non-governmental organisations (Darnton et al., 2011; Moloney et al., 2010; Productivity Commission, 2005).

Reviews of behaviour change theories and strategies reveal a wide range of models and assumptions (Darnton, 2008; O'Dwyer et al., 1993; Jackson, 2005; Shipworth, 2000) which have differing emphasis and variables. Although there is no universally accepted theory of behaviour change, models identify a range of factors, whether internal or external, which can shape behaviour, depending on the context (Kollmuss and Agyeman, 2002). The dominant understanding is that behaviour is a causal consequence of individual attitudes. Thus initiatives designed to achieve change in households focus on the factors that shape human behaviour, and ways of influencing individual motivations, values, beliefs is common across many programmes. Even so, there is little agreement about what strategies are most effective for changing behaviour.
Strategies and interventions to change behaviour in relation to environmental performance and energy use are informed by rational choice and social-psychological models, which make assumptions about the links between attitudes and motivations in influencing human action. Most programmes aimed at retrofitting involve rebates and similar rationally based incentives to encourage uptake of sustainable technologies, and are promoted to households on the basis of efficiency and saving money. Policy aimed at reducing energy and emissions has been based on what is referred to as the ‘ABC’ approach to behaviour, in which energy use is seen to be the outcome of individual attitudes (A), driving behaviour (B) that people choose (C) to engage in (Shove, 2010). As noted by Barr and Gilg (2007: 362), ‘Most policies, especially at the national level, make an implicit assumption that the means by which to resolve environmental issues is to make individuals aware then provide accurate information on how to ameliorate the problem, which in turn should lead to a decision to act, and then finally a behavioural change’.

In strategies of intervention, based on the information deficit model of behavior change, the core presumption is that given better information or more appropriate incentives, individuals will choose to adopt pro-environmental behaviours (Blake, 1999; Shove, 2010). However, studies demonstrate that whilst information may increase knowledge, it does not necessarily lead to action (Abrahamse et al., 2005; Shipworth, 2000), and attitudes are not always a strong, direct, or consistent predictor of environmental behavior; the disparity between attitudes and actions is described as the value-action gap (Barr, 2006; Blake, 1999; Kollmuss and Agyeman, 2002).

Attempts to promote pro-environmental behaviour including energy-led renovations have been based mainly around economic behaviour and social-psychological models. The basic tenet of the rational choice model, which guides much of existing policy, is that consumers make decisions by calculating the individual costs and benefits of different courses of action and choosing the option that maximises their expected net benefits. Rational choice models foreground the role of information, education, social marketing
and other voluntary measures to influence individual’s choices and behaviours in determining behavioural outcomes. Critics of rational choice models argue that many of the choices people make are derived more from emotional responses rather than from cognitive or conscious deliberation (Jackson, 2005), and that human behaviour is derived from social, moral and altruistic motivations in addition to self-interest. Further, social and interpersonal factors continually shape and constrain individual preference (Shove, 2003; Guy, 2006).

In an international review of behaviour change initiatives, Southerton et al. (2011: 14) noted that the focus tends to be on individuals as ‘it is perceived to be politically easier to tackle individual consumer decisions as opposed to cultural conventions and social norms’. Government policies and non-government organisations actively encourage households to take responsibility for environmental issues (Connolly and Prothero, 2008) through campaigns, educational programs and regulation. Collectively, these efforts are often aimed specifically at reducing household energy and water consumption.

‘Behaviour’ in behaviour change campaigns and programs is framed using a social psychology definition, which makes assumptions about the links between attitudes and motivations in influencing human action. By understanding human action in this way, it is believed householder behaviour can be changed utilising a suite of techniques such as personal contact, extracting a commitment from participants and community engagement (McKenzie-Mohr, 2011). Often, fundamental changes are sought solely through provision of information (Sofoulis, 2005 Sofoulis, 2005).

Interventions to change energy use in homes tend to focus on the provision of information and advice, or fall within the scope of structural strategies, which often include technical applications such as the introduction of energy saving
infrastructure or technology (Steg, 2008). Generally speaking, behavioural interventions can be targeted at the individual, interpersonal or community, or structural levels (Halpern et al., 2004; Jackson, 2005) aiming to influence attitudes (change them to desirable attitudes or make desirable attitudes more conspicuous), norms (social or person expectations of correct behaviour) or broader opportunities or rules for action. Interventions include informational (information campaigns, labelling, feedback, etc.), social (eliciting a verbal commitment, social comparison and support, etc.), structural and economic approaches (market-based instruments, investment in infrastructure, regulation, etc.) (Steg and Vlek, 2009).

Psychological strategies are aimed at changing motivations, cognitions and norms related to energy use and conservation. The assumption is that such changes will be followed by changes in behaviour and consequently by energy savings. Most psychological studies so far have focused on the effectiveness of informational interventions, with limited studies looking at technical interventions (Abrahamse et al., 2005; Steg, 2008).

Within social psychological theory approaches to understanding or accounting for energy use behaviours are founded on expectancy value, norm based, or unconscious habit. Recent efforts have also focused on providing integrative theoretical frameworks that encompasses these diverse determinants of behaviour including attitudes values, beliefs, contextual forces, personal capabilities and resources, and individuals habits and experiences (Stern, 2000; Wilson and Dowlatabadi, 2007). These efforts are criticized for underestimating the importance of addressing factors beyond the individual’s control (Darnton, 2008). Further, as the number of contextual factors increases, along with uncertainty over their history, their dynamic qualities, their interdependence or their precise role in promoting or preventing different behaviours, ‘the more muddled the picture becomes’ (Shove, 2010: 1275). Although recognizing that much consumption is derived from habits and
routines, in the behavioural model such activity features as an internal factor, interacting with other factors to determine the end behaviour. However, this view is at variance with sociological theory, where habits or routines are a consequence of human practices, not a factor determining behavioural outcomes.

Economic and psychological approaches are highly influential in shaping policy and strategies aimed at reducing environmental impacts. Within these approaches, pro-environmental behaviour is portrayed as a product of both internal (psychological) and external (social, economic, physical) drivers and constraints (Nye et al., 2010; Stern, 2000; Wilson and Dowlatabadi, 2007, 2010). However, these are criticised for their emphasis on individual attitudes and values, neglect of some key aspects of consumption including habit and routinised activity, and inability to fully explain environmental actions (Darnton, 2008; Jackson, 2005). For instance, studies have demonstrated that pro-environmental intentions and behaviours do not necessarily correlate with reduced energy consumption in the household (Gatersleben et al., 2002; O’Callaghan et al., 2012); and the linkage between attitudes towards energy saving and actual behaviour is not consistent (Abrahamse and Steg, 2009). Current environmental policy and programs aimed at householders assume particular causal links between householders’ concern for the environment and their uptake of sustainable technologies. This assumption is reinforced by taking for granted a link between householders’ attitudes towards the environment and changes to behaviour in the home. Efforts to improve the environmental performance of everyday household activities based on such untested links further assume that the installation of sustainable technologies, accompanied by piecemeal changes to behaviour, will curb household consumption and mitigate their domestic contribution to climate change—an assumption which is disputed by Maller and Horne (2011).
Research by Poortinga et al. (2004) examining household energy use suggests that attitudinal variables may be too limited to fully explain all types of environmental behaviour, and that contextual factors have a role. In a study of households in Melbourne, Newton and Meyer (2012) found individual predictors to be less influential than contextual factors in accounting for per capita energy consumption. Lutzenhiser (1992: 53) argues that economic rational and attitudinal approaches are ‘severely flawed’. Both are detached from their socio-cultural context, and separated from much that is potentially explanatory (Guy and Shove, 2000; Moloney et al., 2010).

There has been recent growth in interest in research of energy consumption using sociological approaches that explore lifestyle, social structures and practices, and cultural context (Lutzenhiser, 1993; Guy, 2006; Shove and Wilhite, 1999; Røpke, 2009; Moloney et al. 2010). The sociological literature challenges the dominant techno-economic paradigm, and rational choice model of behaviour, which emphasise technological solutions and individualism, arguing for an integrated approach to understanding energy consumption, and resolving the relationship between technology and behaviour by locating human activities within the wider socio-technical context, as a more effective means to reducing energy consumption (Crosbie and Guy, 2008; Warde 2005).

4.4. **Empirical studies: renovation and environmental performance**

Interest in renovation of the existing building stock to achieve environmental objectives is growing. Although the environmental performance of buildings and energy efficiency has become an important task for all those involved in the development and management of buildings (Malmqvist and Glaumann, 2009), this is still a relatively unexplored area, with few studies relating to the existing building stock in Australia. This paucity may be related to the difficulties associated with such an undertaking, due to diversity in age and construction of the building stock, and obtaining detailed information relating to
the design and construction for older buildings. Most empirical investigation has occurred alongside policy goals to reduce energy use and related CO$_2$ emissions. This review is focused on improvement of environmental performance through renovation of existing dwellings as this forms a key strand of policy in Australia. Table 4.2 identifies the approaches used: a number of studies examine the importance of operational and embodied energy (and CO$_2$) in renovation activities. Studies by Kohler and Yang (2007), Itard and Klunder (2007) and Ireland (2008) indicate that from a technical perspective, renovation-based approaches can offer advantages over demolition for total energy use over the life cycle. The study by Ireland (2008) compares the embodied and operational energy in upgrading 3 existing homes and building 3 new houses. As well as quantifying the embodied CO$_2$ using LCA modelling, the study predicts the likely operational CO$_2$ using National Home Energy Rating (NHER) software, but does not verify predicted performance against actual energy performance during occupation.

A study of 25 dwellings in South Australia by Pullen (2000) highlights the diversity of the dwelling stock and implications for energy performance. This study examined the total energy over the life cycle for existing dwellings of different constructions and ages (ranging from 1 to 108 years), dwelling types and size (ranging from 91m$^2$ to 320m$^2$), and number of occupants (from 2-6 persons). One of the principal findings of this study is that energy performance, for both operational and embodied energy, varies between buildings of different ages and constructions, thereby recognizing the diversity of the existing dwelling stock, an issue which been largely overlooked, although the heterogeneity of the building stock and the consequences for energy is acknowledged as important (Productivity Commission, 2005). The study also acknowledges that total energy use depends on a number of factors, including the pattern of occupants’ energy consumption. Even where designs are apparently identical, there are differences in location, climatic conditions, typography, siting and orientation, occupants and their patterns of use—which all have an influence on energy performance. Although this study
examined energy bill data, it did not examine the relationship with occupants’ practices in any detail.

Other studies have examined specific retrofitting strategies to improve the performance of existing residential building stocks, and selected residential buildings, based on modelling cost, energy savings and greenhouse gas emissions. A recent study by the Moreland Energy Foundation on behalf of Sustainability Victoria (2010) predicted energy cost savings of various upgrades to fifteen case study dwellings dating from 1900s to 1970s in Melbourne (of which two have local heritage significance), including modifications to the building shell and high efficiency appliances, using thermal simulation and a house energy rating programme (FirstRate 5). Fan pressurisation tests were also carried out. However, the modelling methodology used tends to overestimate the savings which are likely to be achieved from upgrading the efficiency of the building shell (pers.comm Ian McNicholl, Sustainability Victoria, 2012). An integrated methodology was used in another recent Australian study to examine the total energy performance of a range of single family dwellings with heritage significance of different ages and construction, which incorporates thermal performance rating (using AccuRate), verified by in use energy billing data, together with an assessment of embodied energy and other life cycle impacts to determine the broader environmental benefits associated with renovation (Wong et al., 2011). In accordance with the dominant technical approach, this study focuses on the building envelope and appliances, and does not consider the influence of occupants’ practices on energy use.

It is apparent from this review that simulation is widely used to assess environmental performance of dwellings. Where the performance of existing buildings is assessed, this is often predicted by simulation of a building against a reference building, or audit based on specific limited parameters, guided by
building standards assessments which are concerned with simulating thermal efficiency and energy savings for a limited number of building designs and based on standardized occupant behaviour. The relevant literature is dominated by modelling studies and published measured data is scarce. Of the few empirical studies that involve monitoring household energy consumption associated with renovations, analysis indicates that there can be significant differences between theoretical and actual energy used (for example, Bell & Lowe, 2000; Haas et al., 1998; Hens, 2010; Hong et al., 2006; Jones et al., 2013), and energy savings may be lower than predicted (Sustainability Victoria, 2010; Ding and Ge, 2010). However, the reasons underlying this have not been explored in depth.

These studies are largely focused on technical aspects relating to the building design or supply to improve energy efficiency. The shortcomings associated with technical approaches are discussed further in Section 4.5.
<table>
<thead>
<tr>
<th>Author</th>
<th>Date</th>
<th>Dwelling/units</th>
<th>Building type</th>
<th>Method</th>
<th>Country</th>
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</thead>
<tbody>
<tr>
<td>Adalberth</td>
<td>1997</td>
<td>3 Res</td>
<td></td>
<td>Mathematical LCA model.</td>
<td>Sweden</td>
</tr>
<tr>
<td>Haas et al.</td>
<td>1998</td>
<td>400 Res</td>
<td></td>
<td>Data on energy consumption and mathematical modelling.</td>
<td>Austria</td>
</tr>
<tr>
<td>Bell &amp; Lowe</td>
<td>2000</td>
<td>4-30 Res</td>
<td></td>
<td>Monitoring energy usage before and after refurbishment; tenant survey, and interview.</td>
<td>UK</td>
</tr>
<tr>
<td>Fay et al.</td>
<td>2000</td>
<td>1 Res</td>
<td></td>
<td>Hybrid LCA embodied energy analysis, input-output anaysis, and CHENATH (NatHERS).</td>
<td>Australia</td>
</tr>
<tr>
<td>Pullen</td>
<td>2000</td>
<td>25 Res</td>
<td></td>
<td>Hybrid LCA, input-output analysis, process analysis and energy bills.</td>
<td>Australia</td>
</tr>
<tr>
<td>Treloar et al.</td>
<td>2000</td>
<td>1 Res</td>
<td></td>
<td>LCA: input-output analysis.</td>
<td>Australia</td>
</tr>
<tr>
<td>Thormark</td>
<td>2002</td>
<td>20 Res-m</td>
<td></td>
<td>DEROB-LTH (LCA).</td>
<td>Sweden</td>
</tr>
<tr>
<td>Mithraratne &amp; Vale</td>
<td>2004</td>
<td>3 Res</td>
<td></td>
<td>NZ LCA model, and ALF (Annual Loss Factor) simulation method.</td>
<td>New Zealand</td>
</tr>
<tr>
<td>Cavallo</td>
<td>2005</td>
<td>3 Res</td>
<td></td>
<td>House energy rating (tool not specified), energy bills and air infiltration (blower door test).</td>
<td>USA</td>
</tr>
<tr>
<td>Hong et al.</td>
<td>2006</td>
<td>1,372 Res</td>
<td></td>
<td>Modelled heating energy consumption using SAP, on-site monitoring of temperatures and energy use before and after interventions.</td>
<td>UK</td>
</tr>
<tr>
<td>Itard &amp; Klunder</td>
<td>2007</td>
<td>2 Res-m</td>
<td>EcoQuantum (LCA).</td>
<td></td>
<td>Netherlands</td>
</tr>
<tr>
<td>Bragança et al.</td>
<td>2008</td>
<td>1 Res-m</td>
<td>MARS-SC (based on SBTool) (LCA).</td>
<td>Portugal</td>
<td></td>
</tr>
<tr>
<td>Ireland &amp; Empty Homes Agency</td>
<td>2008</td>
<td>6 Res</td>
<td>Inventory of Carbon and Energy (ICE) (LCA), and NHER Scheme method.</td>
<td>UK</td>
<td></td>
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<tr>
<td>Lollini et al.</td>
<td>2008</td>
<td>24 Res-m/Comm</td>
<td>SBTtool (LCA), PHPP, and RetScreen.</td>
<td>Italy</td>
<td></td>
</tr>
<tr>
<td>Building Research Establishment</td>
<td>2009</td>
<td>8 Res</td>
<td>BREEAM assessment, and SAP/SBEM energy rating.</td>
<td>UK</td>
<td></td>
</tr>
<tr>
<td>Hens</td>
<td>2010</td>
<td>1 Res</td>
<td>Calculation of energy use compared with monitoring of energy use</td>
<td>Belgium</td>
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</table>
before and after interventions.

<table>
<thead>
<tr>
<th>Name</th>
<th>Year</th>
<th>Type</th>
<th>Methodology</th>
<th>Notes</th>
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</thead>
<tbody>
<tr>
<td>Nemry et al.</td>
<td>2010</td>
<td>Res</td>
<td>GaBi 4 (LCA)</td>
<td>Europe</td>
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<tr>
<td>Ortiz et al.</td>
<td>2010</td>
<td>Res</td>
<td>LCA Manager</td>
<td>Spain and Columbia</td>
</tr>
<tr>
<td>Sustainability Victoria &amp; Moreland Energy Foundation Ltd</td>
<td>2010</td>
<td>Res</td>
<td>FirstRate5, AccuBatch, air infiltration (blower door test)</td>
<td>Australia</td>
</tr>
<tr>
<td>Ingram et al.</td>
<td>2010</td>
<td>Res</td>
<td>Compared energy use using steady-state and dynamic energy assessment methods: SAP 2009, RdSAP, 2005; and IES&lt;VE&gt;</td>
<td>UK</td>
</tr>
<tr>
<td>Ding &amp; Ge</td>
<td>2010</td>
<td>Res</td>
<td>BASIX, monitoring of energy use, and calculation of payback using Net Present Value</td>
<td>Australia</td>
</tr>
<tr>
<td>Wong, Sivaraman &amp; Heritage Council of Victoria</td>
<td>2011</td>
<td>Res</td>
<td>Integrated process model using AccuRate and SimaPro (LCA)</td>
<td>Australia</td>
</tr>
<tr>
<td>Jones et al.</td>
<td>2013</td>
<td>Res</td>
<td>Energy and Environmental Prediction (EEP) model (SAP, 2005) for various interventions</td>
<td>UK</td>
</tr>
<tr>
<td>Tweed</td>
<td>2013</td>
<td>Res</td>
<td>Qualitative interviews and participant diary. Monitoring energy consumption (energy consumption data not published in this paper)</td>
<td>UK</td>
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</tbody>
</table>

Notes: Res, residential; Res-m, mixed; Comm, commercial use.
Taking a different approach to improving energy performance of existing dwellings focusing on the social aspects of energy demand and the interface with renovation activities, research by Haines et al. (2010) employs a user-centred approach to understand what householders in the UK Midlands value about their homes and the practices they currently adopt in improving their homes. In an empirical study of energy-led renovations, based on 20 in-depth interviews with householders across four European countries, Bartiaux et al. (2011) noted that renovation activities are closely related to the physical attributes of the building, the materials the house is built of, the type of house etc., and products that are available. In addition, the authors also found that renovations are carried out for many different reasons, the most widespread reasons being: aesthetic reasons, convenience and comfort; and to make good general wear and tear. A qualitative, in-depth study by Maller et al. (2011) explored the relationship between homeowners’ concerns for the environment, home improvement and household daily routines with householders in Australia but the links were found to be weak. Recent research endeavours to combine technical and human aspects of environmental performance (for example, Banfill et al., 2012; Hong et al., 2006; Soebarto et al., 2004). Whilst increasing understanding of reasons underlying home-renovation, and exploring how occupants daily practices may influence energy performance in the general dwelling stock, none of these studies explicitly investigate the issues associated with improving the environmental performance of dwellings with heritage significance.

Although there is increasing interest in energy use relating to the existing dwelling stock, reliable information relating to renovation activities is very limited (Meijer et al., 2009) with little research on renovation of existing dwellings published in the academic literature in Australia or overseas. Previous research has tended to focus on technical options for improving performance; and combinations of technical, economic and policy analysis; there remains a lack of documented, monitored or evaluated studies that investigate the interaction between energy performance of dwellings and
occupants’ activities. Little is known about renovation activities, the reasons why homeowners undertake renovations, the inter-relation between renovation and energy practices, whether and how occupants live differently after the renovation, and so on.

### 4.5 Current approaches: key debates

This section outlines the key ongoing debates on current approaches and methods for effecting improvements to environmental performance in the existing dwelling stock.

#### 4.5.1 Performance ‘gap’

There is an established and growing body of evidence of a performance gap between building design (and efficiency) and delivery in terms of end use. Most building assessments are based on information provided during design rather than performance in use. The discrepancy between predicted and actual performance, particularly for energy modelling, is also termed a **credibility gap** (Bordass et al., 2004). Recent studies support the existence of a gap between predicted and measured performance in aspects of the building envelope and appliances such as heat pumps and solar thermal systems (Sanders and Phillipson, 2006; Energy Saving Trust, 2010; 2011; Wingfield et al., 2007). Deficient design, defective installation, and behaviour of occupants are amongst the factors that affect predicted performance—but which are brushed aside (Gwilliam, 2011; Lowe et al., 2007; Soebarto et al., 2004). In a study of 1,372 households in the UK by Hong et al. (2006), property and utility data for dwellings ranging in type and age from pre-1900 to post 1976 were analysed before and after intervention. The study found significant differences between modelled and actual heating energy consumption and thus the energy efficiency improvements did not deliver the reductions in space heating consumption predicted, even after the effects of increased comfort were taken into account. As well as defects in installation, the study noted occupant
ventilation practices associated with a new gas central heating system, and preferences of householders for less efficient but familiar room heaters. The reasons for the disparity in performance are related not only to design and construction, but also to the ‘operation’ of buildings—and the fact that they are part of the complexity of everyday life.

This discrepancy in performance has led to questioning of the effectiveness of current approaches and methods of assessment in achieving performance objectives. Several authors underline the importance of using empirical data to assess energy efficiency improvements (for example, Stafford et al., 2011). Rather than reliance on simulations, they argue there is a need for methods that begin to understand and address actual performance. This is particularly relevant to heritage buildings: a study by Ingram et al. (2011) suggests that a lack of accurate information relating to the design and construction, together with ill-founded assumptions about the activities of occupants, could result in deficient or ineffective retrofits.

In a technical framing, the assumption is that improvements in energy efficiency will lead to reduced energy demand and greenhouse gas emissions. However, the presumption that energy efficiency is likely to lead to lower energy consumption is a point of much debate (Caird et al., 2008; Herring, 1999; Hertwich, 2005; Brookes, 2000). The energy efficiency benefits from technological improvements such as increased levels of insulation or a more efficient heating system, may be reduced through rebound effects\(^6\) (Hertwich, 2005; Sorrell et al., 2009; Brookes, 1990, 2000) whereby some or all of the energy savings are used in increased comfort, or energy efficient appliances are used more often (Herring and Roy, 2007) thereby negating in large part the predicted reduction in energy use (Sanders and Phillipson, 2006). Where

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\(^6\) The rebound effect was first described in 1865 by Jevons in his famous work *The Coal Question* where he argued that improved efficiency in coal use would lead not to a reduction in national coal consumption, but rather an increase. If the rebound effect is larger than 100 per cent, all gains from the increased fuel efficiency would be wiped out by increases in demand (the Jevons paradox). Thus technological improvements could not be relied upon to reduce fuel consumption.
the efficiency measure leads to increased energy consumption, this is referred to as *backfire* (Brookes, 2000; Saunders, 2000). Rebound effects have been observed or measured in empirical studies (for example, Caird et al., 2008; Druckman et al., 2011; 2012; Gram-Hanssen, 2012; Hens et al., 2010; Hong et al., 2006). For households, rebound effects vary depending on the service, whether space heating, cooling, lighting, etc. (Greening et al., 2000). Published studies reviewed by Sorrell et al. (2009) estimate between 10-30 per cent take-back for household heating, depending on circumstances and method of measurement. Larger take-back is noted in dwellings with lower initial temperatures (Hong et al., 2006; Sanders and Phillipson, 2006). However, the extent of rebound effects that will occur in a given case, and what determines the extent is uncertain. Such unintentional effects may reduce the ability of a primary policy measure to achieve its goal, or even undermine the validity of efficiency policies. Even so, government holds tightly to the position that in the long term, energy efficiency improvements usually result in large overall energy savings.

The empirical evidence suggests that building solutions, whilst necessary, are not sufficient to reduce energy consumption (Janda, 2011; Stafford et al., 2011). Further work is essential to understand how renovation and energy consumption are intertwined from the occupants’ perspective.

### 4.5.2 Role of occupants

The energy performance of buildings is highly complex, involving the interaction of many interrelated factors, many of which are not well understood. The conduct of occupants is increasingly recognised as a critical element in meeting environmental performance aspirations (Stevenson and Leaman, 2010). A need to understand the influence of occupants in environmental performance within the residential sector has been established. Firth et al. (2008) found significant variation in heat and electrical energy consumption in similar dwellings. In a separate study, Gill et al. (2010) found a
variation of 2.5 to 5 times in energy-related consumption between dwellings of homogeneous design. According to a study by Gram-Hanssen, (2010), housing occupants living in exactly the same type of dwelling can use three or more times as much energy for heating as their neighbour, suggesting that the inhabitants ultimately determine how energy efficient a home is.

Both ‘technical’ and ‘non-technical’ factors have a critical influence on the total energy requirements of residential dwellings (Gram-Hanssen, 2011b; Schuler et al., 2000). Previous research has tended to focus on the building envelope with inadequate attention given to the occupants (Crosbie and Baker, 2010), although occupant characteristics and patterns of use play a prominent role in the variation in energy consumption in different households (for example, Druckman and Jackson, 2008; Gill et al., 2010; Gram-Hanssen, 2010a; Haas et al., 1998; Sardianou, 2008). Based on statistical analysis of variables from the results of other research, Guerra-Santin et al. (2009) suggest that the technical characteristics of a building account for 42 per cent of the variation in energy consumption, whereas the occupancy characteristics account for some 4.2 per cent. In-depth case study research of 26 dwellings by Gill et al., 2010 found that 51 per cent and 37 per cent respectively of the variation in heat and electrical consumption could be explained by behaviours, indicating that occupants can have a significant impact on performance and should be accounted for alongside other building mandates. Thus a growing body of evidence indicates that occupants’ practices are at least as important as the efficiency of the building envelope, systems and appliances when seeking to explain household energy consumption.

It is becoming apparent that energy performance depends not only the technical features of the building but also on the users, although these may be at variance. An energy intensive lifestyle in a very energy efficient residence can lead to higher than expected energy use (Jeeninga et al., 2001 in Guerra-Santin and Itard, 2010). As expressed by Soebarto (in Williamson, 2005: 6):
‘rating the energy (or environmental) performance of a house design will not guarantee that when built the house will actually have a low operating energy. A number of previous studies have shown that actual energy performance depends on the way the occupants “use” the building and does not necessarily relate to the building design (for example work by Ballinger et al., 1991, Haberl et al. 1998).’

Although a significant determinant of energy use, there is remarkably little data available on the behaviour of building occupants (Productivity Commission, 2005: 134, 219).

There are calls for real world evidence to support policy (Shipworth et al., 2010), qualitative and quantitative studies to improve understanding of domestic energy consumption (Firth et al., 2008), and user-centred approaches that prioritise understanding of routines, habits, conventions and conceptions of normality over efforts to make individual technologies or behaviours more efficient (Haines et al., 2010; Shove, 2003a). Within construction research, in the rapid and unpredictable development of energy and buildings, there is a need to examine the processes, understandings and motivations which produce observed patterns and systems in energy and buildings (Schweber and Leiringer, 2012).

4.5.3 Concept of thermal comfort

Existing approaches are founded on a particular conceptualisation of thermal comfort which is aimed at achieving constant temperature set points and standardized conditions. The widely accepted definition of thermal comfort is ‘that condition of mind in which satisfaction is expressed with the thermal environment’ (ASHRAE, 2004; 2010). This is almost identical in wording to the International Standard ISO 7730 (International Organization for Standardization, 2005)—both of which are based on the physiological understanding and measurement of thermal comfort (Fanger, 1970). This
notion of comfort has informed the establishment of universally applied comfort standards and guidelines for the built environment. Although established codes and standards informing design decisions are underpinned by scientific research (Djongyang et al., 2010), the science of thermal comfort is contested, involving debates about: the cultural and/or physiological nature of comfort; the relative significance of different variables under different climatic conditions; and the possibility of adaptation (Brager and de Dear, 1998; Halawa and van Hoof, 2012; Humphreys and Nicol, 1998; van Hoof et al., 2010). In support of the argument that thermal comfort is socially and culturally constructed, Chappells and Shove (2005) and Humphreys et al., 2007 point to field studies which show how people of different cultures, value and maintain very different indoor conditions and interpretations of comfort (see for example, Wilhite et al., 1996; Isaacs et al., 2010). An alternative conception as an achievement, thermal comfort is seen as ‘personally idiosyncratic, culturally relative, socially influenced and highly dependent on temporality, sequence and activity’ (Jaffari and Matthews, 2009:1). They suggest that individuals may devise their own strategies to manage comfort.

This approach to thermal comfort is supported by a study of six dwellings in Australia (four in Adelaide, one in Brisbane and one in Darwin) by Soebarto et al. (2004) where assessment of the environmental performance revealed some anomalies between actual performance and assessment ratings. Like most heritage buildings, these architect-designed houses were constructed prior to the introduction of energy performance regulations. The indoor and outdoor temperature and relative humidity were monitored for 6-12 months, and records of energy consumption obtained from utility companies. Internal conditions fluctuated with external conditions, and there was no attempt to maintain constant thermal conditions. The occupants used passive design techniques to achieve thermal comfort and they asserted that other benefits associated with living in the dwellings, i.e. openness and connection with the outside, outweighed any minor thermal discomfort. Despite having energy consumption well below the average house in the same location, these
buildings were not able to achieve the required rating when evaluated using housing energy rating tools (*FirstRate* and *NatHERS*), and so could not have obtained verification using the prescribed software. This study illustrates that a narrow, purely engineering approach is not necessarily the way forward; and designing buildings for a more expanded range of indoor temperature i.e. accepting a more ‘elastic’ definition of thermal comfort that reflects variation in outdoor conditions, and meets occupants’ aspirations, could significantly reduce energy demand. As Chappells and Shove, (2005: 39) argue:

‘Rather than figuring out more efficient ways of maintaining 21–23°C in the face of issues of sustainable consumption and global warming, society should be embarking on a much more searching debate about the meaning of comfort and the ways of life associated with it. In this way, it might be possible to exploit existing diversity and variety both in people’s expectations and in the built environment and so avoid a commitment to an unsustainably standardized future’.

### 4.6 Gaps in current approaches

Having outlined the relevant debates relating to improving the environmental performance of existing dwellings, this section identifies the gaps in current approaches.

#### 4.6.1 Renovation as a path to improving environmental performance

The focus of policy is on the improvement of building performance through technology application, however the influence of occupants on the effectiveness of such technology application has not been mentioned in the policy literature. Where the policy literature does focus on environmental and energy-related behaviours it pays relatively little attention to occupants activities relating to energy use, focusing more on steering individual behaviours to encourage installation of particular products or technologies which aim to reduce consumption through improving energy efficiency. This is
of concern because research has indicated that occupants activities can have a significant influence on the energy use in buildings (Gill et al., 2010; Stevenson and Leaman, 2010), and the risk is that the policy of renovating homes may not achieve potential energy efficiency or CO₂ reduction targets.

The assumption is that retrofitting energy efficient technologies to housing will reduce energy consumption and CO₂ emissions, however, as research indicates, occupant behaviours related to energy use influence these factors (Janda, 2011; Gill et al., 2010; Morley and Hazaz, 2011; Smith and Pett, 2005; Stevenson and Leaman, 2010). There is a lack of evidence to substantiate claims that regulations (and HERS) lead to designs that are more energy-efficient, save energy and/or costs and reduce greenhouse gas emissions (Australian Broadcasting Corporation, 2011; Williamson, 2005). Studies indicate that high star ratings do not necessarily mean using less energy, and similarly houses with low ratings do not always in reality use a high amount of energy (Stein and Meijer, 2000; Williamson et al., 2001) raising doubts over whether the policy goals of improving energy efficiency and reducing greenhouse gas emissions are being achieved. In an exploratory study of 31 dwellings in Adelaide, less than 10 years old and in a range of construction, floor areas, numbers of occupants, a variety of heating and cooling appliances and use patterns likely to be typical of the larger population, no significant correlation was found between actual household heating and cooling energy use (or greenhouse gas emissions) and the star ratings of the Nationwide House Energy Rating Scheme (NatHERS) (Williamson et al., 2001). However, a later sample of 8 contemporary passively designed, naturally ventilated dwellings in Queensland using qualitative and quantitative data sets, supported NatHERS assumptions that higher rated homes (i.e. 9 stars) provide better thermal performance without the need for additional heating and cooling, although substantial performance differences were observed (Miller et al., 2012).
As suggested by Maller and Horne (2011), there is considerable uncertainty about whether the strategy of renovation is effective in achieving the aims. A lack of data comparing predicted and actual performance in terms of energy use and CO₂ emissions in dwellings in Victoria means that it is difficult to determine if the current approaches relying on energy efficiency of the building and systems and current methods of assessment are effective in reducing environmental impacts. There is considerable disagreement about the effectiveness of energy efficiency of the building and systems and current methods of assessment, and a report by the Productivity Commission (2005) has criticised the lack of detailed and comprehensive evidence on the effectiveness of current performance-based standards. The intent in introducing regulatory standards was to ensure energy efficient designs for the building fabric, however, no monitoring or post completion evaluation is carried out to ensure that designs are constructed in accordance with the plan and the standards are being achieved. No systematic, in-depth studies have yet been completed in Australia to determine how buildings actually perform after energy efficiency measures have been introduced.

4.6.2 Understanding occupant practices

The technical approach to building performance, recently extended to include retrofitting, regulation and energy efficiency, encompasses notions about costs and benefits, decision-making and the uses of buildings, relies on aggregate data and assumptions that simplify the behaviour of occupants. For example, energy efficiency regulations incorporate performance-based approaches to energy efficiency using models that draw on extensive assumptions and default settings regarding the operation and occupation preferences of building occupants. Despite the fact that it significantly amplifies and dampens the effects of technology-based efficiency improvements, the role of human social behaviour in energy performance has been largely overlooked (Lutzenhiser, 1993). Hence, in the dominant discourse of housing energy efficiency policy, little attention has been given to the conventions and practices of households and their use of such systems. Research that enables an understanding of
buildings according to the varied activities of occupants is advocated by Hitchings (2009) to provide insight into the how people, their practices and buildings combine to shape the ways in which performance is achieved.

Both the technical characteristics of buildings and the occupancy patterns of households are important determinants of energy demand of private households (Gram-Hanssen, 2011b, Smith and Pett, 2005). Existing methods do not take account of the complex behaviours of occupants, which is one of the reasons for the disparity between predicted and the actual performance. As illustrated in the study by Soebarto et al. (2004), occupants may not follow assumed patterns. Whilst renovation of the existing building can improve the energy efficiency, and retrofitting renewable technologies can reduce dependency on more CO₂ intensive supplies, the activities of occupants ultimately decides the amount of energy used. As Janda (2011: 3) asserts, ‘... buildings don’t use energy, people do’. A building’s energy efficiency may be improved compared to before the modifications, but the activities of occupants may result in unexpected outcomes: increasing energy use and carbon emissions (nullifying the impact of the physical modifications); or decreasing energy use and emissions. Thus, understanding the interaction between occupiers behaviours and energy efficient renovation is crucial, if such programmes are to be deployed effectively.

To be credible, approaches and methods need to demonstrate reliability in their predictions. However, rating a house is difficult because every house is different and there are many potential sources of error such as assessor mistakes, imprecise simulation algorithms, and incorrect assumptions about physical features like air infiltration rates. Furthermore, ratings are designed to rate the house and not the occupants so standard assumptions are made for all occupant-related inputs such as the number of people, number of appliances, and thermostat settings. Thus a rating that is accurate for the ‘typical’ family could still be highly inaccurate for any particular family.
Simulation programs for energy rating do not simulate appliance usage, i.e. lighting, water heating and entertainment systems. There is also a question of inconsistency; in an example in Perth, Western Australia, a design demonstration house initially gained 5 stars using NatHERs, 7.2 stars using AccuRate (in its testing phase) and AccuRate version 1.1.4.1, 7.3 stars (Karol and McMinn, 2008 Karol and McMinn, 2008), which could suggest some anomalies in the different versions of the software, or assessor interpretation and data input. A further example in Tasmania (Wallis and Dewsbury, 2009) highlights issues that affect the rating: making modifications to the design; interpreting and inputting data (which accounted for variation in thermal performance for the case study house by 1.4 stars or 31 per cent depending on the assessors and software users understanding, education and methods of inputting data); and differences between design standard and as-built construction.

There have been issues reported in the inconsistency of the rating software: for example, a study comparing predictions for fifteen floor plans (10 single-storey and 5 two-storey) were simulated using FirstRate, NatHERS and AccuRate V1.1.2.0 in three locations: Melbourne, Sydney and Brisbane. When assessed using FirstRate or NatHERS, houses with suspended timber floors achieved lower star ratings than otherwise identical houses with concrete slab-on-ground floors – particularly relevant to older heritage dwellings. Limitations of AccuRate and its predecessor, NatHERS, have been addressed including improved natural ventilation modelling, user-defined constructions, improved modelling of roofspaces, sub-floor spaces, skylights and horizontal reflective air gaps, and increase in zones (Delsante, 2005). However, in a recent study (Dewsbury, 2011) undertaken by the University of Tasmania, in collaboration with the Australian Government, the CSIRO and industry partners, for the purpose of validating empirically the AccuRate software, which compared a detailed house energy rating simulation with measured data, discrepancies were found between the simulated and measured temperatures of the test cells. The study concluded that AccuRate software may not be accounting for
climatic inputs appropriately, and the software may be under-valuing some inputs, which could have a significant effect on energy calculations if the buildings were simulated for house energy star rating purposes (Dewsbury, 2011). Dewsbury also notes that residential buildings constructed prior to 2000 have significantly different envelope thermal performance requirements.

4.6.3 Occupant comfort: socio-technical understandings

As discussed in section 4.5.3 strategies for improving thermal performance are closely entwined with physiological understandings of thermal comfort and other aspects of building design and use. Studies have sought to make the link between internal temperature and comfort, however, as noted by Issacs et al. (2010: 273) ‘comfortable warmth[,] is clearly a matter of subjective perception’. The Bonnyrigg Solar Village project, involving the construction and instrumentation of 12 passive solar designs and 3 standard reference houses, by the University of New South Wales, New South Wales Housing Commission and the Energy Authority of NSW monitored temperatures and energy consumption, and investigations of the available data indicated that dwelling thermal characteristics were generally not an indicator of either energy consumption or comfort. Aside from this study, the National Evaluation of Energy Efficient Homes (NEEHA) project is probably the most concerted attempt in Australia to provide evidence predictors of household energy consumption and comfort from the dwelling construction properties and other characteristics of 146 houses and households in the city regions of Adelaide, Melbourne, Sydney and Perth (Ballinger et al., 1991; Williamson, 2004). The study, undertaken over 20 years ago, found that energy-efficient dwellings were experienced as more thermally comfortable than standard dwellings, but with some summer and winter discomfort. Whilst inconclusive, the data did point to a lack of correlation between the design elements and actual household energy consumption. In this and in a study of 31 dwellings by Williamson et al., (2001), the strongest consistent correlations observed related to the type and use of heaters and coolers, and not to the features of the building design or construction. In a follow up study of 22 houses in and
around Adelaide, decreased discomfort in extreme conditions is attributed to
the increased penetration of fully ducted air-conditioning systems (92 per cent
compared with 16 per cent in the previous survey) (Williamson et al., 2007). A
recent study of 8 contemporary passively designed, naturally ventilated
dwellings in Queensland using qualitative and quantitative data sets, showed
no direct correlation between any single building element and thermal
performance. However, houses which incorporated a range of options for
managing thermal comfort, including occupants actively interacting with the
house, were more successful in meeting annual, seasonal and extreme day
requirements (Miller et al., 2012).

The interpretation of comfort continues to be the subject of debate, as the
environmental conditions required for comfort are not the same for everyone
comfort as ‘a subjective state of satisfaction that varies with the individual and
number of circumstantial factors’. The primary physical factors that affect
thermal comfort are air temperature, humidity, radiant temperature, air
movement, a person’s metabolic rate, and clothing type (ASHRAE, 2010).
Besides these, non-physical factors such as age of the users and degree of
acclimatization also influence a person’s perception of whether or not he or
she is thermally comfortable in a certain condition (Grondzik et al., 2011;
Soebarto et al., 2004). Humphreys (1978), Auliciems (1981), Brager and de
Dear (2003), Cole et al. (2008) consider the effect on thermal comfort of
variables such as outdoor temperature, past thermal experience and socio-
cultural systems. However, ‘non-uniformity of the environment, visual stimuli,
age, and outdoor climate are generally considered secondary factors’
(ASHRAE, 2001: 8.12). Even though social and cultural factors been shown to
affect perceptions, and shape and maintain practices and conventions of
comfort, social and technical aspects are segregated in the conventional
approach—with consequential impacts for energy consumption.
It has become accepted that tightly controlled conditions equate with better comfort. The notion of thermal comfort as a relatively constant state has guided international building practice; static or set point temperature standards are now enshrined into building codes and built into the assessment tools whereby heating and cooling is invoked when the internal temperature falls outside of a narrowly prescribed temperature range. This fixed paradigm of comfort is questioned in the literature by those (including Humphreys, 1997; Roaf et al., 2010) who support a more dynamic model for comfort requiring a different approach from one that assumes only a narrow temperature range is acceptable. Field studies demonstrate that in reality thermal comfort and preference are not fixed values and are affected by many non-physical factors (Humphreys and Nicol, 1998). Despite this, the thermostat settings in the BCA approved simulation tools cannot be modified by the user. This narrow interpretation in assessing the performance of a house presents immediate difficulties when the house is not intended to be air-conditioned, but is designed to allow the occupants to control their conditions through interaction with the building, as in many passive solar designed, vernacular or traditional buildings. As indicated in section 4.5.3 above this alternative paradigm of different user profiles and occupants’ comfort perceptions and preferences can result in under-rating and overestimation of heating and cooling where internal temperatures fall outside the boundaries of the comfort zone, even though occupants expressed a high level of satisfaction with their comfort conditions and the houses demonstrated actual lower energy use (Soebarto et al., 2004).

A further paradigm sees the focus of thermal comfort shifting beyond the individual (Cole et al., 2008) to socially and culturally constructed understandings (Chappells and Shove, 2005; Shove et al., 2008). An analysis by Wilhite et al. (1996) of heating, cooling and washing of practices among households in Japan and Norway reveals deeply embedded cultural understandings of comfort and their implications for energy use. For example, Norwegians choose to heat the whole house creating a thermally consistent building envelope, whilst the Japanese use an array of technologies to heat
individual bodies not surrounding spaces). An Australian study of 31 households in and around the Adelaide metropolitan area in South Australia, Williamson et al. (2006) concludes that an understanding of comfort based on householders’ expectations and patterns of behaviour may closer reflect reality. Within the cultural studies literature, several authors argue that comfort expectations are related to different ‘energy cultures’ that is, human beliefs and actions as well as technology and the material environment (Aune et al., 2011: 207; Heidenstrøm et al., 2013).

Close control encourages high energy consuming buildings, and is an expensive strategy in terms of environmental impacts (Baker, 2009; Roaf et al., 2010). Further, increased expectations of thermal comfort have had an impact on energy consumption, contributing to rising energy use in the residential sector, despite energy-efficiency improvements. Chappells and Shove (2004, 2005) argue that expectations of comfort, cleanliness and convenience are unsustainable, and current thermal standards based on physiological and physical criteria add to worldwide energy consumption. This view has lead to the development of complimentary adaptive approaches to thermal comfort (see Brager and de Dear, 2001 Brager and de Dear, 2001; Nicol and Humphreys, 2002; Tuohy et al., 2010) based on the findings of studies of thermal comfort conducted in the field. The adaptive approach allows for different comfort temperatures according to variations in clothing, activity, and local climate, social and cultural context. Further, the comfort temperature is linked to the context whereby the comfort temperature is a result of the interaction between the occupants and the building; this approach claims that people will adapt themselves to the environment, or make adjustments to the building, for example opening windows to increase air-flow. A study by Jaffari and Matthews found that householders’ comfort practices may be influenced by various non-physical factors including individual habit and previous experience, resources (in terms of time or money), understandings (including folk wisdom and hearsay from different sources including the media and friends), individual aesthetic sensibilities, personal
characteristics and recent thermal history (Jaffari and Matthews, 2009). The adaptive approach is now included in some standards and guides for comfort in particular for buildings which are not heated or cooled, including: ASHRAE Standard 55-2010; CIBSE Guide Section A1 2006; CEN Standard EN15251: 2007. Although the revised ASHRAE Standard 55-2010 continues to focus on defining the range of indoor thermal environmental conditions acceptable to a majority of occupants, it also makes way for design solutions intended to both provide comfort and to respect the imperative for sustainable buildings. The adaptive approach has been shown to reduce energy use in buildings (Tuohy et al., 2010) as well as counteracting the homogenising tendencies of global comfort practices on culture, climate and buildings (Healy, 2008).

4.6.4 Social and cultural considerations

According to the literature review presented here, probably the most significant shortcoming associated with existing approaches and methods to regulate the energy performance of buildings is a failure to address social and cultural considerations associated with energy, comfort, and sustainability. Arguably, building performance should take into account a much broader range of considerations (Leaman et al., 2010; Lutzkendorf and Lorenz, 2006): the goals of the occupants, the design intention, and whether the way to achieve goals has a negative impact on the environment or the community (Soebarto et al., 2004); and contribution to cultural heritage (Wood, 2005, 2006, 2006). There is a debate that building energy performance should consider: personal and individual contexts and circumstances; alternative metrics (of comfort); design quality; value; and evaluation of the design and construction approaches and processes (Miller et al., 2012).

Cogent arguments for wider implications of the current approach to environmental sustainability in the building sector extend to a pervasive reliance on air conditioning and related thermal comfort standards tending to higher energy use (Roaf et al., 2010), alongside a perceived continuing
inability to support buildings utilising natural ventilation (Kordjamshidi et al., 2007; Soebarto et al., 2004), with consequences for diversity among individuals and buildings (Healy, 2008), and the loss of building features that individuals value more than energy efficiency (Productivity Commission, 2005). There is a lack of information about whether buildings that rate highly on energy efficiency result in positive social impacts (Hes, 2007).

4.7 Digest: current approaches

This chapter has highlighted a number of deficiencies in current approaches to improving environmental performance of existing dwellings. Whilst policy mechanisms may have some impact, this thesis suggests that approaches which rely on individual behaviour change and the adoption of sustainable technologies are inadequate. It is evident that a technical-rational framing that focuses on the technical efficiency of buildings and systems represents a simplified view that does not bear out in reality. While important, the focus on technological solutions fails to account for the predilections of the human occupants of houses. An examination of theory and previous research in the area indicates that energy consumption is underpinned by more than individual behaviour change and technology adoption. Such approaches tend to overlook social and cultural dimensions of energy use. Greater attention needs to be given to occupants, in particular their expectations, conventions and practices and how these relate to domestic systems. A user-centred perspective is required to understand how homes are lived in, used and changed. Thus further examination of the ‘dynamics of demand’ for energy from a user perspective is necessary, to illuminate the connections between household aspirations, practices, buildings and technology.

To address the deficiencies identified, the next chapter examines a social practices theoretical approach that considers the practices of occupants within their social and cultural context to explore renovation activities of homeowners seeking to improve environmental performance of their heritage dwellings.
‘Buildings are the embodiment of human energy.’

Kevin McCloud, presenter of Grand Designs and Great British Refurb campaigner

5 Social practices and renovation

Having discussed the limitations of the technical and behavioural approaches embedded in policy measures to improve the environmental performance of existing buildings, this chapter reviews the social practice literature as a conceptual alternative, and examines its relevance to the renovation of dwellings with heritage significance to achieve objectives of reducing energy use and associated emissions.

This chapter begins by exploring theories of social practice and discusses how home-renovation may be understood through a social practice lens. There are two dimensions to practices—both of which are implicated in energy consumption: a distinction is made between renovation practice (the practice of renovating) and everyday domestic practices and how these influence decisions around renovation. In applying practice theory to home-renovation and domestic practices in dwellings that have heritage significance, the focus is on the components of practices and their connectedness, and how different configurations of these elements influence variations in renovation practices.

First, an abridged account of practice theory is presented as applied to home-renovation practice based on conceptual and theoretical discussions in the literature, accompanied by a review of previous empirical material relevant to this study topic. This is followed by a discussion of on-going debates about the use of the approach, its effectiveness and the whether the approach can be
integrated or used alongside other perspectives. Then an analytical framework is presented for the practice of renovating dwellings with heritage significance.

5.1 The emergence of practice

To address the shortcomings identified in rational and behavioural approaches discussed above, ideas and theories of social practices have emerged recently within environmental-based discourses, to bridge the gap between technical solutions and behaviour (Moloney et al., 2008). Both rational and attitudinal approaches, it is argued, consider individual behaviour detached from their socio-cultural context. In contrast with the methodological individualism associated with the behavioural approaches discussed in Chapter 4, practice theories focus on the conditions surrounding the practical carrying out of social life (Halkier et al., 2011).

5.2 Social practices: an overview

A type of cultural theory (Reckwitz, 2002b), the concept of practice theory in social science can be traced to the work of Bourdieu, Giddens, Foucault and others seeking to overcome the structure-individual actor dualism in social theory. In searching for an intermediate level between agency and structure, the everyday and routine performance of social practice becomes the central unit of analysis i.e. where the practice itself, rather than the individuals who perform them or the social structures that surround them become the focus (Giddens, 1984). Thus social practices become the mediating concept between individual action and structure.

It is through the writings of Theodore Schatzki, however, together with key contributions from Andreas Reckwitz, and Elizabeth Shove that practice theories have come to occupy salient theoretical space across the social sciences and humanities, including environmental and sustainability research. In recent years, other writers have joined the discussions, providing insights
on the dimensions and organisation of practices, and how practices change (Gram-Hanssen, 2011c; Røpke, 2009); the significance of material things (Spaargaren, 2011; Shove et al., 2007), as well as demonstrating the inter-relationship between practices and technology (Shove and Walker, 2010), and between practices and consumption (Shove, 2004; Shove and Warde, 2002; Southerton, 2001a).

The relevance of social practices as a theoretical and empirical perspective that links theories of consumption, technology and society has been advanced through the work of Elizabeth Shove, with contributions from others including Alan Warde, Mika Pantzar, Loren Lutzenhiser, Dale Southerton and Hal Wilhite), who draw attention to the relevance of everyday practices for consumption of resources, and stress the routine, ordinary, collective, conventional nature of much consumption. The application of practice approaches to everyday resource use and consumption has become more established, with researchers drawing on recent formulations of practice for the study of everyday life, household routines, energy use and interventions. Some of this work has a clear environmental focus, with the application of practice theory to the interface between technologies, utilities, resource consumption and the problematic of sustainability in households (for example, Gram-Hanssen, 2010a; Maller et al., 2011; Strengers, 2008). However, there is relatively little empirical inquiry in the area of home-renovation practice and environmental performance requirements, and how these intersect with the practices of daily life.

A useful starting point for discussing the main characteristics of practice theories and the opportunities offered by a practices theoretical perspective, is Reckwitz's theoretical mapping exercise (Reckwitz, 2002b). In this account, Reckwitz (2002: 249) defines a practice as ‘...a routinized type of behaviour which consists of several elements, interconnected to one another: forms of bodily activities, forms of mental activities, “things” and their use, a
background knowledge in the form of understanding, know-how, states of emotion and motivational knowledge’, thereby drawing attention to the way that practices are thought of as collections, or assemblies of heterogeneous things such as ideas, devices, knowledge and skills which become associated with one another through more-or-less routine enactments. Reckwitz positions humans as the carriers of practices (or ‘practitioners’) with human activity resulting from rather than determining practices. Here, ‘the individual is the unique crossing point of practices, of bodily-mental routines’ (Reckwitz, 2002: 256). Whilst humans are no longer the central focus in everyday life, as connective ‘nodes’ between practices, they play an important role in determining which practices are sustained and how practices develop and change.

Social practices are differentiated from behavioural approaches where the fundamental assertion is that behaviour is taken to be the product of individuals motivations and capabilities, expressed through interaction in social groups and the wider world. Behaviour is thus the property of the individual, and hard to separate from them (Darnton et al., 2011; Jackson, 2005). By contrast, practices are relatively stable entities which are inherently repetitious and recognisable; they seem to have some independent existence of their own, such that individuals reproduce them when they act (Røpke, 2009). A further distinction is that behaviour is taken to be the product of an array of factors commonly called ‘barriers’ and ‘drivers’ which determine people’s behavioural intentions. In a rational choice perspective, if barriers are removed, the assumption is the required behaviour will follow (see Wilson and Dowlatabadi, 2007). By contrast, practices are not the result of a series of factors, but the emergent outcome of elements, such as infrastructure and institutions, which already exist in the social world (Darnton et al., 2011). Behaviours and practices are not synonymous. The following table (Table 5.1), adapted from by Darnton et al., (2011), sets out the key differences between behaviour and practices.
Table 5.1 Key differences between behavior and practice

<table>
<thead>
<tr>
<th>Behaviour</th>
<th>Practice</th>
</tr>
</thead>
<tbody>
<tr>
<td>Individual as unit of analysis; behaviours are the product of individuals</td>
<td>Practice as the principal unit of analysis; individual as carrier of practice</td>
</tr>
<tr>
<td>Individual choice</td>
<td>Shared, social convention</td>
</tr>
<tr>
<td>Focus on attitudes, values</td>
<td>Focus on the things that people do, ‘bodily and mental activity’</td>
</tr>
<tr>
<td>Causal: arising as an outcome of factors</td>
<td>Emergent nature: practices are emergent arrangements of elements</td>
</tr>
<tr>
<td>Values/beliefs underlying foundations</td>
<td>Needs/desires as outcomes</td>
</tr>
<tr>
<td>External influence on the factors and drivers of behavior bring about outcomes</td>
<td>Co-evolving</td>
</tr>
<tr>
<td>Consequentialist</td>
<td>Recursive</td>
</tr>
<tr>
<td>Response to a specific contextual cue</td>
<td>Practices are seen to emerge from specific contexts</td>
</tr>
<tr>
<td>Habits are a factor determining behavioural outcomes.</td>
<td>Habits or routines are a consequence of human practices</td>
</tr>
<tr>
<td>As if for the first time</td>
<td>Within a continuous flow of activity</td>
</tr>
</tbody>
</table>

Sources: Darnton et al. (2011); Evans et al. (2012); Gram-Hanssen (2009); Shove et al. (2010); Shove et al. (2012).

5.3 Practices as collective

Although encompassing a diverse and sometimes contradictory range of insights, theories of practice are held together by the ontological position that practices—as opposed to individuals, social structures or discourses—are the basic unit of social analysis. In practice-based approaches practices themselves become the focus of enquiry, rather than the individual. For example, a practice-oriented study focusing on how laundry practices are performed will consider the context they arise from and what mechanisms have been involved in shaping or structuring them, and how they are reproduced, rather than on why individuals choose to launder in certain ways. Mechanisms may include ideas held by the human performers of practices as well as infrastructure, technologies present, and other contextual factors. For
some scholars this means viewing practices as sites for interaction between consumers and systems of provision (see Spaargaren 2003, for example) while for others practices are viewed as the animating entities in everyday life, treating humans as carriers of these practices (Reckwitz 2002). Whilst the theory sees practices as collective, it is still open for differences between individual practitioners, and for seeing rational knowledge input and aspects of ways of thinking as part of an explanation of practices (Gram-Hanssen, 2010b: 155). The three key components of the [practice] nexus identified by Schatzki as linking doings and sayings in order to constitute a practice may vary independently of one another between participants (Warde, 2005). Thus individuals become the conduits of practices, where practices—which are inherently social and shared—recruit practitioners, and where practices may be assisted or constrained in various ways by existing social and technical systems (Røpke, 2009; Hargreaves et al., 2012-13; Hinton, 2010).

Social organisation is considered a necessary condition of the existence of a practice (Warde, 2013), whereby performances become practices through engagements and commitments to normative specification of appropriate performances. Such criteria of acceptability may be expressed in processes of formalization and codification by which the objectives or purposes in a domain of activity, and the ways to go about attaining such goals are specified. Warde (2013) argues that these formal and authoritative agents are an essential component of the ordering, or organisation of many practices. This point is particularly relevant to renovation where statutory regulatory institutions and other authorities (such as professional associations and industry organisations) specify appropriate performances through documentation of rules, procedures and standards. However, Warde (2013: 24) also observes that codification of a practice may have little direct effect on actual practices.
5.4 Practices in context

The second key feature of the practice theory based approach is that practices are seen to emerge from specific contexts, rather than the outcomes of choice-making agents. In this respect, they can be thought of as co-evolving and adapting to and with their surroundings, and the structuring effects of other processes. As Randles and Warde (2006: 229) observe, ‘Practices do not float free of technological, institutional and infrastructural contexts’. A social practices perspective argues that practices are mediated through existing cultures, conventions and routines. Therefore, in examining particular practices it is necessary to give attention to the social context—political, economic, legal, and cultural institutions—to understand the socio-technical complexity of action. As Lutzenhiser points out, ‘While the physical-technical-economic model assumes consumption to be relatively homogenous and efficiency to be driven by price, the empirical evidence points toward variation, non-economic motives, and the social contexts of consumption. Economics can supply normative guides regarding when investments would be economically desirable, but it tells us little about how persons actually make economic decisions’ (Lutzenhiser, 1993: 269). Practice theory provides a way to explore how understandings, social structures and technical systems help hold together a specific practice (Gram-Hanssen, 2010: 163), although they may not interact or overlap in predictable or replicable ways to support the propagation of a particular practice.

The use of the concept of practices in socio-technical analysis, begins with the collective or social context shaping and framing daily actions as opposed to individual choice. Applying the concept of social practices to environmental actions and more or less sustainable patterns of consumption, these are viewed, not as the result of individuals’ attitudes, values and beliefs constrained by various contextual barriers (Wilson and Dowlatabadi, 2007), but as situated within and occurring as part of social practices (Warde, 2005). It is argued that practices are embedded in a range of socio-technical systems, which constitute a diversity of institutions, regulations, infrastructures
and technologies (Warde, 2013). They are also framed and shaped by the norms and values of the societies and contexts in which they take place (Moloney et al., 2010). Central to the analysis of domestic consumption practices is a focusing on how activities are constructed and reproduced, a concern that is largely ignored by the ‘technocratic approach’ of demand management strategies adopted by most governments and behaviour change programmes (Shove, 2006: 293). Thus a social practices theoretical approach represents a wholly different paradigm of social research. The next section examines the constituents of practices in more detail, and how this relates to home-renovation practice.

5.5 Constituents of practices

Loosely defined, there is no single unified theory of social practice (Schatzki et al., 2001: 2, 13). However, there are some common features in the ways in which practices have been described and used to shape analysis. In defining what a practice is, some theorists focus on the components or elements that make up a practice (e.g. Reckwitz, 2002; Shove and Pantzar, 2005a), and others on the connections between these components (e.g. Schatzki, 2002; Warde, 2005), and still others on the position of practices as providing a link between individuals’ lifestyles and broader socio-technical systems of provision (e.g. Spaargaren and Van Vliet, 2000). There is no universally agreed definition of practice with proponents each having their own interpretation of how practices are constituted and reproduced (Røpke, 2009; Gram-Hanssen, 2010b). So, for example, Schatzki (2002) applies the concept of linkages to hold practices together, whereas the other practice theorists apply the concept of components and reserve the concept of linkages for the active integration undertaken by practitioners when practices are performed (Røpke, 2009).

The scholarly accounts of the practice concept also differ with regard to the components to be included (as illustrated in Table 5.2). Of the different
accounts, Schatzki (2002) identifies three components: practical understanding, explicit rules, and teleo-affective structures. Explicit rules refers to ‘formulations, principles, precepts and instructions that enjoin, direct or remonstrate people to perform specific actions’, governing what and how things should be done (Schatzki, 2002: 79). Teleo-affective structures refers to ends, projects, and tasks typically linked with emotions and moods. Both Gram-Hanssen (2010b) and Bartiaux et al (2011) refer to teleo-affective structures, suggesting that practices are guided by a direction toward an objective that has a substantial meaning for someone (Gram-Hanssen, 2010b). Warde (2005) ‘translates’ and renames Schatzki's three components as understandings, procedures and engagements and also includes items of consumption. Inspired by Schatzki, Reckwitz and Warde, Shove and Pantzar (2005) adopt three components: competences, meanings, and products—explicitly including the material component—and their dynamic interaction to understand practices. Although not explicity included in this framework, the importance of rules and procedures are also noted by Schatzki (2002), Warde (2005), Gram-Hanssen (2010b), and Strengers (2009) in shaping practices. Strengers (2009: 43) distinguishes between two types of rules: ‘explicit rules’ (Schatzchi (2002), and the ‘rules of social life’ which are ‘techniques or generalizable procedures applied in the enactment/reproduction of social practices’ (Giddens, 1984: 21). Strengers also observes that rules can be standards, theories and recommendations developed by influential commercial or institutional organisations, which can hold the same status as many laws, becoming the source of new common understandings about appropriate and inappropriate practices.

Furthermore, Gram-Hanssen (2010b) makes a further distinction between two main types of competences: know-how and non-verbal (practical) knowledge accumulated through everyday experiences, and explicit, rule based or theoretical knowledge. The arrangement of these various components configures how practices are rendered identifiable and how practices are performed.
Table 5.2 Practices and their key components

<table>
<thead>
<tr>
<th>Theoretical</th>
<th>Empirical studies</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Practical understanding</strong></td>
<td><strong>Theoretical knowledge</strong></td>
</tr>
<tr>
<td>Body</td>
<td>Understandings</td>
</tr>
<tr>
<td>Mind</td>
<td></td>
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<td>The agent</td>
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<td>Structure/ process</td>
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<td><strong>Rules</strong></td>
<td><strong>Rules</strong></td>
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<td>Knowledge Discourse/ language</td>
<td>Procedures</td>
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<tr>
<td><strong>Teleo-affective structures</strong></td>
<td><strong>Common social understandings</strong></td>
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<td>Engagements</td>
<td>Meanings and images</td>
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<tr>
<td><strong>Things</strong></td>
<td><strong>Material infrastructures</strong></td>
</tr>
<tr>
<td>Items of consumption</td>
<td>Products</td>
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As demonstrated in Table 5.2, there is no single typology of the components that configure practices. The most frequently cited components are: cultural conventions, images, meanings and representations; objects, materials and technologies; normative understandings of competent performance; organisational and institutional systems; and spatial and temporal organisation (Evans et al., 2012). With variation in components and their relative significance across theoretical perspective and theorist, there is no universal agreement on a social practice and what it constitutes. However, there are elements in common whose boundaries intersect, and there is agreement that a practice involves connected components of bodily and mental doings and sayings, objects and materials, and skills and competences.

The practice components outlined are understood as broad categories covering a variety of elements, and which may not have clear boundaries in relation to each other. Taking the competence component, which covers the skills and the knowledge needed to carry out the practice, as an illustration. Whilst some competences are generic, used in many practices, such as the abilities to read and write, others are more specialised, such as bricklaying or plumbing. Some knowledge may be codified in formal rules, principles, precepts, and instructions. Skills and knowledge are often learned by experience and training, and they become embodied in the practitioner, whereas other parts remain tacit in the form of know-how. Although partly embodied in the practitioners, the practice perspective implies that competences are seen as part of the practice (which only exists through the performances) and are social, in the sense that they are shared.

Amongst proponents there is broad consensus that practices are not only coordinated entities but also require practical performance for their existence (Schatzki, 1996; Warde, 2005; Røpke, 2009). Conceptualizing practices as both entity and performance, a practice-as-entity is relatively enduring and relatively recognisable (Shove et al., 2007: 71), yet its existence depends on
performance. Equally, the performance is shaped by and constitutive of the complex relations which comprise the practice-as-entity (Shove et al., 2007). Reckwitz (2002) argues that re-ordering of the constituent components through which practices as entities are arranged leads to changes in the ways practices are performed. Also, practices (as recognisable, intelligible, and describable entities) are reliant on practitioners continuing to perform practices in particular ways and knitting together the various constituent components in the course of their everyday lives (Evans et al., 2012). Strengers and Maller (2011) determine a practice as being coordinated entity of elements comprising practical knowledge, material infrastructures and common understandings, thus mirroring the components used by Shove & Pantzar (2005). They go on to define a practice as a performance carried out by individuals (practice ‘carriers’) who actualize and sustain the practice; their empirical study considers diverse cooling practices in Australian households, where a householders’ ability to respond to heat is shaped by the components of cooling practices, including common understandings, practical knowledge (about different ways to keep cool), available housing infrastructures, and how these elements interconnect. The distinction between practice-as-entity and practice-as-performance in practice-based approaches assists in understanding variations in practices. As noted by Evans et al. (2012) at one level the practice of eating is almost universally understood as an entity, but at another level, there are many variants of the practice, including where people eat, what they eat, what is considered good manners, and so on. Thus, whilst a practice-as-entity is relatively stable, performances may differ among social groups. This differentiation is useful in understanding renovation practice which can vary. Renovation practice-as-entity and its variations in performance are considered further in section 5.7.1.

5.6 The role of material infrastructures

The material infrastructures are those material components such as the space and fabric, and things (or what Shove et al. (2007) refer to as the ‘stuff’ of
practices). One of the strands that divides scholars in practice theory, is the role and extent of agency that objects, things, artefacts, and technologies have in the theory (Schatzki et al., 2001). Practices are inevitably, and often essentially, bound up with material entities (Schatzki, 2012), a view upheld by other practice theorists such as Bourdieu, and other contemporary theoretical approaches including Science and Technology Studies and Actor-Network Theory (Latour, 2005). Latour (1987) holds that material artifacts should be understood as having the same status and agency as human actors. Drawing on the work of Bourdieu and Latour, Reckwitz (2002a) asserts that material objects and their use are an integral component of practices. In his formulation, however, artefacts only have an effect insofar as they are handled by human agents, and their importance cannot be the same or equal that of human bodies and their embodied understandings. The crucial role of things and their use for social practices is expressed in the elaborate definition of the concept of social practices provided by Reckwitz (2002), already referenced in section 5.2, where the importance of the role of knowledgeable and capable agents in shaping social life is retained.

In seeking to tease out the role ‘stuff’ plays in the development, persistence and disappearance of patterns and practices of everyday life, Shove et al., (2007) draw on the work of Schatzki (2002) and Reckwitz (2002) where material objects, including technologies, artefacts, and infrastructures, become active participants in social practices. However, not all social practice theorists attribute this role and agency to materials; some viewing them as ‘mediators’ of social practices, rather than active ‘ingredients’ of them (Strengers and Maller, 2012). In discussing the inclusion of materials as ‘non-human actors’ or as an element of social practices, Strengers and Maller (2012) observe that the material strand of social practice theory accounts for technologies and infrastructures as an element of recognisable practice entities, such as cycling, laundering or cooking (Schatzki, 2002). By definition the material element of a practice intersects with others, such as practical knowledge about how to
perform a practice; and common understandings about what one ought to do and why (Pantzar and Shove, 2010; Strengers and Maller, 2011). Simultaneously, theories of practice focus attention on the performative nature of practices, and the role materials and other elements play in transforming or potentially fixing a practice in place (Pantzar and Shove, 2010). The importance of the role of material objects in the constitution and performance of practices is discussed further by Shove and Pantzar (2005) and Strengers and Maller (2012), where these contribute to both resistance and change in practices.

It is evident that people interact with technologies and relate to them in many different ways in everyday life, and Gram-Hanssen (2009) asserts that technology is intimately linked to household practices at many levels. It is claimed that material objects, including appliances, technologies, infrastructures that embody energy and energy use, reinforce energy-related practices (Stephenson et al., 2010). Regarded as a key component, things can be a powerful force in the dynamics of practice according to McMeekin and Southerton (2007) who argue that as technologies are absorbed into practices, new meanings and uses are developed. In describing social practices, Wilhite (2007, 2008) emphasises the relevance of material structure and technologies, and contends that agency is distributed between technologies, socio-cultural context and the individual agents. A practice-oriented approach thus acknowledges the influence of non-human agency.

Things or technologies are positioned as a ‘necessary and irreplaceable part of certain practices’ (Reckwitz, 2002a: 210). Within renovation, material infrastructures encompass physical elements including the envelope of the building and its components, products, technologies, and material resources, systems of energy and water provision in home-renovation. The role of material infrastructures is twofold. First, the practice of renovating a house is
closely related to the physical attributes of the building, and the products and technology available (Bartiaux et al., 2011). Outcomes rest on the possibilities afforded by ‘structural’ limitations, with householders’ ability to engage in sustainable social practices constrained by existing infrastructures and systems of provision (Evans and Abrahamse, 2009; Shove, 2010; Spaargaren, 2011). Second, household practices and material goods are ‘mutually constituted’ (Hand et al., 2005: 671), with acquisition of domestic hardware and reconfiguration of spaces implicated in practices and everyday routines (Hand et al., 2007; Maller et al., 2011). As such, physical elements, from the building envelope to appliances, electrical sockets and everyday household technologies, are an integral component and their configurations have a role in shaping everyday practices (Southerton et al., 2004; Strengers, 2009). Gram-Hanssen (2009) argues that the configuration of physical infrastructure, including household appliances and the energy system, is strongly linked to household energy-consuming practices. It is apparent that material infrastructures inform the expectations and understandings householders are likely to hold. So, for example, air-conditioning and heating technologies have led to new understandings of comfort that prioritise the control of temperature and humidity in indoor environments, and standardisation over variation (Fountain et al., 1996; Cooper, 2009; Strengers, 2008; Healy, 2008). Using a social practices approach, Shove et al., (2007) argue that objects, products, technologies, resources and systems of energy and water provision, along with rules and procedures, not only shape renovation projects, but in turn, the structure, appliances and housing infrastructures, moderate and mediate what people do in their daily routines. It follows that material infrastructures are a critical component in shaping both home-renovation and daily household practices. The interplay between household daily practices and renovation practices is further explored in Section 5.7.
5.7 Household practices and renovation

Wilhite et al. (1996) point to the cultural embeddedness of energy consumption practices, and emphasise the relevance of social and cultural factors on how individuals practice comfort in the home. Describing renovation activities and creating a home using the term *nest-building*, Wilhite and Lutzenhiser (1999) argue that although involving the use of materials and energy, this is essentially a social activity. Consumption is viewed not solely as an isolated activity taking place at a final end point, but rather as a result of the interplay of multiple forces in society. They cite inward and outward-directed social motives as influencing a range of new material loads for homes, and implications for energy consumption. In discussing the social nature of energy consumption in the home, Wilhite and Lutzenhiser equate energy consumption with social base and peak ‘loads’, identifying the determinants of energy loads as: status and display, sociality and conventionality, security and convenience, and embeddedness in systems and structures.

Even so, little attention has been given to understanding home-renovation activities in relation to consumption and the environment. In discussing different approaches for explaining home improvement, and drawing on theories of consumption, technology and practice, Shove and Hand (2005) suggest that investment in domestic kitchen improvements is related to materiality of consumption and the relationship between objects and the particular practices of which they are a part. A study of the experiences of households who had extended or significantly remodelled their home by Hand et al. (2007) examined the opportunities and motivations to extend. The analysis, which focused primarily on the social organisation of domestic practices, related spatial adjustments to the acquisition of new technologies and goods and to daily practices; the authors showed how apparent individualistic solutions and strategies draw upon (and reproduce) remarkably similar aspirations, which are about supporting particular images of domestic
life. More conspicuous aspects of home improvement including extensions or ‘green’ improvements such as solar panels—which are often clearly visible—may be related to homeowner aspirations, and contribute to identity creation, and novelty (Gram-Hanssen and Bech-Danielsen, 2004; Maller et al., 2012).

Social practice theory highlights the collective and conventional nature of consumption, with attention given to routine or inconspicuous activities (Gronow and Warde, 2001; Southerton, 2001b; Warde, 2005). As posited by social practices, consumption is embedded within and derived from practices, with items and services appropriated in the course of engaging in particular practices (Strengers, 2010; Warde, 2005), and is, in turn, related to the collective development of what people take to be ‘normal’ ways of life (Shove, 2003); so, for instance, a new kitchen is acquired in order to accomplish particular practices—these might be eating and cooking but might also include other family-oriented activities, socialising or entertaining. In her influential book, Shove (2003) also demonstrates how new norms and higher standards of comfort, cleanliness and convenience, together with the introduction of new technologies, have a significant impact on households’ energy consumption. One illustration is the increase in air conditioning for space cooling, and associated rise in energy use (Wilhite, 2009; Strengers, 2008), a trend noted earlier in Chapter 2 of this thesis. Energy consumption in the home has recently become the focus of attention, however, reflection on the characteristics of energy consumption implies that a new and different approach is required, which argues that energy consumption, especially in the context of comfort, is a form of inconspicuous consumption (e.g. Shove, 2003), not orientated towards display. ‘Only at best obliquely and indirectly does the purchase or use of water, coal, gas, or electricity confer self-identity, mark attachment to social groups, or exhibit social distinction’ (Shove and Warde, 2002: 248). Consumption is regarded as a central part of individuals’ everyday practices and often ‘unseen’ habits (Hobson, 2003). In practice-oriented approaches, such consumption is reconceptualised as a by-product of
everyday life, where people consume resources in carrying out day-to-day practices.

As argued by Wilhite (2010), Warde (2005) and others, there is potential for social practices to provide insight into household consumption, and to contribute to the development of innovative policies aimed at reducing household energy consumption, which is identified as a key feature in policy to address environmental performance. However, in analysing energy consumption in everyday life, consuming energy is not in itself considered a practice; it is an element in, a consequence of, or a necessity for many different practices. Rather than consciously consuming energy in their everyday life, people instead consume particular services, which have implications in terms of energy consumption (Hinton, 2010; Shove and Warde, 2002). In understanding the ‘dynamics of demand’ for energy consumption (Shove, 2006: 294), it is necessary to focus on the different practices for instance, food preparation and cooking, clothes washing, bathing, or communicating and entertaining, and also what could be called ‘the practice of making a home,’ which includes keeping a comfortable temperature and lighting as well as cleaning, maintaining, decorating, and furnishing the house (Gram-Hanssen, 2009), and even renovating (Aune, 2007). As observed by Gram-Hanssen (2008a), homeowners may have no consideration of energy or the environment, however, the decisions involved in renovation may indirectly influence the day to day routines, and thus the amount of consumed energy in the household.

Given the growing interest in more sustainable patterns of household energy use, social practices can provide insight into decisions about home-renovation practices and the structures within which they occur, and how these intersect with other routine activities carried out in the course of day-to-day living—encompassing both conspicuous and less conspicuous aspects of
consumption—and the implications for environmentally significant consumption.

This section has discussed the interface between household practices, renovation practices and environmentally-significant consumption. Based on published studies that recognise social practices, the following sub-sections go on to discuss how home-renovation practices may be currently understood, incorporating homeowners’ aspirations, and energy efficiency.

5.8 Renovation studies: environment, expectations and comfort

In a study of energy consumption in existing owner-occupied detached houses in Denmark dating from the 1940-50s and 1960-70s, Gram-Hanssen (2011) concludes that there might be other arguments for renovating besides energy and environment, including cultural heritage, and people’s personal relation to their homes. She argues that renovations might be understood through lifestyle, status and consumption. Other motivations identified include maintenance, or satisfaction from working physically on their house, and enjoyment of the project and the process. In most of these cases concern about energy is not the main reason for doing the renovation, even though the renovation attempts to improve energy efficiency. Some renovations might also include making a home more comfortable, i.e. to provide a higher indoor temperature or bathrooms and spas, and thus may enable increased energy consumption.

In an empirical study of renovation practices, including energy renovations, based on 20 in-depth interviews with householders across four European countries, Bartiaux et al. (2011) found that renovations are carried out for many different reasons, the most widespread being: aesthetic taste; convenience and comfort; general wear and tear; or in order to personalise the
home (for example, renovating a kitchen in order to make it suit the personal
taste and the daily routines of the household). Bartiaux differentiates between
householders’ incentives of saving money, saving energy—or in a more
abstract way, saving the environment. In their investigation of home
improvements and everyday household practices, Maller and Horne (2011)
contend that there is a weak association between homeowners’ concerns for
the environment, home improvement consumption and household practice.
Further, the findings of a study drawn from interviews with 50 householders in
the UK indicated that while environmental concerns might motivate a minority,
issues such as aesthetic tastes and effects on lifestyle are central to why
people reject economically viable, simple and well-understood domestic
energy-efficiency interventions (Crosbie and Baker, 2010). The study
concluded that promoting energy-efficient interventions in terms of
environmental issues was less likely to be effective than promotion of direct
benefits to participants in terms of their lifestyles. The significance of amenity
motives in home-renovation is also noted by Wilson and Dowlatabadi (2011).

In another study (Gram-Hanssen, 2010a) examined the daily habits of 5
families, each living in identically-designed homes supplied by the same
district heating system widely different amounts of energy were used for
heating. Each household had different experiences, and narrated different
ways of using and understanding heat within their homes.

Further insight into variation of comfort practices is provided in an
ethnographic study of Japanese and Norwegian households’ heating, lighting
and bathing practices, and Wilhite et al., (1996) suggest that local cultural
factors play an important role. Empirical ethnographic research conducted in
Denmark by Jaffari and Matthews (2009) explores the interplay between
individual, social and technological factors. Based on observation of a single
family and measurement of physical parameters, Jaffari and Matthews (2009)
propose that comfort can be understood in relation to regular activities,
habitual and routine practices. Although renovation is not specifically addressed in the above studies, several authors (Gram-Hanssen, 2011; Gram-Hanssen et al., 2012; Maller and Horne, 2011, Wilhite and Lutzenhiser, 1999) have suggested a connection, and it is also noted in 4.5.3, that renovations may be influenced by understandings and expectations of comfort.

Analysis of homeowner renovation activities based on a practice theory perspective offers much potential to understand and interpret the material and other dynamics of renovation, the rationale underlying homeowners’ renovations of existing heritage dwellings, and socio-technical systems and cultural contexts, and how these may be related to differences in domestic energy consumption and environmental performance.

The next section explores the challenges in applying a social practices approach to renovation.

5.9 Practice theory: theoretical and empirical challenges

As Røpke (2009) points out, there are some difficulties with focusing on practices: it may be difficult to know how to exactly delimit a practice; or to effectively distinguish between a practice’s constitutive elements and the context of the practice; the social nature of practices inevitably confers variability in enacting practices between different groups, which can present problems in the classification of practices from empirical observations; difficulties in the operationalisation of practice theoretical approaches and methods of ascertaining practices. The integration with and effectiveness of practice theoretical approaches is also the subject of discussion. These are considered further in the following sections.
5.9.1 Delimiting renovation as practice

One of the challenges presented by theories of social practice is delimiting the practice (Warde, 2013). While there is no unifying definition of a practice, it is loosely described as ‘bundles of activities’ (Schatzki, 2002), an organised cluster or set of activities which are recognisable across time and space (Røpke, 2009: 2491; Shove et al., 2007) and that are performed by people—not only by a few particular individuals but by larger groups of people (Røpke, 2009). Examples of practices given by Schatzki (1996: 89) are ‘cooking practices, voting practices, industrial practices, recreational practices, and correctional practices’ illustrating a range in their diversity and complexity, as some practices appear more involved than others.

Although some practices are carried out by individuals, others often involve some sort of interplay with other people. When the parts differ, it could be argued that the practitioners are involved in different practices, although they meet in a common situation. Røpke (2009) argues that where the activities of the actors are mutually conditioned and the practice cannot be accomplished without the participation of all parts, it seems better to conceptualise such activities as one practice. For instance, in home-renovation, different contractors are often involved in seemingly separate activities, such as building a wall, plastering or painting, but all are participating in the practice of renovation through shared purposes of engagement (Warde, 2013).

Elsewhere, renovation and retrofitting are considered to be sub-practices of and emergent from the broader practice of home improvement (Maller and Horne, 2011); and energy renovation is considered a sub-set of home-renovation activities (Bartiaux et al., 2011). As such, renovation may be conceptualised as complexes of practices, which are closely entangled (Shove et al., 2007). In Schatzki's terminology, practices may be understood as an organised constellation of actions which forms a bundle or cluster of activities (Schatzki 2002: 71). As Reckwitz (2002: 249-50) puts it: ‘a practice represents a pattern, which can be filled out by a multitude of single and often unique
actions reproducing the practice’. A pattern may be interpreted as a regular and intelligible form or sequence discernible in certain actions or situations.

There is some discussion over whether renovation constitutes a practice, as it may be carried out infrequently. Although a practice is regarded as a routinised type of activity (Reckwitz, 2002), a distinction is made between everyday routine practices which are identified as having environmental implications and other ‘less routine’ practices (Maller & Horne, 2011: 63). Thus a distinction is made between domestic practices, and renovation practices. Home improvement and renovation is discussed within the scope of social practice in the literature (Bartiaux et al., 2011; Hand et al., 2007; Maller et al., 2011; Moloney et al., 2008; Watson and Shove, 2008). Gram-Hanssen (2009) argues that practices need not be frequent or regular; they can comprise occasional, rare, or novel sayings and doings, tasks, and projects. Although undertaken only intermittently, the practice of renovating is carried out by many people in numerous houses across many countries and therefore is recognized as a practice (Bartiaux et al., 2011). There is evidence that home-renovation is becoming a ‘ubiquitous’ phenomenon (Maller et al., 2011: 1), a view supported by the statistical data of the housing sector in Victoria, as demonstrated in Chapter 2. Reproduced by sufficient numbers of practitioners, renovation is viewed as a valid and increasingly normal practice (Shove, 2010; Shove et al., 2007).

Home renovation is regarded as a complex activity, akin to an integrated practice (Warde, 2005), defined as the ‘more complex practices found in and constitutive of particular domains of social life’ (Schatzki, 1996: 98), and constituted by shared purposes of engagement (Warde, 2013). Task-based instrumental activities associated with renovation might include, for instance, installing insulation, a heating or hot water system, lighting, replacing windows, fitting a new kitchen or bathroom, reconfiguring spaces within the dwelling and extending to provide additional facilities, but also what could be called ‘the
practice of making a home’, which includes keeping a comfortable temperature and lighting as well as decorating, adding window and floor coverings—which are all considered to be different integrated practices (Gram-Hanssen, 2009).

Warde argues that some complex and heteronomous practices—termed composite or compound practices—have multiple organisational underpinnings, with performances following from the intersection of several integrated practices (Warde, 2013). Following Watson and Shove (2008), and referring to Warde (2005: 145), Bartiaux et al. (2011: 69) consider home renovating to be an integrated practice because ‘competent practitioners will avail themselves of the requisite services, possess and command the capability to manipulate the appropriate tools, and devote a suitable level of attention to the conduct of the practice ...in addition to exhibiting common understanding, know-how, and commitment’, thereby satisfying the components that co-ordinate and institute practices as recognisable entities.

With reference to do-it-yourself home improvements (DIY), Shove et al. (2007) use the concept of projects as a way to understand to how practices are organised in relation to each other to achieve an objective: ‘In everyday life, projects, which take many forms, are significant devices deployed in bounding and in making sense of the temporal now, and in actively orchestrating and interweaving complexes of practices’ (2007: 144). Thus renovation is a complex practice, consisting of many different and connected parts.

5.9.2 Integration with behavioural theoretical approaches

There is some contestation over whether social practices can be combined with other theoretical perspectives, in particular, the extent to which practice theory might be compatible with other behavioural accounts of energy use (see Shove, 2011; Whitmarsh et al., 2011). In a recent debate in Environment and Planning A journal, Shove (2010) is emphatic in arguing social theories of practice on the one hand, and of behaviour on the other, are ‘like chalk and cheese’, and points out their distinctive differences. ‘Whereas social theories of practice emphasize endogenous and emergent dynamics, social theories of
behaviour focus on causal factors and external drivers. Likewise, people figure in the first case as carriers of practice and in the second as autonomous agents of choice and change. It is useful to be clear about the incommensurability of these contrasting paradigms, and hence about the impossibility of merger and incorporation.' (Shove, 2010: 1279). Taking issue with Shove’s theoretical stance, Whitmarsh et al. (2011) argues for an interdisciplinary approach, with integration of a range of perspectives to address the complex and multi-layered problem of sustainability. However, Shove (2011: 264) responds by arguing that ‘contrasting paradigms are valuable because they generate different definitions of the problem’.

In his empirical studies of pro-environmental behaviour change interventions and how practices interact with these Hargreaves (2011) is intervening in a debate in the literature around the possibility of integrating or at least holding open the possibility of working with both choice based approached to behaviour and practice based approaches to everyday life. Hargreaves suggests, ‘some (e.g. Shove, 2010) argue that the terms practice and behaviour are incompatible, …This article does not fundamentally depart from this position, but it also contends that given the contemporary ‘doing’ of numerous ‘pro-environmental behaviour change interventions’, it would be unwise to ignore them altogether, and empirically misleading to call them by another name. Whilst preserving this important distinction, therefore, the aim in the rest of this article is to use practice theory’s broader and more holistic perspective as a means of exploring what actually happens within behaviour change interventions and, in so doing, to try and understand the effects they have on the social practices they tackle (even if they tackle such practices unwittingly)’ (Hargreaves, 2011: 84). Reflecting on the relationship between practices and behaviour change interventions, Hargreaves reconceptualises behaviour change initiatives as ‘attempts to intervene in the organisation of social practices.’ (Hargreaves, 2011: 84). Whilst maintaining the distinctive differences between behavioural and social practices, Strengers et al. (2012)
discuss whether, in implementing social and environmental change, it may be worthwhile to conceptualise behavioural and social practice theoretical approaches as ends of a ‘theoretical continuum’.

5.9.3 Effectiveness of practice theory

As practice theories have only limited empirical application to date, the extent to which practice theory enables scholars and researchers to accomplish more than is possible without it remains unclear. In his influential review of practice theory, Warde (2005: 146) suggests that ‘[t]he argument remains to be made that theories of practice perform better than, or at least as well as, other approaches claiming similar merits...’. In responding to criticisms of practice-based approaches made by Jackson (2005), Evans et al. (2012) posit that there is not yet an empirical base for exploring policies initiated in the light of theories of practice. However, they argue that research that has analysed existing behaviour change interventions using theories of practice shows how the actual workings of initiatives are better explained in terms of the dynamics of interconnected practice, citing as an example the analysis of the London Congestion Charge (Shove and Walker, 2010). Also, in the ethnographic study of a workplace behaviour change initiative—Environment Champions—in process, Hargreaves (2011) argues that theories of practice provide a more robust account of how the intervention actually operated in situ than is offered by the framework within which it was most likely initiated. Practice-based approaches thus present an opportunity to re-frame common behaviour change problems, and reorient policy initiatives.

5.9.4 Operationalisation and methods

One of the challenges in operationalising practice theoretical approaches is that elements of a philosophical account of practice cannot be easily transposed into empirical analysis. In his review of the potential of practice theoretical perspectives for analyses of consumption, Warde (2005) argues
that general theories of practice tend to be idealised, abstract and insufficiently attentive to the social processes involved in the creation and reproduction of practices (Warde 2005: 135). The potential usefulness of practice theory, therefore, requires more analytical translation between applied practice theoretical concepts and operative methodological procedures (Halkier et al., 2011).

Given the abstract nature of practice theory, application in empirical studies raises questions—for instance, it may not be so obvious how to delimit a practice. Defining something as a practice must make sense to people; but apart from that, there is little guidance. Røpke (2009) suggests that the actual delimitation of a practice must be determined by a study's research purpose. A further complication in delineating a practice, is that some practices may be interconnected, or can be considered sub-practices in relation to a more general heading: for example, washing the car can be considered an element of motoring (Røpke, 2009). As noted earlier, Bartiaux et al., (2011) regard energy improvements as part of broader renovation practices.

It is argued that practices are best understood through their performance rather than reports of their performance (Røpke, 2009). A better understanding of some practices associated with energy use such as comfort could be achieved by paying attention to practices and, where possible, observing behaviour in context. Direct observation through round the clock observation either in person or remotely, requires participants to agree to such surveillance, due to ethical implications. This would also involve significant costs in terms of researcher time and, if remote surveillance was pursued, monitoring equipment. However, Hitchings (2012) confirms that talking to participants is a suitable approach for understanding householders’ practices, and overcomes the ethical issues associated with observing householder daily practices (Strengers, 2009). Through focusing questions on particular practices in the places that these practices occur, Hinton (2010) argues that it
is possible to understand the ways that individuals exert agency in their interactions with related socio-technical systems, and how these systems may constrain and enable particular forms of practice and experiences. The methodological implications of the practices approach and methods adopted for this research are discussed in more detail in Chapter 6.

### 5.10 Analysing renovation practice

Whilst several recent analyses of household renovation activity have been inspired by theories of practice (Bartiaux et al., 2011; Gram-Hanssen, 2011a; Bartiaux et al., 2011; Maller et al., 2011; Shove et al., 2007), there are no other relevant examples of practice theory having been applied specifically to renovations of heritage dwellings, or providing insights into the tensions with environmental sustainability.

Building on the work of Shove and Pantzar (2005), who conceptualise practices as fluid constellations of material infrastructures, symbolic meanings and images, and competence/skills, this thesis proposes to extend this conceptual approach to better understand the improvement of environmental performance in existing buildings with heritage significance by using a practice theory framework (Figure 5.1) which focuses on the following key components for understanding homeowner renovations:

- Common understandings and meanings
- ‘Competences’ (knowledge and practical skills)
- Material infrastructures (incorporating physical infrastructures and rules and procedures).

Although different authors have emphasised somewhat different elements, these components provide a logical basis for the study of renovation practices and for understanding variations within the practice. In this framework,
Material infrastructures are divided into physical and non-physical infrastructures, the latter including rules and procedures, which are considered important to renovation practice. In the context of renovation practices, rules might be the embodiment and reproduction of regulations such as building codes, restrictions relating to certain technologies for heating, standards for indoor comfort temperatures, theories and recommendations developed and/or introduced by institutional bodies. This approach has been formulated based on more recent studies (Gram-Hanssen, 2011; Strengers, 2009). This thesis argues that these components provide the basis for in-depth study into social, cultural and material mechanisms underlying renovation, leading to a better understanding of the linkages between changes to the built environment, energy consumption, and practices. These components are important for understanding how to change a practice.

Figure 5.1 Conceptual framework for analysing renovation practices in heritage dwellings
In contrast to rational approaches which tend to separate people, objects from their context, the social practices analytical framework brings together technical, social and cultural aspects of renovation practices, and addresses the close interaction between people, technology—including buildings—and the wider social context, and the implications for energy performance. The social practices approach is arguably useful because it bridges individual lifestyles and broader socio-technical systems of provision (Hargreaves, 2011; Spaargaren & van Vliet, 2000). Rationalist understandings of human action are unable to provide insight into how and why people embark on material change to their homes (Crosbie and Baker, 2010; Karvonen, 2013). Social practice theory stands out because it focuses on what people do as well as meanings and understandings, through studying ‘doings and sayings’ (Schatzki et al., 2001). The concept of social practice is used both as an approach, and through the component elements listed to investigate how people engage with and experience their home environments, including their interaction with energy technologies in renovation. The framework developed is able to provide deeper understanding of meanings and understandings associated with heritage dwellings, knowledge and skills, and the influence of material infrastructures and institutions on renovation practices. From a policy perspective, for example, this may include how financial incentives influence engagement in a practice (through subsidies or energy certificates for installing photo voltaic panels and generating renewable energy); the ways in which information might influence practices as it affects understandings; knowledge of rules and regulations and how these may be interpreted, together with know-how relating to improved energy performance in houses. The framework also incorporates the role of the building, technology and infrastructure in shaping renovation practices. At the same time, there may be other mechanisms configuring renovation practices in heritage dwellings. The social practices framework is particularly useful in recognizing the complexity of renovation which has many elements, including the physical diversity of the
housing stock, the introduction of new and improved building products, the various actors and competences, and the activities and opinions of occupants.

A practice-oriented perspective offers the potential to provide insight into the relationship of renovation activities with the dynamics of everyday life; social interaction; social structures and technical systems; knowledge and know-how; material culture; cultural conventions; and common understandings relating to the renovation of heritage dwellings. Further, the framework provides a meaningful structure to relate details of micro-level variations in households to macro-level understanding of the dynamics of renovation and energy demand in a society (Schatzki et al., 2001).

5.11. Digest: social practices and renovation

This chapter explored theories of social practice and how home-renovation may be understood through a social practice lens. Drawing on the literature, this chapter identified what a social practice is, and how a practice is differentiated from behaviour; in examining the constituents of practices, the role of material elements and rules have been explored. Key theoretical and empirical challenges in applying the approach to renovation were discussed.

A social practice framework is presented as a conceptual alternative to technical-rational and behavioural approaches for empirical investigation of the renovation of dwellings with heritage significance, to achieve objectives of reducing energy use and associated emissions. This conceptual framework positions heritage home renovation practices as a series of interrelated components encompassing common understandings about home renovation, including heritage and the environment; competences, including knowledge and skills; and material infrastructures, such as technologies, systems of provision, rules and guidance.
It is argued that practice theory provides a meaningful theoretical framework for considering issues relating to consumption in the home, the acquisition of material goods and services and their use, as well as less tangible issues relating to user understandings, expectations and conduct associated with interventions. A focus on practice also provides insights into how new technologies and products are adopted into domestic life leading to new practices and social norms. In contemporary studies, social practices recognises the interconnection between technology and human action and the wider social context; and this theoretical and empirical approach bridges between theories of consumption, technology and society in energy and environmental policy. It follows that a practice theoretical perspective can offer valuable insights into homeowner renovation practices, how these relate to everyday activities, and the implications for environmental performance.

In seeking to apply practice theory to home-renovation, a distinction is made between renovation practice (the practice of renovating) and everyday domestic practices, and how these influence decisions around renovation. The next chapter proceeds to operationalise the conceptual framework and methods for investigating for the empirical study of renovation practices in heritage dwellings.
Chapter 6

‘The dynamic interactions between people and their built environment form a complex system that renders research of any detail or duration in this area a major challenge.’


6 Research design and methods

Framed using a practices-orientated perspective grounded in the socio-technical tradition, this research employs the conceptual framework developed in the previous chapter for studying renovation practices in heritage dwellings. The following sections set out the methodological approach, reasoning for the methods employed to address the research questions in section 1.4, and their limitations.

6.1 Qualitative approach and methodology

Practice-orientated research usually focuses on everyday activities such as bathing (Scott et al., 2009), showering (Hand et al., 2005), defrosting the freezer (Shove and Southerton, 2000), or doing the laundry (Pink, 2005). More recently, social practice has been used in analysis of retrofitting to address environmental sustainability (Bartiaux et al., 2011; Maller et al., 2011). This research investigates home-renovation practices in heritage dwellings and how these intersect with the everyday lives of householders in achieving objectives to reduce energy use and associated emissions. In researching the topic under investigation, this thesis differentiates between the following major themes: the practice of renovations in heritage dwellings—with particular attention to those interventions that have energy-related environmental impacts—and the everyday household routines that are related to renovation activities.
To understand the complex social and cultural factors driving household energy demand, a quantitative survey alone is insufficient; rather, qualitative research must play a central role (Crosbie, 2006). Qualitative research methods are essential to understanding effective energy efficiency interventions, and energy consuming practices, a view supported by others (e.g. Ballinger et al., 1991; Pink, 2011; Williamson et al., 2010). A study of weather-sealing by Wilk and Wilhite (1985) is one of the first studies identified on energy-related performance that was based on a predominantly qualitative approach. Moloney et al., (2008) conducted interviews with households in Melbourne to explore the mechanisms shaping homeowners’ practices relating to housing renovations, and the extent to which these mechanisms support or impede the achievement of sustainable housing. In a recent study to understand the uptake and effectiveness of household energy-efficiency interventions, Crosbie & Baker (2010) interviewed 50 residents of social housing to understand energy-efficiency interventions from the participants' perspective. A major attribute of these studies is the focus on naturally occurring, ordinary events in natural settings, so that they have a strong handle on what real life is like. Further, the emphasis on people’s lived experience makes qualitative data fundamentally well-suited for locating the meanings people place on events, processes, and structures of their lives, and connecting these to the social world around them (Miles and Huberman, 1994). It follows that qualitative research can more ably deal with complex social situations and do justice to the subtleties of social life (Denscombe, 2003).

As a wide span of daily practices is associated with renovation, this research considers a range of relevant everyday practices rather than detailed exploration of one practice or daily routine.

The principal qualitative methods of data collection to undertake this analysis are presented in Table 6.1. All of the methods referred to have a place in
household energy studies: whilst survey-based research and secondary data analysis provide a wealth of information on the different demographic and technical factors that affect household energy consumption, these cannot provide the depth of information necessary to understand how social and cultural aspects of people’s lives shape renovations and the various factors that influence household energy consumption.

Table 6.1 Data collection methods for exploring social and cultural contexts of energy use

<table>
<thead>
<tr>
<th>Method</th>
<th>Scope and limitations for exploring social and cultural contexts</th>
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<tr>
<td>Self-report surveys</td>
<td>▪ As self-report surveys use closed question formats it is difficult to use this approach to uncover the reasons for energy consuming choices made by research respondents. For example, they can be useful for obtaining information concerning how many people in a given population own particular household appliances, but not why respondents choose to buy or not to buy particular appliances. Therefore, this approach supplies little data on how social and cultural contexts shape household energy consumption.</td>
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| Administered surveys/structured interviews | ▪ The closed question format of administered surveys severely limits probing questions. Thus, as with self-report surveys it is difficult to address questions concerning social practices and cultural expectations that underlie the reasons why different groups consume different amounts of energy.  
  ▪ The closed format of administered surveys can also restrict the recording of supplementary observational data. |
| Focus groups                  | ▪ Suitable for identifying major themes but not so much for the micro analysis of subtle differences.  
  ▪ Focus groups provide the opportunity for the researcher to listen as people share and compare their different points of view. This provides information concerning not only what people think and what they do, but also why they think and act in the way they do. |
Therefore, this approach can provide the depth of information necessary to exploring the social and cultural aspects of household energy consumption, because it allows an exploration of the opportunities and constraints faced by research participants in their everyday energy practices.

- Most suitable for small groups sharing similar backgrounds.
- Cost effective for gathering data in a specific geographic locality.
- Usually takes place out of the natural setting where practices occur. Therefore, not suitable for exploring actions in individual cases.

| Monitoring energy consumption | Can be useful for identifying patterns or changes in consumption (depending on the data and time period) but detailed data may be difficult to obtain.
- This approach provides no information on why people make particular energy consuming choices and decisions unless combined with other methods of data collection. Therefore, monitoring energy consumption on its own cannot provide the data necessary for exploring social and cultural aspects of domestic energy consumption. |

| Secondary analysis of data | Qualitative data sets available for secondary analysis are limited and quantitative data sets do not provide the necessary depth of data for exploring social and cultural factors (although these may be usefully combined with qualitative data).
- Data quality is dependant on methodology applied in the original research.
- The re-use of qualitative data remains theoretically and methodologically under-developed.
- Typically, secondary analysis of data is exploring different questions to those for which the data was gathered in the original study. This often means there are gaps in the data in regard to the questions being asked by the secondary analysis. |

| In-depth interviews | Open-ended questions used in in-depth interviews offers a greater opportunity to ask probing questions than any other data |
collection method. Therefore, in-depth interviews can be used to uncover reasons why research respondents make particular energy consuming decisions and the constraints and opportunities shaping those decisions.

- This approach can supply the data necessary for exploring how social and cultural contexts shaping patterns of household energy consumption.
- In-depth interviews in research participants’ homes have the advantage that interview data can be supplemented with observational data.

Source: Adapted from Crosbie (2006); Patton (2002)

Based on the foregoing, qualitative in-depth face-to-face interviews were selected as the method of collecting primary data. Whilst interviews are more time-consuming than other forms of data collection such as a questionnaire survey, interviews offer several advantages, most importantly, interviews are able to elicit depth of information (Bryman, 2008; Robson, 2002). Semi-structured interviews offer several other advantages over structured interviews or survey questionnaires: a less structured approach is more informal, offering greater flexibility in the sequencing of questions and wording. Further, the amount of time and attention given to different aspects can be varied depending on the interviewee’s responses; and a semi-structured approach allows probing of interviewees to determine homeowners’ actual motivations (Crosbie and Baker, 2010; Bryman, 2008; Harrell et al., 2009; Kvale, 1996; Robson, 2002; Silverman, 2010). In offering a greater opportunity to ask probing questions, the depth of data is significantly higher than that provided by any other data-collection method (Wilk and Wilhite, 1985; Bryman, 1988). This method is, therefore, appropriate for collecting in-depth data on homeowners’ experiences of renovation and understanding homeowners’ motives, practices, structural and other factors influencing the outcome.
The researcher employed an interview guide approach (Patton, 2002), using an outline or schedule of topics that are of importance to the research: measures utilised to improve environmental performance (focusing on energy use); understandings of renovations, heritage, the environment and other priorities; conflicts and how these were resolved. The interview schedule is appended (Appendix 3). Within the interview guide approach, open-ended questions were employed to elicit information about homeowners’ experiences; this approach allows participants to give their own explanations for actions and allow the interviewer to expand on points of interest that arise (Wilk and Wilhite, 1985). One of the strengths of using this approach is that the data collected is more systematic and comprehensive than in the informal conversational interview, while the tone of the interview remains fairly informal (Crosbie and Guy, 2008). This method also enabled the researcher to ask probing questions about energy-related practices, to discover why participants make particular energy-consumption decisions in renovations, and to identify the constraints and opportunities that affect them (Wall and Crosbie, 2009; Wilhite et al., 1996). A pilot interview was carried out to trial the topics covered and questions; the pilot interview highlighted the importance of comfort as a motivating factor for occupants, and this theme was included in subsequent interviews.

In a recent study of eco-renovation of 20 households in the UK, Haines et al. (2010) note that although not without its challenges, a good deal of useful information can be elicited through talking about everyday practices in interviews. Hitchings (2012) also confirms that householders are able to narrate stories about their homes and way of life, and discussion using semi structured interviews with research participants is a suitable approach for understanding householders’ practices. This method is considered an appropriate means to elicit the perspective and practices of homeowners seeking to improve environmental performance of heritage buildings, providing insight into homeowners’ renovations, and in-depth understanding of the complex range of mechanisms and social interactions involved.
A limitation of the method employed in that the collection of data on household practices relies on self-reports rather than direct observation, and the possibility of over-reporting exists (Black et al., 1985). Participants are liable to over-state pro-environmental attitudes and self-reported behaviours, (such as turning down the thermostat), because it includes a social desirability component. By conducting interviews with homeowners in their own homes, it was possible for the researcher to observe participants’ living conditions and aspects of their normal daily lives, lifestyle, and living standards, including thermal comfort. As well as semi-structured interviews, the research employs accompanied house tours. This allowed the researcher to verify interventions, noting visible components, such as the technologies, household appliances and artefacts that are associated with the building and renovation. These methods encourage participants to relate their experiences, explain what they have done and why, as well as providing the opportunity to observe the material context in which renovation and everyday practices are carried out. As well as direct observation, homeowners’ accounts of renovations were corroborated through documented sources including approved building plans, and energy usage verified from utility bills, where these were made available (further details are included in Appendix 1 and 2). However, only 3 of the 20 households provided utility bills (nos. 15, 16 and 20).

In conducting this research, data is collected in the settings that the researcher wants to study (Willis et al., 2007), using techniques borrowed from ethnography. O’Reilly O’Reilly (2005) defines ethnography as:

‘iterative-inductive research (that evolves in design through the study), drawing on a family of methods, involving direct and sustained contact with human agents, within the context of their daily lives (and cultures), watching what happens, listening to what is said, asking questions, and producing a richly written account that respects the irreducibility of human experience, that acknowledges the role of theory as well as the researcher’s own role and that views humans as part object/part subject.’ (O’Reilly, 2005: 3)
Ethnographic methods involves a ‘collection of several methods for generating and analysing qualitative data that are grounded in a commitment to firsthand experience and examination of some social or cultural phenomena’ (Schwandt, 2007: 93). Within ethnographic research, methods may be combined flexibly to achieve the aims (Abercrombie et al., 2006). It is asserted that qualitative, ethnographic approaches have an important role to play in research to reduce domestic energy consumption (Henning, 2005; Pink, 2011). According Wilk and Wilhite (1985), close and careful study of small groups and lengthy discussions with individuals can provide detailed knowledge. Whilst acknowledging that such intensive, open-ended studies do not usually produce statistically valid results that can be freely generalised to the larger population of energy users, they can yield finely grained and detailed information which cannot be obtained through survey questionnaires and they often provide unexpected insights and lead to productive new lines of inquiry. Importantly, consumer preferences and practices are placed within a wider context of other life decisions and consumption is linked to other processes and activities in society in general. As such, issues can be examined in a contextually sensitive way and the researcher can gain a full understanding of their meaning and implications (Crobbie and Baker, 2010; Hitchings, 2009). The overall approach was interpretive, focusing on renovations from the perspective of the homeowner, taking the emic or insider perspective (Boyle, 1994) by in studying the practices of home-renovators in situ. In terms of the nature of the data gathered and process of analysis, the research yields two levels of data: first, the explanations offered by respondents of their actions in response to direct or indirect questioning; the second, comprises ‘synthetic explanations’ composed by the researcher as the interviews are dissected and analysed (Wilk and Wilhite, 1985: 624). Thus the first level of explanation becomes data for the second-level of analysis. The analysis process is described as switching between the emic viewpoint and etic perspective and testing these against each other (Boyle, 1994: 181).

The next section explains the reasoning for using case studies to explore home-renovation practices.
6.2 Case study research

Case study research offers several advantages which are of particular relevance to this study. One of the strengths of case study research is the ability to undertake an investigation into a contemporary phenomenon in a real life context (Yin, 2009). Case studies enable ‘an examination of a specific phenomenon such as a program, and event, a person, a process, an institution, or a social group’. and are therefore ‘about real people and real situations...[they commonly] rely on inductive reasoning...[and] illuminate the reader’s understanding of the phenomenon under study’ (Willis et al., 2007: 238-239). Thus, taking a case study approach enables an examination that looks holistically and in depth into home-renovation practices and the context on which homeowners operate (Eisenhardt, 1989; Yin, 2009). It is holistic and thus supports the idea that much of what we can know about human activity is best understood as lived experience in the social context. As case study research is not limited to one research paradigm, it is suitable for transdisciplinary inquiry (VanWynsberghe, 2007), and is therefore appropriate for the scope of this investigation. This research therefore combines ethnographic techniques with the case study method to provide in-depth data of a richness and detail that would be difficult to obtain from more representative research designs, such as surveys. The qualitative case study method is regarded as especially helpful in the evaluation of renovation practices to improve environmental performance of heritage buildings in Victoria because the phenomena of practices is an emerging area of empirical research (Evans et al., 2012), and homeowner practices relating to renovation of heritage dwellings to improve environmental performance cannot be adequately understood from other available data sources or methods.

As a research method or strategy, case studies have traditionally been viewed with some scepticism when compared with other social research methods. External validity or generalisation of findings, lack of rigour, and objectivity are criticisms that may be levelled at qualitative and case study research
(Denscombe, 2003; Rowley, 2002). The conventional view is that depth is at the expense of a lack of generalisability (Abercrombie et al., 2006). Whether generalisation is an appropriate requirement for case study research is part of an on-going debate between the different schools of research philosophy and strategy (see Flyvbjerg, 2006; Rowley, 2002; Yin, 2009). Nevertheless, in addressing the charge that findings may be untypical, Bryman, (1988) argues that this can be largely overcome by increasing the number of cases in the study. Further, Flyvbjerg (2006) emphasises that the researcher should be sensitive to the diversity of the cases. In accordance with this and advice from Bryman (1988), this study includes multiple cases, with respondents drawn from a variety of social and geographical milieu, to maximise the likelihood of wider relevance of results.

There is a considerable body of opinion which maintains that the case study is an invaluable tool for studying social settings and contributes to generating practical and valued knowledge for society. In outlining several of the positive features of case study research, VanWynsberghe (2007) argues that case studies can contain evidence that may be translated beyond the case itself and thus have wider application. Translating case studies can serve broad social functions to describe the values of society, explore contradictions, offer new insights that cannot be achieved using other approaches, and present new perspectives and interpretations on events. Further, case studies are ‘[p]articularly well suited to new research areas or research areas for which existing theory seems inadequate [...] is useful in early stages of research on a topic or when a fresh perspective is needed...’ (Eisenhardt, 1989: 548-549). In examining some of the myths associated with this method, Flyvbjerg (2006) argues that the case study is a necessary and sufficient method for complex research tasks in the social sciences, and holds up well when compared to other methods in the gamut of social science research methodology. He concludes that ‘good social science research is problem driven and not methodology driven in the sense that it employs those methods that for a given problematic, best help answer the research questions at hand’ (2006: 242).
Cases were selected on the basis of suitability in terms of the research purpose, questions, propositions and theoretical context (Denscombe, 2003; Miles and Huberman, 1994; Stake, 2005). Cases were selected on the basis of expectations about their information content, that offered variation in different dimensions, and included cases which were especially problematic (Flyvbjerg, 2006). On a practical level, the selection of cases was affected by restricted access to information and costs imposed by local authorities for providing copies of documents, limited financial resources available to support travel, and time constraints (as noted by Rowley, 2002). One of the advantages of case study research is that it allows for a variety of data collection methods depending on the circumstances and the specific needs of the situation (Denscombe, 2003). Case study research fosters the use of multiple sources of data; typically, a variety of evidence from different sources, such as documents, archival records, physical artefacts, interviews and observation were employed (Rowley, 2002; Robson, 2002; Yin, 2009), thereby facilitating validation of data through triangulation.

6.3 Context for the study

As indicated in Chapter 1 of this thesis, the State of Victoria was selected as the context for this study for a number of reasons. As well as being the first jurisdiction in Australia to enact heritage legislation, with a well-established framework for heritage protection at both state and municipal government levels, the State of Victoria is also at the forefront of policy to improve environmental performance of buildings, having lead the introduction of minimum regulatory standards for energy efficiency. Inevitably, a number of practical considerations also influenced the selection of Victoria as the area for the study, not least the ability to negotiate access to homes and to conduct face-to-face-interviews with householders, and cost constraints associated with carrying out this fieldwork, as well as obtaining data relating to building case studies. This was largely achieved through utilising the researcher’s existing network of contacts initially, purposive sampling (Bryman, 2008;
Denzin and Lincoln, 2005), and snowballing (Robson, 2002) The use of these techniques to identify participants is further discussed in section 6.6.3.

Residential dwellings were selected for this study as these form the largest contingent of heritage–registered buildings in Victoria. As noted in Chapter 2, household energy use is continuing to grow despite measures to improve efficiency (Sandu and Petchey, 2009; Falk and Settle, 2011). This pattern of consumption, combined with a lack of information about renovation practices relating to the older building stock, means that the focus on residential buildings is entirely appropriate for this research. As this research seeks to understand households’ perspective of renovation, owner occupiers of heritage buildings were selected as the unit of this study rather than tenants, as the latter are considerably constrained in their ability to modify their dwelling (Maller and Horne, 2011). Sixty nine per cent of Australians own their own home outright or have a mortgage (Australian Bureau of Statistics, 2011), therefore, buildings being renovated are inevitably owner occupied. This strategy also offered the most direct means of access to the buildings, and availability of information (Rowley, 2002). However, within this group, efforts were made to interview men and women of varying age groups, education levels, income, in different locations in central Victoria (this geographical area offered the highest concentration of population, and access to potential cases, as well as being within reasonable travel distance). Buildings of different construction were selected to provide variation within the range of older building stock.

Having designed an appropriate research strategy to investigate the practices in various building renovation scenarios using a selection of households that live in heritage buildings to empirically understand differences in renovation practice, and identify the tensions associated with improving environmental performance of dwellings with heritage significance, the next section describes the procedures for data collection and analysis.
6.4 Data collection and analysis: methods

Ethics procedures were followed in conformity with RMIT University requirements and approval was obtained from the University Ethics Committee. Information about the research purposes, and how data would be used and stored were distributed to participants prior to each interview, and agreement in writing obtained from participants. Data were anonymised prior to transcription.

Multiple methods and instruments are used for collection and analysis of data for this study, selected for their appropriateness in addressing the research aims and questions. These are discussed in the succeeding sections.

6.4.1 Selection of methods

In order to answer the research questions in a systematic way, the collection and analysis of data has been subdivided into several steps: first, a review of the current state of knowledge on the existing dwelling stock based on its physical characteristics (e.g. age, type and size, construction materials) and renovation activities was undertaken; next, the research identified key factors affecting energy consumption in older dwellings, from scrutiny of the literature; planning appeal decisions were also analysed to identify the issues associated with improving environmental performance of heritage dwellings; as well as being instrumental in identifying the key issues (discussed in the next section), this also assisted in the selection of buildings for further investigation.

6.4.2 Analysis of planning and building appeal decisions relating to heritage buildings and energy performance

As indicated in Chapters 3 and 4, energy performance and heritage conservation in Victoria is regulated through both the planning and building regulatory frameworks, as part of an overlapping legislative scheme. Within
the State Planning Policy Framework (SPPF) retaining heritage significance is an objective, along with energy efficiency and minimizing greenhouse gas emissions, and promoting renewable energy. The policy framework deals with environmental performance at various levels—for example, at a broad level in the objectives of planning in section 4 of the Planning and Environment Act 1987 and in the State Planning Policy Framework, in design guidelines, or in specific local policies—whereas the building regulations contain specific standards for the thermal performance of the building, and space heating and hot water services. The two regimes are regarded as complimentary [Hasan v Moreland CC [2005] VCAT 1931], although the detail in relation to energy efficiency are seen as matters primarily to be resolved through the application of building regulations [Diamantopoulos v Yarra CC [2010] VCAT 266].

The Building Appeals Board deals with appeals relating to permit applications made under the Building Act 1993. However, it was not possible to obtain useful information from their database relating specifically to heritage buildings, or search reasons for an appeal using keyword terms such as energy efficiency. The Building Appeals database does not include the detailed reason for an appeal, as these are classified only as emergency or modifications—with limited descriptions of works; nor are they referenced by section of the Act. Further, where a Registered Building Surveyor (RBS) allows a dispensation to a heritage building, this is not recorded. Modifications of building permits affecting heritage buildings that are of significance to the State of Victoria are notified to Heritage Victoria, and these are recorded in the events record for each heritage place on the HERMES database (administered by the Department of Planning and Community Development), however, there is no facility to search these (pers comm. Janet Sullivan, December 2010).

A systematic search of Victorian Civil and Administrative Tribunals (VCAT) appeal decisions was conducted using the AUSTLII database. A series of
searches were undertaken using a combination of the following key search terms:

- heritage;
- alteration; renovate; renovation; retrofit;
- existing building; dwelling;
- sustainability; energy; energy efficiency.

From these keyword searches, appeal decisions were identified and, based on the contents of the decision statement, twenty five appeal decisions dating from 1999 to 2011 were analysed to determine the key issues relating to renovation of heritage dwellings and efforts to improve energy performance. Whilst analysis of planning permit appeal decisions was carried out, it was not possible to corroborate this information from the other data sources.

A key issue that emerged is whether environmental objectives should over-ride heritage significance and loss of heritage values [Forsyth & F Brindley v Moreland CC [2001] VCAT 375; Maddever v City of Boroondara CC [2006] VCAT 718; Kwan v Boroondara CC [2009] VCAT 2542; Tobias v Maribyrnong CC [2010] VCAT 82]. Several decisions, relating mainly to the installation of solar panels on dwellings in a Heritage Overlay, sought to balance the competing heritage and environmental objectives. The importance of environmental objectives is noted in the appeal decisions, although not regarded as outweighing heritage significance. It is worth noting, however, that all of the proposals were subsequently permitted on appeal, albeit with some amendment or conditions to reduce impact on heritage significance. As an example, the Tribunal did not accept the removal of the chimney which was regarded ‘as an important element in preserving the integrity of the building. The building itself makes a contribution to the heritage values of this heritage precinct’ [Forsyth & F Brindley v Moreland CC [2001] VCAT 375]. The Tribunal determined that the panels should be sited in a different location, behind the chimney, even though this would result in reduced operational performance. The compromise here was the operational loss and implications in terms of the
cost-effectiveness of the system, which was regarded as secondary to heritage significance.

Elsewhere, the installation of a roof-mounted air conditioning unit sited on the rear elevation of a dwelling located in a Heritage Overlay was found to have an unacceptable impact in both heritage and visual terms. Retrospective permission was granted for the unit subject to conditions specifying the location, position, and a painted finish to reduce its visual impact [Anna De Casa Pty Ltd v Port Phillip CC [2005] VCAT 1820]7. In a later appeal decision, solar panels and an air conditioning unit were allowed to remain on the north-facing roof of a dwelling in a Heritage Overlay. In this case, the Tribunal took the view that the works did not dominate the existing dwelling or heritage place, and that there was no other alternative location, the north-facing slope being the most efficient [Kwan v Boroondara CC [2009] VCAT 2542]. Each of these decisions hinged on notions of acceptable change and whether there was an alternative location to achieve ‘satisfactory’ performance. The subjective determination of impact on heritage significance is also acknowledged [Challis v Hobsons Bay CC [2011] VCAT 1493].

Visibility is discussed further and, as a general planning principle, solar panels in Heritage Overlay areas should be in the least visible situation in which the unit can achieve satisfactory performance [Maddever v City of Boroondara CC [2006] VCAT 718]. However, visibility is not regarded as being a determining factor in later decisions [Kwan v Boroondara CC [2009] VCAT 2542; Tobias v Maribyrnong CC [2010] VCAT 82; Challis v Hobsons Bay CC [2011] VCAT 1493]. In the latter decision, the Tribunal asserted that the effect of the visible structures on the significance of the heritage place that must be assessed, which is undertaken on an individual basis, and a general rule about visibility is not applicable. The existence of other solar panels and service equipment in the vicinity seems to be a factor in the determination. The perceived public

7 This decision refers to another VCAT decision at 17 Coventry Place, Melbourne which could not be located in the VCAT database.
benefit from micro-generation, as well as benefit to the individual (determined by the efficiency of the equipment and, by implication, shorter payback period) appears to be a central consideration in more recent decisions [Tobias v Maribyrnong CC [2010] VCAT 82]. As the frequency of installations increases in response to government-led environmental initiatives, there appears to be acceptance of PV panels even without objective assessment of the individual versus public benefits of solar installations and heritage objectives.

The appeal decisions also highlight a requirement for existing buildings to meet contemporary standards. In one of the earliest identified appeal decisions, the layout and facilities, and energy efficiency contribute to obsolescence: ‘having very small rooms and its toilet and laundry must be accessed from the backyard. It is not at all conducive to modern day living and to the energy efficiency requirements of the 1990s’ [Knight v Port Phillip CC [1999] VCAT 1532]. The need for modernisation and importance of environmental goals is also referred to in other, more recent decisions [Maddever v City of Boroondara CC [2006] VCAT 718].

Contemporary requirements and expectations of modern lifestyles are the subject of discussion in several appeal decisions: ‘We have different standards of accommodation today. People wish to have access to as much light as possible and be able to use all modern appliances’. The Tribunal also noted that ‘[t]hese houses were built for a bygone lifestyle where people had little appreciation of energy efficiency’ [Mills v Port Phillip CC [2000] VCAT 1587]. In addressing the need for upgrading of older buildings to meet modern requirements, the Tribunal concluded that change should be allowed to occur. The requirement to accommodate higher living standards is supported elsewhere: ‘It is not plausible to require people to live by 19th century internal standards even if they are to live in 19th century structures. Modern standards have to apply ’ [Cook v Port Phillip, [2009] VCAT 2668].
State and Local Planning Policy Frameworks give importance to both heritage conservation and the achievement of environmental sustainability. From the appeal decisions it is apparent that there are tensions between objectives for energy efficiency, heritage conservation, and accommodating requirements for increased living standards. However, further guidance on how this balance may be achieved in practice is scarce.

6.4.3 Research participants: selection

Research participants were selected using purposive sampling (Miles & Huberman, 1994: 30) which involves ‘seeking out groups, settings, individuals where [ ] the processes being studied are most likely to occur’ (Denzin and Lincoln in Silverman, 2010; Stake, 2005). Participants/cases were selected in a strategic way to ensure that those selected were relevant to the research questions being posed (Bryman, 2008). This method was used, not necessarily to select case studies that are representative, but to illustrate some feature or process that is of interest (Silverman, 2010). This method also allowed variation in the cases selected which is important for external validity, as noted in Section 6.4. This study is concerned to elucidate the unique features of the case (Bryman, 2008: 54), and to develop as full an understanding as possible (Silverman, 2010). That said, the case studies chosen illustrate issues that are considered relevant to a wider population of groups of heritage buildings and relevance of findings could be extended to a larger phenomenon.

The selection of cases for this study was guided by the following criteria:

- **Construction type**: to include a variety including lightweight and heavy weight (mass) constructions; and
- **Age**: dwellings of different ages (this is closely related to the form of construction);
• *Thermal performance*: those construction types recognised as having poor thermal performance;

• *Heritage significance*: both state and local level of heritage significance (including individual, or contributory significance as part of a heritage precinct);

• *Nature of actions to improve performance*: to include a range of measures from minor (e.g. installing ceiling insulation without modifications to the building structure); moderate, involving some limited structural intervention or material change in basic services (e.g. installation of solar panels, or provision of new heating system), to major interventions, involving comprehensive renovation (which may also include significant structural works).

Diversity is sought in the physical characteristics (such as age, construction, form) to reflect the variations in the housing stock—with particular focus on those construction types that perform poorly—and different levels of heritage significance. The study is not confined to a single municipality or suburb, although it concentrates on those established suburbs where older housing forms a large proportion of the stock and, therefore, is more likely to be significant in terms of the cultural built heritage. Participants are selected from a number of municipalities within metropolitan Melbourne and from regional Victoria, to ensure that different contextual factors, differences in strategies employed by different agencies, and infrastructure systems are captured. This also provides for variety in demographics of participants. By selecting cases that include diversity in terms of key characteristics and geographical location, and drawing participants from a variety of social and demographic backgrounds, the charge of limited generality is reduced.

Using purposive sampling and snowballing, potential building case studies were identified from various sources: media archives, magazines, community groups and on-line blogs specialising in green renovations, architect’s websites, the search of *Victorian Civil and Administrative Tribunals* (VCAT)
appeals database, and through contact with professional institutes, government officers and practitioners. Several cases were identified where development had been refused by a local municipal council under the *Planning and Environment Act 1987* due to adverse impacts on heritage significance of buildings on the Heritage Overlay. The researcher also made contact with various institutions and organisations in Victoria to request information on potential cases. A direct approach was made to over 50 architects and architectural practices. The researcher compiled a list of those registered architectural practices involved in the physical conservation of heritage buildings including undertaking additions to and adaptive re-use of heritage buildings as well as projects that involve a significant new build component from the Heritage Victoria *Directory of Consultants and Contractors* (Department of Planning and Community Development, 2010), and list of heritage advisors currently employed by municipalities in Victoria. A list of architectural practices specialising in the design and construction of, or advice on environmentally sustainable building (including extensions, retrofitting and/or upgrading services of residential buildings) was compiled from various sources including: articles in magazines featuring individual houses that had been upgraded to improve performance, Internet searches (including architects’ web sites, the *Australian Institute of Architects* (AIA) Awards gallery web page), and Heritage Victoria (DPCD). With the co-operation of the relevant organisations, requests for information were also placed in the *Archicentre* e-newsletter (January 2011) to over 250 architectural practices, and the *Australian Institute of Building Surveyors* (AIBS) e-newsletter (January 2011), which is circulated to all registered building surveyors in Victoria.

In assessing potential case studies, a variety of on-line tools and databases were used to establish whether the buildings came within the parameters for selection, and to identify heritage status. Heritage status was confirmed from several authoritative sources. Information on heritage significance of individual buildings was obtained from the *Victorian Heritage Database*, which is publicly accessible (Department of Transport Planning and Local Infrastructure,
2013b), and from HERMES database (with the permission of Heritage Victoria). For those properties that are included on the Heritage Overlay, it was necessary to search the municipal Planning Scheme using Victoria’s Planning Scheme Online (Department of Transport Planning and Local Infrastructure, 2013a). The researcher consulted published heritage studies documenting heritage significance and values, where available. Google Maps and Streetview were used to confirm the location, construction, age and type of dwellings. This was followed by a visit to the site.

6.4.4 Interviews with homeowners

This study employs an in depth interview approach using a semi-structured format, borrowing from ethnographic methods. Such an approach caters to complex, ‘real-world’ settings and by collecting various types of data, is ideal for providing insights into the culture of homeowners undertaking green renovations (Moloney et al., 2008).

A variety of homeowners and single family dwellings were selected for further, more detailed study. Efforts were made to interview men and women of varying age groups, education levels, income, in different geographical locations within central Victoria. Semi-structured interviews comprised mostly of open questions were conducted in the participant’s home, except in one case where the interview was conducted in a public lounge. The interview, which used a semi-structured format, was designed to take around 60 minutes. Questions prompted participants to describe their home (e.g. age and construction of the dwelling, years of occupation, number of bedrooms, bathrooms, etc.); aspects they liked or disliked about their house; their planned, current or recent home improvement activities, and why the renovations were undertaken; issues or problems they had encountered; incentives, information and assistance they received during renovations. Participants were asked about why they chose to live in a heritage house, and their views on its performance, focusing in particular on those aspects relating to energy use. As part of the interviews participants were also encouraged to
recount their routine practices in the home (relating primarily to energy use but also any other actions taken in the name of the environment, such as saving water or growing food). The interviewer prompted participants with examples when necessary. Interviews were recorded using a digital voice recorder and transcribed verbatim.

Homeowners were asked about the household; the dwelling and its performance; details about the renovations; their reasons for the renovations; the types of help and advice received. They were also asked about their practices that have implications for energy use in particular, space heating and cooling, laundering and bathing. During the course of the interviews, the participants were asked to reflect on the significance of heritage to them, as well as the emphasis they placed on aspects of environmental performance, and how these affected the renovations. In order to gain as full an understanding as possible of motivations, expectations and practices, interviews were conducted face-to-face. This allows a close analysis of the accounts that respondents gave and the relative emphasis they place on different potential influences on their practices. Observations made by the researcher during the interviews and tours were also noted immediately afterwards. The interviews were transcribed and, together with observational notes, were imported into NVivo 9, a qualitative data software package that supports qualitative and mixed method research. Further details of analysis of interviews is provided in section 6.6.8

Prior to conducting interviews, research participants asked to confirm that:
- they owned and occupied the dwelling as their home;
- the dwelling was heritage registered (either included on the Victorian Heritage Register, or the Heritage Overlay), which was then confirmed independently by the researcher;
- they had undertaken renovations within the previous 3 years, were currently renovating or intending to renovate to improve the environmental performance of the dwelling in some capacity (this may include modifying the existing
building, or upgrading the services), either using professionals in the construction sector or ‘do-it-yourself’.

- their willingness to provide data on gas, electricity and fuel use for a 12 month period, and general performance of the dwelling.

Owners were invited to participate in a research interview by letter. In all but two cases, interviews were conducted at the property. In one instance, the building was undergoing major renovations, so the interview was conducted at the owners’ temporary residence (and a visit to the site made at a later date). In the other instance, it was not possible to carry out the interview at the property due to the owner’s work scheduling, and the interview was conducted in a neutral location. Participants completed a consent form. During the interview data was collected on the understandings, practices and experiences of homeowners undertaking alterations, additions and renovations to heritage dwellings in the existing housing stock to improve energy performance. With homeowners’ agreement, interviews were recorded and photographic records made of the dwellings. Where homeowners’ were willing, interviews incorporated an accompanied tour of the house; in all, 10 household tours took place, one preceding the interview, the others immediately following the interview. Snowballing (Robson, 2002) was used to identify further participants, with interviewees asked to suggest other people who may be willing to be interviewed. The number of interviews was felt to be sufficient when the collection of further data confirmed the codes, categories and concepts that had been developed (Denscombe, 2003).

6.4.5 Renovation case studies

In total, interviews were conducted with 26 householders from 20 households (comprising a total of 59 persons). In 7 interviews, the partner of the renovator was also present, although one did not actively participate, taking the total number of participants to 26. Of these, 16 were female and 10 male. In all but three of the cases, households were in the process of undertaking, or had recently undertaken renovations, which ostensibly incorporated improvements
to the environmental performance i.e. to improve energy or water efficiency. The other three were in the planning stages. Actions ranged from modest, more minor (less conspicuous) material changes such as draught proofing measures, or ceiling insulation, which did not require any specialist skills or structural works; in other cases, the works required more specialised skills and involved some intrusion such as installing a new heating system, or solar panels; but the majority comprised major material changes which involved significant structural works, disruption and required professional advice. Major renovations often incorporated reconfiguring domestic space and/or an extension, incorporating a range of interventions to improve environmental performance. All except four cases were categorised as major, involving significant structural works. The four minor works involved inserting ceiling insulation, and installation of solar panels, although during interviews it transpired that the homeowners had undertaken other activities within the home involving retrofitting (for example, installation of a new heating system). A summary of the home-renovators and their renovations selected for this research is provided in Table 6.2.
Table 6.2 Summary of home-renovators and main renovations

<table>
<thead>
<tr>
<th>No.</th>
<th>Code name</th>
<th>Age range</th>
<th>Household type</th>
<th>House type</th>
<th>Heritage status</th>
<th>Main renovations</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Paul</td>
<td>65-74</td>
<td>Married couple</td>
<td>Detached, brick and weatherboard homestead c. 1850</td>
<td>State</td>
<td>Ceiling insulation, PV panels.</td>
</tr>
<tr>
<td>3</td>
<td>David &amp; Jeanette</td>
<td>55-64</td>
<td>Married couple</td>
<td>Terraced, brick workers cottage Late Victorian</td>
<td>Local</td>
<td>Demolition of rear and extension to provide open-plan kitchen/dining/living room; added bedroom, walk-in robe and bathroom at first floor level. New roof. Ceiling and wall insulation to improve thermal performance.</td>
</tr>
<tr>
<td>4</td>
<td>Debbie</td>
<td>35-44*</td>
<td>Married couple</td>
<td>Detached, brick Queen Anne cottage (Federation)</td>
<td>Local</td>
<td>Demolition of rear addition; extension to provide open-plan kitchen, dining and living area. Designed on passive solar principles, including thermal mass, eaves/shading and fans. Double-glazing to new extension. Green switch to turn off standby loads. Converted loft space into bedroom, with roof terrace and en suite</td>
</tr>
</tbody>
</table>

8 To preserve anonymity all participants names are pseudonyms.

<table>
<thead>
<tr>
<th></th>
<th>Name</th>
<th>Age</th>
<th>Status</th>
<th>Property</th>
<th>Location</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>Martin &amp; Bridget</td>
<td>35-44, 45-54</td>
<td>De facto couple</td>
<td>Detached, weatherboard Edwardian cottage</td>
<td>Local</td>
<td>Partial demolition and extension to provide open-plan living space, study, based on passive design principles. Also incorporates other features to achieve energy efficiency: insulation, double-glazing throughout, air source heat pump, PV panels. Water tank (for vegetable garden). Includes use of recycled materials.</td>
</tr>
<tr>
<td>6</td>
<td>Matt</td>
<td>35-44</td>
<td>Married couple, 2 children</td>
<td>End terrace, brick townhouse Late Victorian</td>
<td>Local</td>
<td>PV panels. Existing lean-to addition demolished and new extension on passive solar principles to provide open-plan kitchen/living/family room extension. Reconfigure internal space on ground floor to provide study, and improved bathroom.</td>
</tr>
<tr>
<td>7</td>
<td>Cass</td>
<td>45-54</td>
<td>Couple, 2 children</td>
<td>Detached, weatherboard cottage Edwardian</td>
<td>Local</td>
<td>Extension added to provide open-plan kitchen/dining/family room. Designed on passive solar principles, incorporates thermal mass, double-glazing, eaves. Hydronic heating, double-glazing throughout (except for the family bathroom and 1 bedroom). Roof insulation.</td>
</tr>
<tr>
<td>#</td>
<td>Name</td>
<td>Age</td>
<td>Status</td>
<td>Property Type</td>
<td>Renovation Details</td>
<td></td>
</tr>
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</tr>
<tr>
<td>8</td>
<td>Max</td>
<td>35-44</td>
<td>Single</td>
<td>Detached, weatherboard cottage Edwardian</td>
<td>Insulation to front wall. Additional (energy efficient) lighting, and appliances. Extensive renovation including insulating the ceilings and walls to improve thermal comfort and reduce noise. New ducted central heating system. Removed all lath and plaster from internal walls to install insulation. Reverse cycle air conditioner installed in open-plan kitchen/living room. PV panels.</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Gareth &amp; Fiona</td>
<td>35-44*</td>
<td>Married couple, 2 children</td>
<td>Terraced, brick cottage Edwardian</td>
<td>Extension to provide open-plan living/family/ kitchen and 2 bedrooms and 2 additional bathrooms on upper level. Living space increased by 60 per cent. Designed on passive solar principles, the extension incorporates concrete floor (with underfloor heating), ceiling fans and natural ventilation. Triple-glazing (except for one window to front of existing house). Hydronic heating, and solar hot water. PV panels. Underground water tanks.</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Jill</td>
<td>45-54</td>
<td>Married couple, 1 child</td>
<td>Detached, weatherboard Californian bungalow</td>
<td>Extension, including open-plan kitchen/ family/living room, and separate ‘granny flat’. Insulation to walls, ceilings and under new floors, hydronic heating, split system air conditioning unit (in annex) to improve thermal comfort. Solar hot water, PV panels. Restumping and replastering.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Name</td>
<td>Age Range</td>
<td>Marital Status</td>
<td>Family Type</td>
<td>Home Type</td>
<td>Location</td>
</tr>
<tr>
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</tr>
<tr>
<td>11</td>
<td>Philippa</td>
<td>55-64</td>
<td>Single</td>
<td></td>
<td>Detached, weatherboard cottage Edwardian</td>
<td>Local</td>
</tr>
<tr>
<td>12</td>
<td>Jessica</td>
<td>35-44</td>
<td>Married couple, 2 children</td>
<td>Detached, weatherboard cottage Edwardian</td>
<td>Local</td>
<td>Insulated the ceilings, and some walls (north wall), internal perspex secondary glazing to improve comfort in existing house. Two storey extension to provide open-plan living area/kitchen, with additional bedroom, bathroom and living space above. Designed on passive solar principles with thermal mass, double-glazing. Extended evaporative air conditioning for thermal comfort. Solar hot water system, water tank.</td>
</tr>
<tr>
<td>13</td>
<td>Jeremy</td>
<td>35-44</td>
<td>Married couple, 2 children</td>
<td>Attached, brick cottage Edwardian</td>
<td>Local</td>
<td>Replacement of single story rear addition, with new two storey extension to provide additional living space and one additional bedroom and bathroom above. Double-glazing to new extension, air conditioner to bedroom (in addition to passive ventilation). Solar PV panels. Previously installed insulation to ceilings, hydronic heating, and split system air conditioning unit in main kitchen/living room.</td>
</tr>
<tr>
<td>14</td>
<td>Heidi &amp; Aiden</td>
<td>35-44*</td>
<td>De facto couple, 2 children</td>
<td>Detached, weatherboard villa</td>
<td>Local</td>
<td>Insulation installed in ceilings, external walls and under floors. Hydronic heating to living areas. Reconfiguration of internal space to provide larger</td>
</tr>
<tr>
<td>No.</td>
<td>Name</td>
<td>Age Range</td>
<td>Type</td>
<td>Style</td>
<td>Renovation Details</td>
<td></td>
</tr>
<tr>
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<td></td>
</tr>
<tr>
<td>15</td>
<td>Frida</td>
<td>65-74</td>
<td>Single</td>
<td>Detached, weatherboard cottage Late Victorian</td>
<td>Replaced roof (Colorbond) and installed ceiling insulation over kitchen/dining and bathroom. New hydronic heating system and gas boiler to improve thermal comfort. Shading to west-facing windows. Energy efficient light globes.</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>Maisie &amp; Michael</td>
<td>55-64</td>
<td>Married couple, adult child and girlfriend</td>
<td>Detached, weatherboard cottage Edwardian</td>
<td>Replacement of existing lean-to with new extension to rear to provide open-plan kitchen/living room, and 2 new bathrooms. Passive solar design with ceiling fans, clerestorey windows to assist with natural ventilation/air-flow and to improve thermal comfort. Hydronic heating. Insulation to ceilings and external walls of existing house. Rationalised lighting and installed low energy light globes.</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>Joy</td>
<td>55-64*</td>
<td>Married couple</td>
<td>Detached, weatherboard villa Mid Victorian</td>
<td>Alterations to create open-plan kitchen/dining, and extension to provide additional bathroom. Works include draught proofing, double-glazing, floor and ceiling insulation. New hydronic heating system run by wood burning stove, solar hot water with electric booster.</td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>Rachel &amp; Jason</td>
<td>35-44</td>
<td>Married couple</td>
<td>Detached, stone cottage</td>
<td>Extension to provide open-plan kitchen/dining/family room with study area, added new</td>
<td></td>
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<td></td>
</tr>
<tr>
<td></td>
<td>2 children</td>
<td>Edwardian</td>
<td></td>
<td></td>
<td>family bathroom, laundry, en suite and walk-in robe. Increased living area by over 100 per cent. Extension designed on passive solar principles to reduce need for heating/cooling. Incorporates thermal mass. New extension includes extensive glazing which is double-glazed to reduce heat loss. New wood stove in living area. Solar hot water, and PV panels. Electric underfloor heating in bathrooms. Ceiling insulation, block-out blinds and fitted carpets to improve thermal comfort in old part of house (converted to bedrooms). Water tank.</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>Julia &amp; Jeff</td>
<td>55-64</td>
<td>De facto couple</td>
<td>Detached, stone and weatherboard villa Late Victorian</td>
<td>Local (individual)</td>
<td>Various material changes to the building to achieve thermal comfort and reduce energy consumption, including: installing ceiling and floor insulation; draught sealing doors, windows and chimneys; secondary glazing to selected windows. Curtains. Installed electric wall heaters to individual rooms, split system air conditioning unit in kitchen. Solar hot water.</td>
</tr>
</tbody>
</table>

Notes: * Estimate as age not provided.
6.4.6 Participant households: composition

The research participants are located in eight different municipalities across central Victoria, in eleven postal code districts, of which nine are in the inner and middle suburbs of Melbourne, and two in regional Victoria. Sixteen households are located in metropolitan Melbourne and four in regional Victoria.

Twenty six homeowners from twenty households were interviewed between January and May 2011. Interviews ranged from 33 minutes to 1 hour and 30 minutes in duration, but were, on average, around an hour in length. Sixteen participants were female and ten were male. Ages ranged from 37 to 65 years, although four participants did not provide details of age. Six homeowners were aged 35–44 years, four aged 45–54 years, seven aged 55–64 years and two homeowners between 65 and 74 years. The profile of the participants varied from single persons, parents in their 30s and 40s with young children from 6 months of age, families with teenagers or young adults living at home, to empty nesters in their 60s and 70s. Nearly all homeowners identified their cultural background as Australian; however, two had non-Australian heritage, with one identified as having been born in Papua New Guinea, and the other from New Zealand. Two did not provide details. Education levels ranged from TAFE certificate to postgraduate qualifications, although ten participants did not provide any information about educational attainment. The group overall was well educated with fourteen homeowners having a tertiary degree or postgraduate qualifications as their highest educational achievement. This is reflected in homeowners’ occupations which were largely managers, and professionals (Australian Bureau of Statistics, 2009a). Eleven worked full-time, eight part-time, two were retired, one participant was on maternity leave, and one employed in home duties (no details provided for others). Income levels for individual participants ranged from AU$50,000 to $220,000 per annum. Most homeowners earned between AU$60,000 to $90,000, although twelve declined to provide this information. Seventeen homeowners lived with a partner, and nine had children (ranging in age from less than one year old up
to 15 years). In three households adult children (aged 16 years or over) were sharing the family home with their parents (in one case, this was a temporary arrangement whilst renovations were being carried out elsewhere). In three households, the homeowners lived alone. The demographic profile of home-renovators participating in this study largely concurs with the findings of the report on the *Alterations and Additions Market*, which found that higher income households, from professional and managerial backgrounds have a greater propensity to undertake home improvement projects (BIS Shrapnel, 1994).

The period that renovators had owned the dwelling ranged from 1 to 27 years. Six had owned their home for 5 years or less, another six had owned their home from 6 to 10 years, five from 11 to 15 years, with five having lived in their current home for 16 to 20 years, and one for over 25 years). The average length of ownership was 10 years. Two participants had owned a house for 16 years but had occupied it for only a few months, having purchased it initially for their children to occupy whilst at university, and then rented it out to tenants, and had moved in following renovation and retirement. Several had owned their property for a number of years, but had rented it to tenants for a period whilst working inter-state or overseas, then moved back. One person had first lived in the house as a child, but obtained ownership after the parents died. So although there was a long connection with the house, this was not reflected in the period of ownership.

6.4.7 Heritage dwellings: characteristics

All single family dwellings, the type of dwellings ranged from attached and terraced houses, to separate dwellings. All compact in form, dwelling sizes ranged from two bedroom/one bathroom cottages to five bedroom/three bathroom dwellings. Predominantly single storey (in 12 out of the 20 dwellings accommodation was arranged on a single level), the other 8 had accommodation on two levels (of these, 6 were originally built as single storey
dwellings but had been extended to include accommodation on an upper level as part of these or earlier renovations).

The age and style of the dwellings varies, with the date of construction ranging from c.1850s to 1930s. Architectural styles include an early Georgian homestead, mid to late Victorian workers’ housing, Queen Anne (Federation) villas, Edwardian houses, and a Californian bungalow. Most dwellings (15) are detached, the remainder being attached or forming part of a row (terraced). The dwellings were all originally single-storey, except for one. All were built using traditional methods of construction and materials predominant in the geographical area including bluestone, double brick, and weatherboard. Ten of the dwellings are masonry, and 10 are weatherboard construction. Both constructions are considered to have poor thermal performance. All the buildings have recognised heritage significance, being on the local Heritage Overlay at the time the research was conducted, with one also included on the Victorian Heritage Register, as fulfilling the criteria for state significance. The heritage significance varies from individually significant, to contributory (as part of a street, or a wider area). Each building has individual heritage values which contribute to its significance, the most common being architectural, or historic value. Although constructed originally as dwellings (not converted later for residential use), the buildings have all been altered or extended to some degree during their lifetime, some successively, with later modifications overlaying or replacing earlier changes.

6.4.8 Analysis of interviews

In the preceding chapter, a conceptual framework was developed to understand the practice of renovation for improving energy efficiency of buildings with heritage significance, and this is used to underpin interpretations of the evidence from case studies.
Interviews with homeowners were recorded and transcribed verbatim into text as Word documents and uploaded into NVivo 9, together with other information relating to case studies including the researcher’s field notes, photographs, floor plans, magazine articles, planning reports and appeal decision notices, to facilitate analysis. A key feature of NVivo is that it enables systematic analysis of large amounts of data in a non-standard format (Denscombe, 2003; Miles & Huberman, 1994; Richards & Morse, 2007). NVivo acted as a database for all the data, which was organised around ‘nodes’ created for each case study, each consisting of a collection of references. A set of nodes was then developed to structure analysis of the qualitative data based on themes drawn from the literature and repeated review of the qualitative research process. This process assisted in navigating the diverse collection of data, and enabled data to be extracted to answer particular research questions. To further analyse the data, queries were constructed in NVivo to interrogate the data (transcripts, photographs, field observations, scanned documents) that had been coded by the researcher as related to participants and one or more themes in structured ways.

Analytic coding was used to analyse interview data; this technique involves listening to interviews and re-reading transcripts; initially breaking down the data into chunks of text and categorising these into topics, based largely on the interview schedule and questions. As part of the analytic coding, annotated notes were added to the transcribed interviews as new insights emerged. Memos were also used to record reflective comments on the data, and possible explanations. Data relating to topics was then grouped into a framework for further analysis; this framework was the subject of refinement during the analysis (Denscombe, 2004; Bazeley, 2007; Richards & Morse, 2007). The entire dataset was reviewed for ‘patterns and processes, commonalities and differences’ (Denscombe, 2003: 272; Miles and Huberman, 1994). A set of themes relevant to the research question were derived from analysis of the data (Bazeley, 2007; Bryman, 2008; Kvale and Brinkmann, 2009; Miles and Huberman, 1994; Ryan and Bernard, 2003). In order to verify
the plausibility of the data, and ensure internal validity, the researcher looked for themes emerging from a number of interviews that appeared to be crucial for understanding renovation (Denscombe, 2004); a recurrent theme indicates that the issue or idea is something that is shared among a wider group, rather than an individual, thereby demonstrating that the qualitative analysis is reasonably representative of the whole, and establishing the generality of observations (Bryman, 1988).

As this research is interested in the interactions between homeowners renovations and everyday practices, the analysis was framed into two separate but intersecting themes: renovation practices in heritage dwellings—with particular attention to those interventions that have energy-related environmental impacts; and the everyday household routines that are related to renovation activities. This approach provides a structured way to organise and manage data and themes (Bryman, 1988), and is used as the framework to present the analysis of qualitative data in the following chapter.

6.5 Digest: research strategy and methods

This chapter explains the research strategy, including the theoretical approach, methods of data gathering used, the selection of cases for inclusion in the study, and the basis for analysis to address the research questions. An approach that employs qualitative methods is employed, as this offers the ‘best fit’ for answering the research questions. The analysis of individual ethnographic case studies provides the opportunity to gather rich data for understanding not only the experience of homeowners, but also for identifying the components that underpin renovation practices at an individual building level, and opportunities and constraints on social organisation of practices to meet legislative and regulatory objectives within the existing dwelling stock. Since a variety of cases are selected for in-depth investigation, there are opportunities to understand homeowners’ motivations, commonality and differences in practices relating to heritage-listed dwellings, context-specific
issues, variations in socio-technical regimes, as well as examining the different approaches and strategies to improve the environmental performance of the older building stock. The research findings are presented in the Chapters 7 and 8.
‘Homes are the domain of slowly shifting fantasies and rapidly shifting needs. The widowed parent moves in; the teenager moves out; finances require letting out a room (new door and outside stair); accumulating stuff needs more storage (or public storage frees up some home space); a home office or studio becomes essential. Meanwhile, desires accumulate for a new deck, a hot tub, a modernized kitchen, a luxurious bathroom, a walk-in closet, a hobby refuge in the garage, a kids refuge in the basement or attic, a whole new master bedroom.’

Stewart Brand, 2004 p. 10

7 Home-renovation practice: common understandings

The analysis of data here involves interpretation of the meanings, purposes, and consequences of home-renovations to investigate what is important in shaping renovation practice in heritage dwellings, and how these are implicated in local, and perhaps wider, contexts. The extracts and interpretations have been explicated from over 500 pages of interview transcripts and memos, along with numerous official planning documents, architects’ building plans, and images.

In examining practices, this and the following chapter draw on empirical findings from interviews with owner-occupiers of heritage dwellings to understand the patterns across households undertaking renovations. What are presented, for the most part, are verbal descriptions, accounts, and propositions. In considering the relationship between renovations and household practices, the focus is on those activities that have implications for energy use, in particular, space heating and cooling, bathing, laundering and other domestic chores.
7.1 Key concepts informing the work

The proposition underlying this research is that the social practices conceptual framework developed in Chapter 5 can offer useful insights into homeowner renovation practices. This conceptual framework is used to underpin interpretation of the evidence base for the research and, together with other analytical concepts, addresses the second-level research question:

(iii) What are the renovation practices of homeowners undertaking home improvements in the context of heritage significance, environmental performance, and other motivations and aspirations?

Based on analysis of data collected from interviews, attention is focused first on the renovations engaged in by homeowners that ostensibly include measures which improve the environmental performance of dwellings and renovation practice (the practice of renovating)—as considered in Chapter 5—and second, on the everyday practices associated with the renovations.

Recalling the discussion over practice as entity in Section 5.8.1, this thesis argues that renovation is a complex practice, consisting of many different and connected parts, which are closely entwined. In accordance with the definition of a practice posited by Røpke, (2009) renovation is an organised cluster or set of activities which are recognisable across space and time. In terms of organisation, renovation is generally structured into several consecutive stages; and it is not uncommon for home-renovation to extend over a year, or even longer. During performance—first, the homeowner identifies an opportunity, options are created—often in consultation with ‘expert-practitioners’—which are evaluated and a preferred scheme agreed, followed by implementation on site, usually to a schedule. Thus the activity is defined in space and time.
7.2 Analytical framework

In exploring the renovation of dwellings with heritage significance using theories of social practice, the analysis of the data is framed by the dwelling as the ‘domain’ of activity, an approach utilised elsewhere (Hargreaves, 2011; Maller et al., 2011; Spaargaren, 2011) and descriptions of material changes. A site of domestic production and consumption (Hand et al., 2007), the household or ‘home’ is an appropriate spatial frame as it is a critical scale for understanding activities that connect individual actions and societal attitudes (Horne et al., 2011). The nature and extent of material and spatial changes, and whether interior and/or exterior, is particularly relevant to designation of heritage significance, the scope of heritage controls, and assessing impact on cultural heritage values under the statutory planning scheme. Table 7.1 indicates the material dimension, the products, appliances and technologies which are incorporated as part of the renovations by households participating in the study, and associated household practices. Renovation activity is linked to consumption of resources in the form of materials and energy used in construction, and further, the provision of an extension for additional living space is related to the use of energy to supply space heating as well as of services. Renovation activity intersects with the spatial, temporal, and social structures of everyday life, for example, provision of additional bathrooms is related to practices of bathing, showering, and associated conventions of cleanliness and convenience, and daily routines (Shove, 2003). These elements are linked together in the framework in Table 7.1 which is used to structure the findings of the research.
Table 7.1 Framework for analysis showing connections between renovation and associated practices

<table>
<thead>
<tr>
<th>Components</th>
<th>Kitchens, living areas</th>
<th>Study</th>
<th>Bedrooms</th>
<th>Bathrooms</th>
<th>Appliances, technology and products</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Material alterations</strong></td>
<td>Expansion/larger space</td>
<td>Dedicated workspace or shared home/office space</td>
<td>Adding bedrooms</td>
<td>Updating and adding bathrooms</td>
<td>Internal: household appliances, air-conditioning, insulation, hydronic heating, automatic timer/thermostat, underfloor heating, double-glazing, lighting, water recycling systems</td>
</tr>
<tr>
<td><strong>Intersection with social practices &amp; conventions</strong></td>
<td>Cooking, socialising, informal dining/entertaining</td>
<td>Home working</td>
<td>Occupancy/privacy, accommodating guests (‘social loading’)</td>
<td>Bathing, showering</td>
<td>Use of IT, entertainment, lighting, whole house heating, micro-generation, water-saving appliances and fittings</td>
</tr>
<tr>
<td><strong>Shared understandings/meanings</strong></td>
<td>Meaning of home; importance and meaning of heritage to householders; environmental understandings; expectations of thermal comfort, cleanliness, convenience, and desirable standards of living</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Competences (knowledge, know-how/experience, practical skills)</strong></td>
<td>Incorporation of sustainable technologies and materials, technical skills, project management; interaction with building professionals; contractor skills and know-how; practical/technical issues associated with installing new technology and practices; time constraints; household management</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Material infrastructures</strong></td>
<td>Housing structure and infrastructures; energy and water systems; heating &amp; cooling technologies; artifacts and objects such as verandahs, shutters/blinds/curtains</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Social and cultural context including regimes, rules &amp; procedures</strong></td>
<td>Planning policy and procedures; heritage rules; building regulations and BCA requirements; subsidies/feed-in tariffs</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
7.3 Renovations and strategies: overview

This section presents an overview of renovations based on the accounts of homeowners that have materially altered, reconfigured or extended their home, or were currently in the process at the time of interview, together with observations made by the researcher during home tours, and information extracted from documents obtained from other sources, including design drawings, and discussions with architects and planning officials. Table 7.2 provides an overview of the types of changes initiated by homeowners and their occurrence prior to more detailed analysis of the interviews and participants accounts of their renovation in Sections 7.5 -7.7 which reveal their understandings and expectations surrounding renovation of their home, competences, and the material infrastructures that shape renovations practices.

Despite the individual accounts, many of the types of interventions undertaken by householders were similar to those of others interviewed. Kitchens and bathrooms are a common focus of renovations. As are additions, with most of the renovations undertaken by participants including extensions to the building (17) to create additional living space, frequently a large new ‘family room’ combining a new kitchen (16) with dining area and informal living space, thus supporting the view that kitchens are becoming increasingly multifunctional spaces and bathrooms are multiplying, reflecting context-specific arrangements relating to the temporal and ideological restructuring of domestic practices (Hand et al., 2007).
Table 7.2 Main homeowner renovations

<table>
<thead>
<tr>
<th>Renovation</th>
<th>Number of households (n=20)</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Kitchen and bathrooms</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No new kitchen or bathroom</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>New kitchen only</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>New bathroom only</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>New kitchen and one bathroom</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>New kitchen and two bathrooms</td>
<td>11</td>
<td>1 refurbished an existing bathroom, and added a further bathroom</td>
</tr>
<tr>
<td>New kitchen and three bathrooms</td>
<td>2</td>
<td>1 refurbished one bathroom and added two additional</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 family had added an en suite shower room in an earlier renovation, then resited the family bathroom and added a further bathroom on the upper storey</td>
</tr>
<tr>
<td><strong>Extensions</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Extension on ground level only</td>
<td>10</td>
<td>9 replaced sub-standard or smaller single storey additions</td>
</tr>
<tr>
<td>Added second storey</td>
<td>7</td>
<td>1 had already been extended by the previous homeowners</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 extended into the roof space of the existing dwelling as well as an extension to the ground floor</td>
</tr>
<tr>
<td><strong>Solar hot water</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Installed solar hot water</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>No solar hot water</td>
<td>8</td>
<td>6 would like to install SHW but unable to due to planning constraints (3); technical issues (1); space limitations (1); and combination of these reasons (1)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 would like to but does not qualify for a rebate</td>
</tr>
<tr>
<td><strong>Renewable energy</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Installed PV panels</td>
<td>11</td>
<td></td>
</tr>
</tbody>
</table>
In 4 households, the reason given for extending was to increase the number of bedrooms so that children could each have their own bedroom. Other participants were contemplating the needs of elderly members of the family, or building in adaptability for the future as requirements change. The creation of a dedicated workspace within the home was another reason for extending; overall, 11 households made specific provision for a study or home office, which is consistent with the professional and managerial occupations of participants, and indicative of increasing home working practices noted by
Hand et al. (2007). A further reason was to have a ‘spare room’ for relatives or guests to stay when they visit, but which may remain unoccupied for much of the time, supporting the concept of social loading (Wilhite & Lutzenhiser, 1999).

Bathrooms are the second most common focus of renovation activity, as illustrated by Table 7.2. Bathrooms are multiplying as people build additional en suite facilities and extra showers and toilets. Of the 20 households interviewed, 16 had renovated an existing bathroom and/or added at least 1 bathroom, with 12 households having two bathrooms, and a further 2 households having 3 bathrooms. Of these, 13 added an en suite. In total there are 40 bathrooms for 59 people (including 19 children), or a bathroom for every 1.5 persons). In one household, a family of 6, the internal layout had been altered in an earlier renovation to fit in an en suite shower room and then, as part of the recent renovations, the family bathroom had been resited, and a further bathroom added on the upper storey as part of a master suite. The reasons given for increasing the number of bathrooms was to provide en suite facilities for adults in the household separate from children (‘family bathroom’), with guests also being provided with their own bathroom in some renovations. Whilst the practical exigencies associated with everyday life were uppermost in providing additional facilities, in two households, a private bathroom was provided as part of a parents’ ‘retreat’, indicating an increased desire for privacy and separation away from family space.

Extending and reconfiguring often frees up under-used living space within the existing building which is then made available for other purposes. In 8 households, the formal dining room had been dispensed with (appropriated for other uses, such as additional bedrooms or for home office/study) and the eating area combined as part of a larger open-plan, multifunctional room designed as a communal space for the family. This open-plan configuration may not be compatible with the layout of older dwellings, which tend to have
smaller, compartmentalised rooms. To create an open-plan arrangement, the options are to remove internal walls to create a larger space within the existing envelope or add an extension. In 3 cases, the homeowners decided to knock through to create a larger internal kitchen/dining space.

Material changes were often associated with a life course event such as retirement, a growing family, or other change in family circumstances, indicating that concerns about the practicalities of everyday living are predominant. Contingencies feature in renovation practices; in one case the renovations were coincident with the family moving in with and caring for an elderly relative and, in two households, renovations were also designed to accommodate young adult family members still living at home with parents.

Aside from extensions, retrofitting solar hot water and solar photovoltaics (PV) are amongst the most popular interventions amongst homeowners to improve energy efficiency (Table 7.2), assisted by government subsidies for installation and generous feed-in tariffs for renewable energy systems. Of the 20 households in the study, 12 had installed solar hot water and, of the others, 6 said they had intended to install solar hot water but were unable due to planning restrictions, technical problems and/or space constraints. Similarly, 11 households had installed PV, with a further 4 households including this in the current renovations. However, 3 households were unable to because of physical and technical constraints, and planning restrictions.

One homeowner did not install PV panels because he did not agree with the particular technology configuration. The installation of solar and PV fixtures is regarded as potentially contentious because of the possibility of adverse impacts on heritage significance, since many of these systems alter views of the structure and roofline (as discussed in section 6.6.2). The planning policy framework includes provisions for protecting heritage and also for encouraging renewable energy systems to reduce CO₂ emissions. The prevalence of these
in this study indicates that, in the contest between the environment and heritage, there may indeed be a shift in favour of the former among renovation preferences.

While all homes have to comply to the same regulations, a variety of design strategies was observed across the 20 renovations, in terms of building form, passive solar design/engineering principles, and materials, indicating different design approaches, with different strategies and combination of elements employed to improve performance, and varying preferences. This variation suggests that a range of strategies is possible, although some may be more/less effective than others. While each renovation is individual, some common strategies may be observed across dwellings in the study. The most common design strategies adopted by homeowners interviewed in this study involved changes to the building envelope to improve thermal efficiency (for example, by retrofitting insulation and double-glazing); reducing energy or water use by installing more efficient appliances (commonly, heating or cooling systems); adoption of passive design features such as thermal mass, thermal chimneys, and shading; and generation of electricity through installation of renewable energy systems.

In a few case studies, homeowners changed the way in which the spaces within the dwelling were used to optimise performance; in addition, some recounted habitual practices employed to actively manage ‘performance’, such as closing down the house in the morning to exclude heat and opening up in the evening to increase air-flow (actively engaging with the building to improve thermal comfort). Of the homeowners interviewed, 18 out of the 20 renovations involved changes to the building envelope, compared to 9 that involved changes to practices within the home; some changes in daily household practices are inextricably linked to technical interventions—in one example, laundering and dishwashing changed from night time to the middle
of the day following the installation of solar PV, to take advantage of renewable energy.

The proposition is that the renovation strategies adopted by homeowners are related to practice, and these are de-constructed into elements of practice in the following sections. First, the different understandings communicated by homeowners participating in the research are presented, and how these shape renovations.

### 7.4 Common understandings associated with renovation

Based on analysis of interviews with homeowners, this section discusses common social understandings and how these intersect in home-renovation practice. A component of the framework outlined earlier, common understandings is recognized by practice theorists as an integral element in social practices (see Table 5.2).

#### 7.4.1 Heritage: different understandings

From observations made during tours, and analysis of the interview data, homeowner’s understandings of what is significant has a bearing on the renovations, what is to be lost or retained and incorporated into contemporary practices.

*At ridiculous expense we kept the chimney … we probably spent $30,000 on simply just keeping the chimney which in hindsight we didn’t have to do it but we did it anyway.* (Gareth)

*They come up with ridiculous things and wanted to take out the old chimney down the back here and this wall, and things like that. And [I] said “No! They are the things I love about the house”. (Debbie)*
Home-renovators retained elements of the building often at additional cost or complication, despite there being no requirement, even though it did not improve environmental performance. Other home-renovators gave examples of how they had retained elements of the building that were original or historic, which resonated in some way with the occupant’s images, memories and emotions. Joy was keen to restore the draughty French doors leading out onto the verandah, and reinstate other features that had been lost:

*I actually have memories of it when I was small so, you know, and my sisters have memories of it when they were young as well. So, there are some things we wish to reinstate* (Joy)

Several homeowners refer to retaining material fabric or intactness, although the extent to which this was demonstrated in practice varied.

*We kept the original kitchen fireplace and chimney as well. I didn’t want to remove more than we had to in terms of the original bit of the house.* (Maisie)

*We’ve actually had an architect working with us ... and one of the suggestions that he’s put forward is taking the window out of the kitchen and turning it into a French door ... no, we don’t want to compromise it. It hasn’t been compromised in 150 years to any great extent. And we can’t see any reason why we would want to.* (Paul)

In seeking to reconcile housing and other goals with retaining authenticity of the heritage building, homeowners’ verbalised their dilemma:

*In terms of retention of the original fabric, we certainly had to lose more than I was comfortable with to get environmental performance, so we couldn't have insulated the walls if we hadn't lost the hard plaster and it would have been*
harder to insulate the floor if we hadn’t got new floorboards. So I suppose we – that was a compromise, the loss of original fabric. (Jill)

It hasn’t been compromised in 150 years to any great extent. And we can’t see any reason why we would want to change ... The [solar] hot water. It just would compromise what’s there. I just don’t like the concept of it at all. (Paul)

For these homeowners, retaining historic fabric is very important. However, for most, aesthetic and functional concerns predominated over retaining material authenticity. External visual appearance was the quality most appreciated by homeowners from across all age groups and the most frequently mentioned, followed by ‘character’.

Oh we love the way it looks. We both like heritage things anyway, we have got that bent, so we think it looks cute from the front. (Rachel)

We drove past this house and just, and saw the For Sale sign and we both just loved the façade with the turret and the slate roof, and the area to the side of the house [were] probably the main features that we saw that were attractive about the house: so I guess the unique character. (Heidi)

So we wouldn’t want to put [blinds] on the front of the house for ... aesthetic reasons, so the front of the house will just have to have internal curtains. And yeah, it was important not to change the appearance of the house. We wouldn’t – we could probably get better performance if we put shutters on the outside of windows, say, or yeah, we wouldn’t do that ... (Jill)

Character seems to relate more to quaintness and existence of features which embody symbolic meaning of home (Somerville, 1992 in Blunt and Dowling, 2006), or that appeal to visions of domestic life (Shove and Hand, 2005), such as brick fireplaces:
I liked the fact that it had the ceiling rose in the front and the cornice, the fireplaces. (Jeanette)

I had the obsession with keeping the fireplace (Maisie)

Rarity or distinctiveness was also seen as worth retaining, with several participants pointing out features about the house that were unusual or quirky. However, if an object did not have meaning for the owner, then this affected the likelihood of it being retained in the renovation. In the following example, as the building itself did not fit in with homeowners’ image of what heritage should be, their intention was to demolish the building:

I do like heritage properties but I don’t think this fits into my idea of what a heritage property would look like.  
Interviewer: Okay, so what would be your idea of what it would look like? I don’t know. Something uniquely definite about that era or an era of 1901. (Martin)

For some homeowners, the sense of continuity and connection to the past through the physical fabric is important, and appreciable efforts were made during renovations to retain physical elements that contributed to this, rather than replace with new, even though this made upgrading performance more difficult. Maisie and Michael have lived in their weatherboard home for 20 years and set out to disturb the original as little as possible during renovation: they avoided removing the external weatherboards, and although the internal wall plaster was damaged during re-stumping, they retained the timber laths, inserted insulation and then applied plasterboard over the top of the laths.

We tried to retain it yeah because we had to restump and there were cracks and we ended up we kept all the ceilings and we kept all the laths on the walls and then [Michael] and I manually stuffed the walls with bulk insulation. .... Doing it that way at least we didn’t have to disturb the external walls too much. (Maisie)
Another homeowner painstakingly removed the internal plaster (which was not a requirement), and paid to have skilled plasterers to replaster onto the existing laths, rather than fixing plasterboard internally.

And after the re-stumping [the plaster] just shattered into eggshell looking cracks all over the walls. So the plaster all had to be removed, ... all the laths were kept and my partner and some friends, I think, came in and took all the plaster off and we then engaged a team of three generations of lath and plasterers to come and spend a week or two weeks plastering the whole house.

However, this meant that it was not feasible to insert insulation:

[Y]ou can’t insulate in between: the solid plaster is put on either side that I guess three quarters of an inch thick or so on each side of the wall. But we weren’t aware of anything that could be done to insulate inside the actual, in between the laths. And on the outside we didn’t insulate because we would have had to remove the boards around the outside. (Heidi)

Although the floors in her house were uneven, Heidi revealed why she had kept them, and repaired damaged boards:

[T]he old timber floors that you just know have been walked on for, by so many people over so many years: just the historic factor associated with that ... (Heidi)

This sense of history and continuity was important for some homeowners; whilst this mainly focused on the house, for some it also extended to the wider area.

[S]omething else I love about this neighbourhood and about these older neighbourhoods is that they do have so much sort of character and history. ... every street, every block, every house tells a story. (Matt)
Some participants have long associations with the dwelling, having lived or been connected with the building for a considerable number of years. Participants showed attachment or affection, which was demonstrated by what they said and their efforts in looking after the building, or a reverence for the building. Paul and his wife have lived in the house for 27 years, and during that time he has maintained the building to prevent damage or loss, even carefully re-attaching the historic wallpaper.

*We understand the heritage restrictions on it in terms of the current structure we can’t change the place, we can’t take out the wallpaper that’s in the front rooms even if we wanted to and we don’t want. We’ve spent quite a bit of effort re-gluing those papers where they’ve moved off the wall.* (Paul)

Joy has a palpable attachment to the house that she has known since childhood; the house belonged to her grandparents, then passed to her parents, and she bought out her sisters following the death of her mother.

*I’ve just always loved this house. My other sisters are not quite so keen on it. They all go, “Well it’s old and draughty and horrible, and cold”. But ... it’s been our family home.* (Joy)

The length of time living in a house tended to increase the attachment, as noted by Somerville (1997) as the result of the home being the embodiment of past memories, or working on the house (Gram-Hanssen and Bech-Danielsen, 2004) therefore increasing its significance to the occupants. Not all participants related so strongly to the house.

The majority of those interviewed had carried out extensive modifications, or reconstruction of the interior, retaining only the front part of the house.

*[W]e kept the front two rooms and everything else was just gutted and then started again. ... Those two bedrooms were kept purely I think because it was a heritage building, like heritage listed, grade two I think or whatever. But we kept two bedrooms intact ... but the rest of the house, there was nothing really*
significant. There was a chimney at the back, it might have been in the kitchen, which was not essential. Other than that it was only the external façade, so we just gutted it, we went right to the top. (David)

This would appear to support the importance of the aesthetic aspects of heritage, whereby greater value is placed on the image and perceived prestige associated with a heritage building rather than authenticity and integrity, principles endorsed by orthodox conservation (Pendlebury 2009; Strange, 1999). It may also indicate that other priorities, such as functional considerations or environmental performance prevailed. These are discussed further in sections 7.4.3 to 7.4.6.

The meaning of heritage, or ‘images’ as referred to by Shove and Pantzar (2005), would appear to influence the engagement with the building and the renovation practices adopted by homeowners. Shove and Pantzar (2005) discuss the influence of images and symbolic meanings associated with material objects in practices. In the example used by Shove and Pantzar, the practice of Nordic walking is associated with images of enjoying nature, health and fitness, having a good time, and a normal activity. As discussed in Chapter 2, and based on the premise that heritage is socially constructed, heritage has different meanings for different people (Gibson and Pendlebury, 2009). Cultural heritage objects are interpreted in multiple and often conflicting ways: interpretations may be symbolic, but are often linked to contemporary purposes and needs. As noted by Gibson & Pendlebury (2009: 8), significance is not limited to an architectural or archaeological appraisal of fabric, but also incorporates people’s experience.

7.4.2 Importance of heritage

Of those interviewed, stewardship of the cultural heritage was mentioned by 4 participants who consider themselves responsible for ensuring that the building is retained for future generations, including Joy:
Our view is that we’re just custodians, so we just want to keep it for the future, yeah. (Joy)

As noted in Chapter 3, one of the fundamental tenets of heritage conservation is the transmission of the maximum significance for future generations, although this view is not necessarily shared across all of those interviewed.

When asked about the relative importance of cultural heritage and the environment, views were divergent as might be expected. Four of the 26 participants considered retaining heritage features more important than improving environmental performance, due to its scarcity and because it is irreplaceable;

I think that the long term heritage thing is probably more important at this stage, yeah, even though we’re trying to make it as sustainable as possible for the future. In the future that sustainable energy thing may change, but if you’ve already lost the heritage stuff you can’t get it back. (Joy)

Well, the price of conserving heritage sometimes, might be greenhouse emissions. There are lots of places you could save greenhouse emissions, but not lots of places you can preserve heritage. (Jeff)

Several participants indicated that they thought that heritage conservation and environmental performance were of equal importance, and had made an effort to achieve both objectives. Unable to install the PV panels on the front (north) facing elevation, and rather than removing a chimney stack, one homeowner had two arrays installed, each with its own inverter:

We could have just used the west [slope] and one inverter. That probably would have got just about all of them [PV panels] running down there if that chimney wasn’t there. (Tim)
The number of times that I went back and said to [the architect] try again; it’s their job to make sure that they can get these things done and so we don’t actually have to compromise so much that there is an outcome that will deliver both. (Gareth)

Two participants stated that the environment was more important, and should take priority over retaining heritage. Another couple had purchased an existing dwelling with the intention to demolish and replace it with a new, more energy-efficient dwelling. Although they regarded heritage as important, they did not consider the building had any special heritage significance, even though it was included on the local Heritage Overlay for its contribution to the streetscape.

These often divergent views illustrate the paradox in renovation of heritage buildings, on the one hand, there is a drive to upgrade dwellings, whether it be for energy efficiency or other reasons, and on the other a requirement to secure the heritage. Several participants expressed the dilemma between making a building functional and retaining heritage fabric, and this is exemplified in the following quotation:

[I]f the stuff’s here you may as well keep it ’cause there is too much that's lost. But the issue you’ve got to get your head around is the fact that you want to live in it or you’ve got a changed need ... (David)

Most homeowners thought that environmental performance and heritage significance could co-exist, but were unclear how this could be achieved. There were examples within homeowner renovation practices of inconsistency between participants’ stated views endorsing retention of heritage significance, and renovation works that had been carried out, which appeared contradictory. In one example, although the homeowner related during the interview how the ‘dramatic’ roofline was an important element in making the building special, PV panels had recently been installed on the north facing roof slope and, being forward of the chimney, were visible from outside the site. This was contrary to
planning policy. The panels had been installed without the homeowner having first obtained permission from the local council, leading to some protracted discussion and threat of enforcement action. Further, the homeowner supported conserving heritage significance, and had previously advocated for heritage designation to prevent development that was harmful to the character of the area. Either, the homeowner did not perceive that there was any conflict, or took a pragmatic view and was prepared to prioritise the energy benefits over heritage significance and aesthetic values. As previously discussed in Section 6.6.2, a number of planning appeal decisions by the Victoria Civil and Administrative Tribunal (VCAT) highlight this tension.

7.4.3 Renovation and ideas of home

Home-renovators interviewed in this study expressed a range of understandings associated with home. Family life and everyday pursuits feature frequently in the interviews, with renovations facilitating such ordinary activities as playing with children, cooking and eating together:

[W]e’ve changed the purpose of some of the rooms over time and as the kids have grown up. Because when they’re little you certainly want that family room where they can have toys and mess and stuff but you need a separate living room for people to come (Maisie)

Activities such as socialising and entertaining also feature frequently in the images associated with the renovations. In the following examples, Maisie, Philippa and Jessica all viewed the house as constraining family social activities and each created a large open-plan kitchen family room by adding an extension. In the fourth example, Heidi reconfigured the space into a kitchen designed for entertaining:

And we used to have our main living area in the front of the house but we’ve changed living areas too because we basically wanted to have mainly one living area out the back... (Maisie)
It's not a very entertaining house. Like it doesn't flow. ... [The extension] is going to add on about another seven squares. ...So there'll be the kitchen, living area, deck, another bedroom, another bathroom, laundry, pantry, and this will allow the third bedroom here to be converted into a bathroom and that's going to become a dining room. ... Looking after kids it's better to have that, if I need an open area, this house is way too pokey ... And either you start knocking out walls or else you do that [extend], so I'm doing that.

(Philippa)

In talking about her renovation, Jessica also envisions having guests over in relaxed, informal surroundings:

[I]t'll be an easier flow so you know if we're having people over it sort of feels awkward at the moment. It's sort of “So would you like to go into the lounge room”, you know that sort of thing so yeah – it'll be a lovely big space and there'll be living space out here and ... we'll flow out to the garden more.

(Jessica)

Like Jessica, other homeowners have renovated with socialising in mind. Heidi removed an internal wall and reconfigured the space to have more space for dinner parties:

[W]e like to have friends over and put a big trestle table down the middle and have dinner parties, and we like to, we wanted to keep this area open so we could do that, so we took out the kitchen which was taking up most of the space, and just kept one bench with the sink and attached it onto a couple of trellises. (Heidi)

Maisie explains the benefits of the open-plan arrangement:

[T]he kitchen particularly operates better in terms of when we're having people for dinner and you're part of the whole show ... we've got this open bench but
it’s screened so that you can’t see what’s on it. You can’t see the chaos on it from the dining table ... (Maisie)

These images are given tangible expression in the large open-plan family room, which is a common element in homeowner renovation practices in this study (a major component in 14 of the 20 renovations). Within older dwellings, which have compartmentalised spaces, open-plan space is formed either by knocking through existing dividing walls to create a large connected space, or building on a new addition (refer to Table 6.2 in section 6.6.5). This space is often connected to an outside living area, used for family meals, entertaining, etc., as Jessica explains:

[W]e want to have the living space flowing onto the outside and ... we wanted open-plan for the living space (Jessica)

The popularity of open-plan living space seems to be related more to ideals of family life and social activities, than saving energy or reducing use of resources, as larger dwellings are linked to higher operational energy use for space heating and cooling, and lighting (Clune et al., 2012).

The homeowners interviewed regard renovation as assisting in providing continuity and stability to the family. A mature couple, Maisie and Michael, have extended the house they have lived in for 20 years, and provided an extra bathroom to accommodate young adults sharing with parents due to unanticipated housing affordability issues:

Well the kids have grown up too so things have changed ... We haven’t got teenagers living in the house. We’re sharing it with our adult son and his girlfriend, so yeah quite different. (Maisie)

Elsewhere, Heidi and her partner, Aiden bought a house built in c.1910 that required extensive repair and renovation, and have made material changes to
fit with their current way of living, and anticipated future requirements, providing a permanent base for their young family over a long period of time:

[When we bought the house, we both agreed this was where we were going to be for the next 20 years: so we wanted to see it do us through different phases of our life and our children’s lives. So we built that room as a potential games room for when the children are older so they can entertain at home and not be right here with us all the time. (Heidi)]

Family continuity balanced with practicality is also a key consideration in renovations:

\[ In the long term if our family gets bigger ... we built upstairs and the multifunctional space, so that we could change the house around if we wanted to. (Debbie) \]

So we’ll have two living spaces and one; two; three; four bedrooms so we’re sort of future proofing in a way in case say my mum or [mother-in-law] or someone needs to live with us for a while and obviously when the kids get older if they’re living with us, after being overseas and you know, it’s hard to buy houses and that sort of thing now. (Jessica)

[Mother-in-law] couldn’t live by herself anymore and we needed more space and she had this big house with this massive backyard and we thought, “Oh, well, it seems really sensible to do that.” Just for all of us to move here and Todd is her only grandchild and so it just seemed like that was the thing to do. (Jill)

Planning ahead, contingency and flexibility is a recurring theme in the interviews with home-renovators, particularly in relation to space requirements, and changes within the household. This has implications for energy use as dwellings are adapted and modified, alongside fluctuations in household composition, as acknowledged by the following comment:
So our electricity bill is more to do with how many people are living in the house too. I noticed when our eldest son who is here at the moment is not very energy conscious so we have to be on his case a bit about water and energy use. (Maisie)

Although shared living space is a feature of renovations, privacy within the home is also referred to by a number of homeowners, most commonly in relation to bathing facilities, as illustrated here:

[W]e've had two or three lots of visitors and we've having more, so we've got a spare bedroom. They've got their own bathroom, so they don't have to interrupt us in the middle of the night, we don't have to interrupt them. (Jeanette)

So we then put another bedroom upstairs for our daughter, with an en suite and – 'cause, oh, I don't know. It was good space for her if she was growing up with friends and all of the rest of it. (Tim)

Jill and her husband built a ‘granny annex’, to provide self-contained accommodation for an aged relative.

Renovation is associated with new functions in older spaces, including home-working and tele-working, indoor media and leisure, and virtual networks which have been made feasible through ITC technology (Ravetz, 2008). A place for home working features in 11 of the renovations, with 10 incorporating a dedicated study or home office:

I wanted a room as a study and we also wanted a spare room for friends and so on, so that gave us the spare room and in addition to me having the study (Tim)

And we used to have our main living area in the front of the house but we've changed living areas too because we basically wanted to have mainly one
living area out the back. We’ve got a study area in the front but we’ve changed the way we live in the house too.  (Maisie)

In another home there are two separate rooms allocated as offices, with each occupant having their own individual workspace to accommodate home working practices. The incorporation of a dedicated workspace is consistent with the professional and managerial occupations of the participants. The incorporation of a dedicated office or ‘hub’ signals the increased blurring of home and work practices which, together with increased IT equipment, has implications for energy use in the home (Gram-Hanssen, 2010b; Wilhite and Lutzenhiser, 1999).

Comfort is important to home-renovators in the study, and there is a close association between renovation and investing in making a home more comfortable or pleasant:

[We’ve built in a fair bit of comfort; all this heating system and double-glazing and so on. I mean, that just, insulation, it makes it a more comfortable house, so it’s not just an energy efficiency thing, you’re also getting enormous benefits in terms of the comfort of the house. ... we’ve spent $50,000, $60,000 on the house, which could be directly attributable to making it more comfortable, particularly the windows and the heating and making it more environmentally efficient.  (Tim)

[We want to make it comfortable for, as we get older. We want to make it more environmentally sustainable but we also want to maintain the integrity of it, the house, as it was. ... So we’re going to do some additions to the house. So we’re going to add an en suite and a wardrobe, because there’s no storage, and we’re also going to open up the kitchen. One of the main reasons for that is to gain the north sun in the winter and make it warmer.  (Joy)
We did the extension for comfort and when we did it we took into account other things. (Rachel)

The link between comfort and environmental factors is explored further in sections 7.4.5 and 7.4.6.

In the eyes of home-owners, renovating contributes to the organisation of family activities and ‘liveability’; provides for continuity and stability in family life; incorporates changing ideas of normality, particularly comfort and privacy; and facilitates changing social patterns such as increased home working. The next section explores environmental understandings, which have only recently become associated with home-renovation.

7.4.4 Emerging environmental understandings

In recruiting participants, it was made clear that the research was concerned with the environmental performance of heritage dwellings and, therefore, it might be expected that homeowners who volunteered would be likely to have an interest in the environment, and that this would be reflected in the reasons given for undertaking renovations and their practices. Improving environmental performance is championed in the media, through magazines and popular TV programmes about renovation, widely discussed on the internet—where many home-renovators do research and seek guidance—and promoted in government policies and programmes. During interviews, most participants expressed concern about the environment, and a variety of practices were cited by homeowners linked to minimising household impact on the environment, these included taking shorter showers, turning off the tap whilst brushing teeth, making use of the outside clothes line rather than using an electric clothes dryer, putting on extra clothes instead of turning up the heating, turning off lights when leaving a room, recycling/composting and growing vegetables:
This is a very frugal house, we’ve lived frugally, frugal family. ... We live frugally. In summer we take off layers, in winter we put them on. We turn off lights, we use low energy appliances. We try not to waste too much. (Matt)

However, technological solutions predominated in discussions, with the focus being on products and technologies incorporated into the renovations to improve energy efficiency.

Almost all participants cited environmental concerns as reason for renovating which reflected the range of opinions expressed in popular media, focusing on concern for resource depletion, and climate change. When asked about the reasons for reducing their environmental impact, participants’ concerns related to: the negative effects of humans on the environment, in particular, reducing resource use, waste, and emissions; and personal values, altruism or an ethical responsibility to protect the environment. As well as having their own reasons for reducing energy, for some homeowners renovation was a means to be an example that others could imitate:

So it was really important especially given what I do that my house is a shining beacon. (Gareth)

We don’t expect the solar panels by any means to cover our electricity costs. ... But they help in that they are a bit of showing people what you can do ... (Rachel)

Six participants expressed a desire to ‘make a difference’, and 7 stated that they thought reducing their environmental impact, was ‘the right thing to do’. Although equity for future generations was not explicitly mentioned in relation to the environment, the 7 participants that wished to ‘do the right thing’ all had children indicating a possible connection. This correlation was not followed up as it is not central to this research.
Use of energy and water dominated householders’ concerns about the environment. Although concerns generally related to the broader external environment, health and wellbeing were mentioned by 5 participants, mainly in association with concerns about eco-toxicity of materials or construction processes used in particular renovation practices, but also in relation to poor indoor environmental quality through, for example, damp, inadequate heating, and dust. The need to reduce greenhouse gas emissions was also communicated directly by 4 participants. When questioned further, 6 out of the 20 households interviewed said that they purchased green energy (another was unsure), which may be taken as an indicator of environmental concerns. Amongst the reasons given for purchasing green energy were: as a means to reduce emissions associated with the generation of electricity from coal-fired power stations, and also to support the advance of renewable energy. There did not appear to be a relationship between age, income, education, geographical location and purchase of green energy. Of the 6 households who purchased green energy 5 had a graduate or postgraduate qualification; of the 8 who stated they did not purchase green energy, 6 were educated to graduate or postgraduate level. The reasons given for not purchasing green energy were wide ranging: householders objected to paying more; difficulties in changing supplier; being tied in to contracts with existing electricity suppliers; insufficient knowledge; confusing pricing structures for households with solar PV; and a preference for other forms of renewable power supply such as micro-generation, as illustrated by the following comment:

*I reckon green energy is a bit of a laugh in that I can’t really see why you should be paying a premium for green energy. I reckon it should all be green energy. So we haven’t taken up the green energy purchase, but we have got a photovoltaic system on the shed roof. So we took up the opportunity of putting in a bulk buy, federal government part funded system last year. (Paul)*

Like Paul, other homeowners had decided to take advantage of the subsidised solar PV, and favourable feed-in tariff offered to generate renewable energy.
We actually have photo voltaics on the roof. ... We installed those in, oh well 2005 I think. Yeah. Yeah we did get a subsidy. But we haven't got the full subsidy, so where people today are putting up an equivalent system for $2,000, we spent $6,000, so you know, quite early adopters. ... It probably meets about 50 per cent of our needs overall. ... But because this is, you get, the feed in tariff is a lot higher than the purchase price of coal-fired electricity we end up in front. (Matt)

We got the $8,000 subsidy from the federal government, so it was just before that finished ... It was maybe two years ago. We were wanting to install them, but it was probably something that helped make our decision to do it. I was hoping to be able to have the house, so most of the energy that we used was generated by solar panels ... Yes, we’ve managed to achieve that with the solar panels, so we still use gas for our cooking and for various items, but the solar panels that we’ve installed covers off all our electricity. ... It’s a three kilowatt system. (Heidi)

Six panels in total. ... It’s about, I wish I’d gone higher. I think it’s 1.5 [kW] or something, yeah, whatever. But they’re good and I’d like to have more. ... And [the feed-in tariff] saved my electricity bill quite considerably, it’s great. (Philippa)

The renovations undertaken and comments indicate that the policy emphasis on energy efficiency and environmental emissions has had some influence on homeowners’ understandings about generation and these had been incorporated into practices in renovating, assisted by financial incentives. During the interviews homeowners were enthusiastic about their acquisitions and technologies to enhance energy efficiency, and were keen to demonstrate their environmental credentials; most of those interviewed had chosen to install visible measures, such as solar panels or solar hot water; and those items having some prestige, particularly double-glazing and central heating, energy-efficient appliances. During interviews and tours less attention was
given to actions such as draught-sealing or installing insulation which are not so visible.

Whilst technical strategies predominat ed in this study, householders also reported making modifications to their daily practices in order to ‘save’ energy, such as turning down heating thermostats and air-conditioners, or hanging out washing rather than using an electric tumble dryer. However, it was noted in the interviews that, while some practices were modified to meet new environmental understandings, they co-existed alongside existing understandings of comfort, cleanliness and convenience, rather than replacing them. For example, two households retained their existing air conditioning, despite having commissioned a passive solar design, and another extended their air-conditioning.

New environmental understandings were also resulting in some homeowners questioning the use of energy-intensive appliances, such as air-conditioners and tumble dryers. Some homeowners do not have an electric tumble dryer as they consider it wasteful of energy:

*We would always choose efficient electrical devices. We chose not to have a clothes dryer for example, we will put them on racks near the hydronic heating and dry things naturally outside rather than ever use the clothes dryer which I think they all only come in one star rating.* (Maisie)

As part of her laundry routines, Justine, one of a household of 6, prefers to hang washing outside to dry than use an electric tumble dryer:

*I have a lot of washing and I actually hang it all out, which takes probably three times the amount of work than if you just chuck it in a dryer.* (Justine)

In five cases homeowners made a conscious decision not to install air-conditioning (for further discussion see Section 7.4.6), and others stated that
they only used air-conditioning frugally or occasionally in ‘extreme’ circumstances. However, as electrical appliances were not monitored, it was not possible to verify usage.

7.4.5 Energy consumption and costs

Reducing energy costs along with improving thermal comfort were the most common reasons recounted for renovations. Narratives about energy use, energy costs and thermal comfort standards often featured together in participants’ accounts relating to renovation, with several opting for a ‘low energy’ house reflecting contemporary debates about energy costs in Australian households. Whilst the cost of energy was not considered to be an important factor in the renovations for two participants with high household incomes, 12 homeowners (sixty per cent of the research participants) expressed concern about rising energy costs; this was mentioned by homeowners from across different age ranges but was particularly pertinent for those who are retired or thinking ahead to retirement:

*We can see that electricity is just going to increase a lot so but our main driver is to make the house warm and comfortable and liveable and appropriate for, as we get older, yeah.* (Joy)

*So we’re looking in the future context. And, overall, energy demand or costs, or future costs, are our concern and we want to limit them as much as we possibly can.* (Martin)

Renovations were rationalised as reducing the risk against rising energy costs, the aim being an investment to secure long-term affordability through lower energy bills. As one participant stated,

*[W]e thought, “Okay, we’re spending a lot of money, but it'll be worth it, because our power bills will be cheaper,” so that’s why we went with foil and batts everywhere for that reason. We wanted to save on bills and yeah, we*

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9 Renovation costs and payback times were not calculated as part of this study.
could see we’d retire. We wanted a low cost house and yeah, so we were planning to stay here for a long time and get the most from our investment. (Jill)

We want the house to be comfortable but we also want to reduce our costs in the future and we will be pensioners so that we are willing to put some money out now for long term reducing our costs. (Joy)

Energy is not going to get cheaper so we wanted to try and make it a cheap house to run. I guess we’re not tree-huggers, we didn’t have environmental aspirations, I’m sorry, it just came down to the dollar. (Max)

Several homeowners revealed aspirations to be self-sufficient in terms of energy use, and elements of the renovation (such as installation of PV panels) were intended to assist them in achieving this goal. This was mentioned in association with utility bills, and the dividend received from the feed-in tariff paid by the utility company for surplus electricity generated so the goal of self-sufficiency may also have an underlying financial motive.

7.4.6 Expectations: comfort, cleanliness and convenience

Although diverse in nature, the most common reasons communicated by individual participants for undertaking renovations relate to expectations of thermal comfort, and better living standards within the home. Material changes and appropriation of household appliances have become part of making a comfortable home, through renovation. In the following example, the homeowner had become accustomed to warm towels, and wanted to incorporate heated towel rails into the renovation:

[T]he towel rail’s heated upstairs, but here [downstairs bathroom] we couldn’t have the towel rail heated because it’s too close to a water outlet. But we had heated towel rails in our other house, and that was good because you’d only
have them on for a little bit of a morning. I'd get up, turn the towel rail on, go for a walk, come back, nice warm towels for a shower. (Jeanette)

Notable reasons narrated during interviews with 10 homeowners involved ‘liveability’, which is interpreted from the interviews as adapting the house to suit occupants’ preferred way of living; this could involve changes such as improving the flow or internal layout, or increasing natural light to accommodate specific practices. As traced by Shove (2003) and Kintrea (2007), social expectations have changed over time, and this is evidenced by the renovations that have taken place in dwellings included in this study.

The nature of the renovation activities, such as whole house heating systems that are cleaner and require little trouble or effort to operate, and multiple bathrooms, are indicative of the shifting visions and expectations of home and daily life towards greater comfort, cleanliness and convenience—important underlying reasons for making material changes. The desire for thermal comfort is reflected in the renovations, and is referred to by all of the renovators interviewed; for some occupants it was mentioned frequently, and is clearly of primary importance. It should be noted that interviews were carried out in summer, between January and May 2011. During the 3 months December 2010 to February 2011, there were 14 days over 30 degrees, and 3 days over 35 degrees in Melbourne. The hottest day was 41.1 degrees on 31 December 2010 (Bureau of Meteorology, 2013). Although some renovators acknowledge that the house often had construction material or architectural features that moderated the effects of the climate, discomfort due to extremes of heat and cold was an issue reported by all interviewees from their experience of living in a heritage dwelling:

The back of the house was hideous in the summer because it had quite a lot of roof and it had no insulation and it was tin or corrugated steel and it used to get really hot and there was no way for the heat to get out. So it was particularly bad in summer. (Maisie)
We had this shocking bathroom there was no insulation, it was just corrugated iron, it was cold in winter and boiling hot in summer. It was terrible we – it was like a sauna out there in summer, in the bathroom. ... I can remember days with the kids just sitting in the kid’s bedroom and my mother-in-law loaned us this portable air conditioner and we’d just stay in the whole day in the room with the kids because it was just so hot. And then putting them in the bath every now and then to cool them down, it was just shocking yeah. (Jessica)

The sun does beat in here and at the back, even though the back faces the south, I get quite a lot of sun in that kitchen. But it is hot, and it is cold in the winter. (Frida)

When it got hot, it was awful, ‘cause that back room got all the sun and it had very little insulation in a tin roof. (Jeremy)

Summer’s quite good: it doesn’t tend to heat up for probably two or three days, even in a really hot, even in hot conditions. The areas that get hot, the bathroom gets hot so we close, keep the bathroom door closed; my daughter’s bedroom gets hot, so we keep that door closed during the day; and the front room also gets hot, which is the west-facing room, so we keep that door closed in summer. So that tends to keep the house a bit cooler. (Heidi)

In some respects, older buildings have poorer thermal performance compared to their modern counterparts, exhibiting greater fluctuation in internal temperature mirroring the external temperature; this is due mainly to uncontrolled air infiltration and lack of insulation of the building envelope (Ding et al., 2011). Although the common perception that all old buildings perform poorly (Nilsson, 1996; Wong et al., 2011) compared to new buildings, this is countered by some homeowners’ experience. Comparing the recently
completed first floor extension to their 1880s workers’ cottage, one couple acknowledged that the new accommodation on the first floor had its drawbacks:

[I]f it’s a really hot, stinking day, downstairs is quite cool and upstairs is a hot box. ... The front is solid brick, high ceilings, verandah on the front, so this is north, so we get a bit of sun during the day, but it’s not really hot. It took three or four days for the front rooms to be a bit warm and we had people stay there one night and they had the fan on for a bit and then turned it off and they were fine. (Jeanette)

However, Jeanette also acknowledges that the older part ‘ might be cold as a frog in winter’.

Similarly, the new rear extension to Debbie’s house could be more uncomfortable than the older building:

[I]n summer on stinking hot days it’s lovely to sit up in that front room because it stays really cool. We just need to shut the door in the hall and you can feel an immediate difference. I get home from work and you leave that shut, all of the blinds I’ve done everything I can, it’s still a little warm around the back. So we will just escape up the front. Well it’s nice and cool in there. (Debbie)

However, since the renovation she had noticed some decline in ventilation:

[I]t gets quite stuffy in our bedroom and I wish they’d have left the [wall vents] in. So it’s one of those things isn’t it? But we’ve been sleeping with the door open which I never ever, ever used to do, because it’s really, really stuffy in there. (Debbie)

Other homeowners expressed some disappointment in thermal comfort following renovation, particularly during periods of extreme heat:
[There is] insulation in the roof and since I've put the original profile on the roof I've also put additional blanketing as well, so I've got insulation plus blanketing. So I've noticed since that's happened that the house is much hotter, so I've got to do something about that, as it's becoming intolerable in summer. ...Yeah. It’s extremely hot. ... now it heats up much quicker and it’s quite intolerable. Very stuffy and so I’ve got to do something. I don’t know what. But I have to (Philippa)

Thus renovations to improve performance did not always achieve homeowners’ high expectations for year-round comfort, one of the main motivations. Some homeowners accepted that there was a trade-off in comfort because of the design or other desired objective:

[T]he house used to heat up a lot, very quickly, but it does stay cool for a day or so and if the heat continues, it gets hot and then it’s hard then for the heat to escape. I think it’s working ... it is a bit hard to tell, but I think it does stay cooler and does keep the heat to a certain extent, because our architect ... he was very keen on windows everywhere and letting in light and the whole house was very dark. So I think that any performance that we’ve got from insulation has been negated by all the windows. But in the old part of the house it does help, even though we don’t have coverings on all the windows there. (Jill)

The evidence suggests that householders are in the main, seeking to equalize thermal conditions throughout the dwelling, for example through retrofitting insulation where possible, installing central heating, or moderating extreme heat with air conditioning, passive design or combination of strategies. Of the 20 households interviewed, 9 had air conditioning in one or more rooms (of these, 3 households had young children, 2 included occupants over 60 years of age, and another had installed air-conditioning for the benefit of their dogs):

I have got an air conditioner. I don’t like them. I ended up buying one for the dogs, because I actually lost a dog last year because she just came home on
a hot day and she just really, she just collapsed in the backyard. So this year I actually went out and bought an air conditioner for the dogs ... I mean with old dogs they really do feel the heat ... (Philippa)

As noted previously in Section 2.5.4, air-conditioning in homes is becoming increasingly prevalent. Although the proportion of households interviewed with air conditioning is lower than the 76 per cent of households in Victoria, the incidence of air conditioning is increasing due to increases in the total floor area of dwellings, trends towards central cooling and open-plan living, the growing affordability and availability of air-conditioning, and the normalization of usage in Australian society (Australian Bureau of Statistics, 2011c; Strengers and Maller, 2011). In the households interviewed in this study, renovation practices are influenced by understandings of healthiness and the environment. Of the 11 households that did not have air conditioning, most preferred to rely on fans, passive design and natural cooling such as wet flannels or water sprays. Nine participants in 5 households expressed a strong dislike for air conditioning, based on understandings of its effects on health or because of the energy consumption or carbon dioxide emissions associated with their use, and had taken the decision not to include air conditioning in their renovations.

[W]e chose not to do things like that [air-conditioning] that would take more energy. [Maisie]

Two households were undecided about whether they would install air conditioning in the future.

Double-glazing also featured frequently in renovations, with 11 renovators installing double-glazing (one installed triple-glazed, argon-filled units) as part of their renovations. The higher specification glazing was incorporated into the new extensions, and in three households double/triple glazing was also retrofitted to windows in the existing house (a further six renovators stated that
they would like to fit double-glazing to all windows—but expressed reservations over the impact on heritage significance, and lacked knowledge on how to overcome technical issues, with cost also being a factor for some). Double-glazing is seen as a desirable item and as an effective means of limiting heat transfer through the building envelope and reducing draughts, thereby contributing to thermal comfort in winter and summer.

Perceived as clean, convenient, and the most effective in providing ambient comfort, 11 of the 20 renovators expressed a preference for hydronic heating over other forms such as ducted air heating or a wood burning stove:

*Previously it just had ducted gas heating, dreadful absolutely dreadful, more plumes of dust than it did anything else ...* (Gareth)

*And I've lived in a house with ducted heating a lot, and I didn't like that any particle of dust would be thrown around the room. I really didn't like that. And I don't particularly like cleaning either, so it was a good thing to have hydronic heating. Where if there is any dust it's not going to go flying around the room a lot. I liked the idea of being able to feel the warmth but it's that beautiful sort of ambient kind of warmth, and I like the idea of being able to heat individual rooms.* (Debbie)

*I think it’s good for me particularly as I get asthma, and as I get older the asthma is likely to get a bit worse so the clean air is an important thing. The dusty air that comes through ducted heating is probably not the best.* (Frida)

Having removed an existing ducted air heating system that they considered dusty and unhealthy, one family waited four years to install hydronic heating:

*[W]hen we bought the house it had ducted heating which we didn’t like the hot air, and we also didn’t like the idea of an old system blowing out dust particles and things into the house. ... we wanted to save up to get the right heating*
So we’d rather not have heating for four years and then have the hydronic than have the air blowing gas heating. (Heidi)

Another family explained why they had installed hydronic heating throughout the house, for convenience:

[In the existing part of the house, in our living room, we did have our Coonara heater. That was a lovely type of heat and very cosy, but we got sick of splitting logs (Justine)

Expectations about comfort, cleanliness and convenience are a common feature across homeowner renovation activities and, for most of the homeowners in this study, are high priority. This ‘culture of comfort’ contends with narratives of environmental sustainability (Maller and Horne, 2011).

Table 7.3 Key findings: how common understandings shape homeowner renovation practice

- Ideas relating to aesthetic appearance, distinctiveness, attachment, continuity and connection to the past are significant in configuring home-renovation practice. The way in which meaning is attributed to heritage dwellings differs between homeowners, and is reflected in the material changes, which vary between case studies.

- Heritage features are more likely to be retained in renovations where these correspond with homeowners’ own understandings of what is meaningful, and that uphold their comfort expectations or prevailing ideas of what a home should be.

- Homeowner renovations are largely determined by the changing nature of everyday practices, both those currently performed and anticipated in the future, with energy and other environmental concerns of lesser importance than everyday routines in shaping renovation practice.
- Increasing expectations relating to space, comfort, cleanliness and desire for convenience are a high priority in home-renovation practice, and contend with narratives of environmental sustainability.

- The desire to create a thermally comfortable home takes precedence over other considerations. Heating and cooling homes for guests, who are perceived to have different understandings and expectations of thermal comfort, may override environmental considerations.

- Energy efficiency requirements of housing are negotiated at the household level, both during the renovation process and in the daily lived experience of homeowners.

- Thermal efficiency, whilst perceived as important, competes with ideals seen as conducive to practices of contemporary family living. Material interventions of renovation practices are shaped and often overruled by common understandings of ‘liveability’ and maintaining practices of socialising, which may be somewhat incompatible with energy efficiency objectives.

- Reducing energy costs may be pertinent for certain groups of home-renovators, such as those who are retired or thinking ahead to retirement, however, energy consumption is weighed against other requirements, such as health concerns or family needs.

- Home renovators seek to moderate or offset the impacts of the extended material requirements of their renovations through the use of energy efficient technologies, environmentally sustainable or recycled materials.

- The incorporation of interventions to reduce energy consumption or meet environmental objectives depends on their compatibility with frequently performed or daily practices such as caring for family, socialising, maintaining thermal comfort, and other aspects of ordinary routines.
7.5 Digest: common understandings

This chapter has analysed the views of a selection of homeowners’ undertaking renovation activities. Analysis based on the practice framework adopted provides new insights into how the meanings of heritage, environmental understandings, and other motivations intertwine in home-renovation. Using social practice as a lens through which to examine homeowners’ renovations of heritage dwellings sheds light on perceived problems of performance associated with emerging environmental concerns, and cultural preferences to retain heritage elements. The analysis indicates the importance of comfort, cleanliness and convenience: improving thermal comfort was the most common reasons recounted for renovations, followed by reducing energy costs. The social practices framework also reveals the gulf between oft-stated environmental goals and the not-so-stated yet ever-present common understandings around daily living including perceived needs for spare bedrooms, extra bathrooms and so forth. Further, it illustrates the importance of everyday life in shaping renovation practice.

The study of practices involves not only the intersection of actors’ meanings and understandings, but competences and material infrastructures—and this is addressed in the next chapter.
'First we shape our buildings, then they shape us, then we shape them again—ad infinitum.'

Stewart Brand, 2004 p. 3

‘People do not develop ideas and ways of doing ‘from within’ by themselves. Their thinking and doing are shaped by fellow citizens and by the objects and situational factors which form an integral part of the contexts of their behaviours.’

Gert Spaargaren, 2011 p. 814

8 Home-renovation practice: competences and material elements

Practice theorists have come to understand that when studying practices there is a need to pay attention not only to the intersection of actors’ meanings, understandings, and competences, but to rules, resources, institutions and infrastructures (Shove, 2006: 301). In the first part of this chapter we therefore explore the competences, or knowledge and skills (Shove et al., 2012), relating to renovation and associated practices, and in the second part, attention is given to material infrastructures. These components are intimately linked in practice theory (Gram-Hanssen, 2009; Shove et al., 2007; Watson and Shove, 2008).

The proposition is that renovation is an assemblage of understandings, knowledge and skills, and material elements that are brought together within a particular social and cultural context. As previously discussed in Chapter 5, competences in the form of knowledge and skills are an integral component of social practices. Alongside homeowners, renovation involves numerous
participants, bringing together a team of people—often from different organisations and with differing professional backgrounds. The key groups of people involved in the practice of home-renovation are: the main designer, other professional advisers, energy performance assessor, regulators, and possibly product suppliers, building contractors and tradesmen/installers (‘expert-practitioners’), alongside the homeowner/s—each contributing to renovation practice through their own understandings, knowledge and practical skills. Thus home-renovation is a social activity, involving collaborating with a range of persons in different capacities to achieve objectives. This section explores the intersections of competence that underlie renovation, focusing on homeowners’ knowledge and skills and their nexus with the various ‘expert-practitioners’ during renovation.

8.1 Competences: knowledge and skills

As indicated in the composition of research participants in section 6.6.6, competences—whether formal education and experience, life skills or other practical knowledge—varies between homeowners. For the purposes of this study, a distinction is made between two main types of competences: formal (or institutional) knowledge comprising rules and theoretical-abstract knowledge, and know-how or practical knowledge and skills (Gram-Hanssen, 2010b).

8.1.1 Homeowners’ capabilities

In addition to their own ‘expert knowledge’ of everyday life and habits (Sofoulis, 2005), several homeowners in this study have recognized knowledge and skills relevant to the practice of renovation—either formal knowledge gained through their professional employment and experience, or practical know-how gained from previous home improvement projects. Whilst 4 homeowners were able to make use of specialist knowledge gained from working in a construction-related profession, others had gained experience
from undertaking previous renovation activities, and this knowledge and know-how was transferred to the current project. Of the 26 homeowners interviewed, 7 homeowners undertook practical renovation activities, and 6 were involved in an organisational or project management capacity, whilst others carried out research on products and technologies. For the renovations included in this study, homeowners took on those management or practical aspects that were within their capabilities, and could be fitted around their daily routines. Several homeowners were willing to ‘get their hands dirty’, by undertaking activities such as draught sealing, and installing insulation. However, some tasks, such as retrofitting insulation to floors and walls, was often left undone or only partially complete, as this is difficult, dirty and disruptive:

[Y]ou can’t actually get to underneath to be able to put the insulation underneath so the area here at the back doesn’t have insulation. But the area at the front, [Aiden] crawled underneath the house with one of those little suits on and put insulation and chicken wire all throughout everywhere he could reach. So he crawled back as far as he could reach himself. (Heidi)

I think [underfloor insulation] probably would be feasible but messy ... we didn’t really want to touch that part of the house when we did the renovations. (Rachel)

It’s very difficult to get in [to insulate within the roof void] because of this second layer of shingle roofing there. Not impossible but, yeah. ... I’m not sure, if we were to insulate that wall, which is probably what we should do, the expense and the effort of pulling the old boards off, I think, would mean completely recladding with new boards or replacing timbers, the weatherboards that are there. They stand up alright at the moment, a coat of paint probably fine, but I think if we were to pull them off we would do too much damage to them (Paul)

Maisie and Michael have insulated under the timber floor in the new extension, but not the existing dwelling:
We’re planning to do it that’s why we didn’t put the baseboards back but I can’t face it now and I don’t know if [Michael] is keen. … We tried to get people to do it and pay them to do it but nobody was at all interested to do that, yes, they just don’t want to go under there. (Maisie)

It requires sliding under there on your back through dust and cobwebs and spiders and all that stuff So it will happen at some point though, I have to build up a lot of courage. (Michael)

Even though retrofitting insulation is one of the most effective ways of improving energy efficiency (Iyer-Raniga and Wong, 2012) this work is unglamorous and was put off. Where this is an option, homeowners would rather pay contractors to undertake the ‘dirty’ work, but for others doing it themselves reduced costs. Temporal constraints were an issue for some, but the reluctance to do work may also be because householders feel that they do not have the appropriate level of competence. In Victoria, some activities, such as electrical or plumbing work, may not be undertaken by amateurs and requires the services of a registered contractor. Retrofitting activities such as insulation were often carried out by contractors, and incorporated as part of larger renovation projects such as extensions to limit disruption. This is consistent with other research (Hand et al., 2007; Maller & Horne, 2011).

Most homeowners in this study engaged professional advisors to assist them through the process of renovation and navigate institutional arrangements, suggesting they believed that they did not have the requisite knowledge or skills, or else were unable to dedicate time because of employment and other commitments. Environmental performance is an emerging area of knowledge, involves a complex set of things working together, and information may be contradictory. During interviews home-renovators expressed their lack of technical knowledge, or bewilderment at the array of products, and bemoaned their inability to distil the plethora of information in order to realise their objectives, as observed in the following comments:
There was this really frustrating article in ‘Sanctuary’, where this person wrote this whole article about you know, “Insulate or should you not insulate the slab”, and then basically didn’t even come out with a you know, it wasn’t gutsy enough to make a you know, a final conclusion, I said, “That’s so annoying”. (Jessica)

What I didn’t really know about was things like windows and the actual details of the insulation and what products were available and how – I started with higher ideals that were extraordinary difficult to achieve, so we had to compromise them and I think it shows just how hard it is to do some things you lose energy to pursue some of the things (Jill)

Several admitted that the experience of renovating amounted to a ‘learning curve’,

I was learning as I was going on ... (Jill)

We didn’t know what we wanted in a lot of ways and we were educated a lot by the architect (Gareth)

Homeowners interviewed turned to various knowledge sources. Like Jill (above) educated homeowners often carried out their own research to find detailed and practical information. The internet is a popular source of information including online forums, along with TV programmes about renovating, home styling magazines, sustainable house tours or green building expos, along with product suppliers, ‘expert-practitioners’, recommended contractors, and knowledgeable friends:

I watch Grand Designs and I’ve seen some fabulous new technologies they’re using for old windows and et cetera, (Philippa)

I’ve done all the research myself. So I’ve just been on the internet endlessly looking at options for, you know, sustainability, and what’s available, and
what’s the best thing for these type of houses. ... it’s taken a lot of time. And then to find the most ... least expensive of those options as well, yeah. (Joy)

I’ve probably had five or six different quotes over the years ... he’s done work for family so I’m pretty confident he’ll do a good job. (Debbie)

Where possible, homeowners tend to prefer recommendations from their social network, rather than relying on contractor directories from official sources. Homeowners often sought advice from a trusted friend or professional connections:

Well, I’ve done a bit of, of research. I went, I, I had a talk to this friend of mine who’s an architect, a heritage architect, and she told me about a particular architect (Frida)

We used a friend of ours who’s an architect to draw up the plans. (Matt)

A high level of confidence is placed in ‘expert-practitioners’ particularly architects, in terms of design strategies to achieve homeowners’ objectives for comfort, housing and requirements for environmental performance and heritage conservation:

[W]e had to trust their knowledge of what was going to work in terms of energy efficiency (Jeremy)

We have to trust in the architect’s understandings of what is viable for material reuse (Martin)

[W]hen we first did the renovation, I just left that to the architect. I was aware there was a Heritage Overlay but that’s why we hired an architect to do the design work, deal with [the Council] (Tim)
Although the expectation was that their objectives would be achieved through particular design strategies, homeowners admitted that their (possibly unrealistic) expectations were not always met, as illustrated previously in section 7.4.6. Several relied on advice or recommendations from a draftsman, building contractor or energy rating assessor on interventions, products and their performance, which informed their renovations, as in the following examples:

[I]t’s quite difficult, and I was talking to [a contractor] about insulation in, in the walls of weatherboard houses, and he said, well, ... it’s quite fiddley work and therefore it’s slow and therefore expensive. (Frida)

Consequently, Frida has not had the walls insulated.

[W]e spoke to the builder a bit about [the windows] ... he has a fair bit of knowledge about environmentally sensitive designs that sort of thing. We spoke a little bit to ... the draftsman. Although he was not particularly helpful with those sort of aspects of it and we spoke to [the energy rating assessor] (Rachel)

Even though contractors are regarded as a knowledge authority, they are not always reliable. Some homeowners did attempt to verify information from suppliers and manufacturers but definitive information was often hard to find:

So we’ve done a lot of research onto the windows and we’ve looked at you know wood versus PVC versus aluminium and ... [the architect] wanted to do wood. Do we do wood that you have to maintain wood, and so, so you’re painting wood? And, and in the life cycle of the product is it better to do aluminium or PVC? So we’re still grappling with that ...Well, we’re probably not going to do wood ... (Jessica)

Filtering information to identify content that is unambiguous and relevant to their particular situation was an issue mentioned by several homeowners. In
all cases homeowners sought support from a combination of ‘expert practitioners’ and peers. The contributions of key groups of people and how this influences renovation outcomes is further discussed in sections 8.1.2 and 8.1.3.

8.1.2 Knowledge and skills: informing renovation and household practices

It is evident from the analysis of interview data that knowledge and practical skills are important elements in informing and shaping renovation practices, whether through ‘expert-practitioners’, informal networks or other means. This section considers the homeowners knowledge about energy use and how this informs renovation. Concerns over energy prices and the desire to reduce household energy costs were one of the principal reasons recounted for undertaking renovations (section 7.5.5). However, few of the participants were well-informed about their energy usage, despite this information being readily available, as many did not examine their utility bills in any detail:

*I haven’t really watched it. I’m one of these non-rational people in that sense and I’m high income, well, we’re high income together and we can afford to go and buy these things and not have to worry too much. Vaguely, yes, there is a payback and that’s there and I haven’t plotted any of this. ... I’ve watched it, the bills. But I don’t get obsessive about measuring kWhs. (Tim)*

*I’m trying to remember what the bill was now. because all my bills are online I don’t actually physically, don’t see them and spend a lot of time studying them. (Debbie)*

There were two notable exceptions: one household, a family with two small children, was very conscious of their energy and water consumption (the latest utility bill was stuck on the fridge door in the kitchen so it could be read). The other exception, an older couple, had kept a record of their electricity usage over 5 years since purchasing the property, and had also carried out an audit
of devices in the home that use electricity, measuring the power used by individual appliances such as boiling the kettle to make a cup of tea, to determine which everyday practices and equipment used the most electricity. Following monitoring, their energy use had been reduced through a series of renovations:

[D]aily average peak use is just under 15, and daily average off-peak is just under two: So 16.79 to be precise. That’s average daily kiloWatt hour use for the last one, two, three, four and a bit years. Well on a really bad year

Oh, that was, let me see, back in 2007 it was almost 90: 88.72, and in 2007, so that was probably, oh, it was before we had some of the fireplace covers put on, before we had some chimneys capped, before we had the drapes installed. (Julia)

The energy data for this household (no. 20) are reproduced in Appendix 2.

For most of those interviewed there does not appear to be a strong connection between energy use and renovation. This may be because the information is difficult for homeowners to interpret, or perhaps energy efficiency was not the main reason for renovating, or there was an assumption that renovating would inevitably result in improved energy efficiency. Two households reported a reduction in energy usage since completing their renovations. However, it was only possible to verify consumption in three cases due to lack of data. As a significant number of the renovations in the study involved extensions and an increase in the floor area, householders found it difficult to determine whether the renovation had improved energy efficiency, as it was not a straightforward comparison of before and after:

[W]e’ve doubled the space of the house, so we’re actually probably using more, but I can’t say specifically. (Justine)

Further uncertainty existed over their energy consumption for homeowners that had installed PV panels to generate electricity; three had experienced delays in the new meter being installed by the electricity supplier; two had
experienced technical problems following installation of the new metering system; four reported that they had not had an electricity meter reading, nor had they received a utility bill from their supplier for a period of several months so were unable to say whether their energy consumption had reduced. Administrative and technical problems associated with the installation of metering and billing meant that households were unable to monitor their electricity consumption:

*I'm waiting for the smart meter to come in. That's another few weeks of that before that gets installed, which then makes the system fully operational in terms of metering the power we're supplying into the grid and deducting that from what we take out of the grid.* (Tim)

*Well we haven't had an actual electricity bill since we moved back in [in May 2010]  It is difficult to say.  Yes we do have [a smart meter], but it's really not working... . We did have [a] guy come around not that long along and actually read the meter and said that the smart meters were not sending messages back to the poles like they were supposed to in this whole area, so he has got to read everybody’s meter.* (Rachel)

*[W]e’ve gone back to the company and sort of hassled them, we didn’t get a power bill from April to November and we kept hassling them and they couldn’t give us the figures and it was just a crazy nightmare.* (Paul)

Others judged energy use by the final credit amount on their bill:

*I think that was the first bill that I got though with the smart meter and everything hooked up. So prior to that we weren't making anything. We didn’t really know.* (Debbie)

*Yes, so we ended up with a $75 credit on our energy bill for the year I think, is roughly what last year’s energy bill ended up being. It’s a bit hard to gauge because ... there’s been some problems with the billing, so we didn’t receive*
a bill for about nine months, then we had received bills when, and so then we received a credit bill. So I haven’t sat down and gone through them all (Heidi)

Knowledge of the effectiveness of renovations on energy performance is difficult to establish; although monitoring technology is becoming more widely available, actual usage may be difficult for homeowners to decipher. One homeowner who had only very recently had a solar PV system commissioned as part of the renovations, was enable to track electricity generation and monitor use, however, this was untypical:

[\text{T}]he two banks of panels sell to the grid and effectively what we’ve got is state of the art panels but also an inverter which sits in the store room which converts it and then is able to send it back and forth. We get live meter readings you can measure the energy and performance on a minute-by-minute basis. (Gareth)

It is unclear whether the installation of smart meters in Victorian homes would provide households with relevant information on usage. There remains a lack of knowledge amongst homeowners of the effects of renovation and household daily practices on building performance and energy consumption, thus preventing the evaluation of strategies that could inform future design and guide policy.

A further key message that emerges from the data is the influence of the method of assessment used in the context of the renovation, and how this formal knowledge inflects dominant understandings of environmental performance and, in turn, shapes homeowners’ renovation practices. In discussing the renovation, homeowners placed emphasis on the building regulations performance assessment rating (a star rating system, as described in Section 4.2.2), which appears to have become an indication of success in achieving energy efficiency or performance (although this does not necessarily reflect \textit{actual} energy performance):
[The architect] has done a preliminary [ratings assessment] so yeah she’s got, she’s got all the figures and I think – oh we’re aiming for over 5.5 [stars] at least to the total house and obviously the old part of the house would fall [below this]. (Jessica)

[The star rating] was 5.9. Which we were very pleased with. (Rachel)

Two other homeowners specifically noted the increase in the star rating for example, from 2 to 6 stars as a result of the performance assessment of the design. At the time the interviews were conducted, the minimum requirement was 5 stars (representing a heating and cooling load of 149 MJ/m² per year in Melbourne). Further, the star rating may act as a substitute for technical or more detailed knowledge of environmental performance in dwellings, and may not actually enlighten homeowners about activities that use energy. As noted in section 7.4.5 few homeowners were aware of their energy use or the impacts of changes to the building envelope and systems on their energy consumption. Further, the assessment method highlights the operational performance at design stage, which is centred on the characteristics of the dwelling envelope, reinforcing the technological aspects of energy performance at the expense of social aspects, such as household routines and particular understandings of, for example, thermal comfort. There is a perception amongst homeowners that the regulated performance level will translate into an expectation of comfort (Australian Broadcasting Corporation, 2011). The predominant method of assessment appears to be redefining renovation practices, in that homeowners and practitioners are seeking to modify the building fabric in order to achieve a specific star rating, and are being steered towards certain technical ‘solutions’. The generality of the assessment method could lead to conflict with the specificity or idiosyncrasy of

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10 Mandatory performance assessment was not required for those renovations that were approved prior to introduction of the standards in May 2010, or for retrofits that did not fall under the scope of building regulations. This included two homeowners who indicated they had commissioned a voluntary building audit, and had carried out recommended works such as draught sealing which were not subject to building regulations approval.
a heritage building, as effective interventions are specific to a time and place, and not universally applicable (Wilson and Dowlatabadi, 2007: 189). Alternative approaches to the star rating method are available, as outlined in Sections 4.2.3 but were not employed for any of the dwellings in this study.

The limited notion of environmental performance was evidenced during interviews, where many of the homeowners expressed concern about resource depletion and environmental impacts, but few had any appreciation of alternative measures of environmental performance in renovation practices, such as the energy embodied in materials during production:

[W]e didn’t think about that [embodied energy] at all. (Rachel)

[W]e didn’t think about embodied energy. (Jill)

I don’t know - we haven’t looked into that. But you could probably get a far more environmentally efficient house from scratch. (Jessica)

Only three homeowners ‘weighed up’ the energy used in the materials and products during renovations. Of these, one homeowner claimed an interest in ‘environmental economics’:

[W]e look at all the materials that go into it and the energy intensity ... and I’m acutely aware of those. For example, most aluminium is out, wood is in if they can do it - so lots of things like that. (Gareth)

The use of recycled materials was an important part of the renovation for homeowners who subscribe to narratives of environmental sustainability. In this study, 4 homeowners specifically sought to incorporate recycled or reclaimed materials as part of the renovations. The most popular recycled material was timber, which was used for flooring, stairs, kitchen and bathroom joinery and benchtops, and decking. Homeowners sourced, prepared and incorporated second-hand materials and other fittings (such as fireplace
surrounds, door handles) in the renovation to contribute to sustainability. However, as indicated in the following comment, they did not have the knowledge to compare and trade-off between embodied energy ‘savings’ and operational energy:

*We wanted to use some of the building materials already used in the existing property. Without information it is hard to know what materials we can use and the cost of using those materials to have an informed discussion.* (Martin)

In the absence of alternatives, operational energy use (based on predicted energy use for heating and cooling) or cost is seen as a convenient measure of performance. In privileging technical efficiency and operational energy, other aspects of environmental performance, such as energy embodied in materials or household everyday practices are obscured. The focus on meeting minimum regulatory performance standards, according to a study of new dwellings in Queensland (Miller et al., 2012), limits design potential and application of strategies that optimise performance through integration of building physical components, together with active engagement and interaction of occupants (Cole et al., 2008).

### 8.1.3 Distributed knowledge and skills

It is not uncommon for the renovation of a heritage dwelling to entail input from a sizeable team; in one instance, the homeowner engaged several 'expert-practitioners' comprising an architect, structural engineer, building surveyor, energy performance assessor, heritage consultant, and a main contractor who employed several tradesmen, including specialist installers. Such a large team was not typical of all of the projects in this study, however, most homeowners enlisted 'expert-practitioners' to assist them navigate the process of renovation; in 14 cases the homeowner engaged an architect or a designer, often along with other building professionals (such as an engineer, heritage specialist, energy rating assessor) to provide technical knowledge and specific expertise. This confirms that the practice of renovating a heritage dwelling
involves knowledge and skills beyond those held by the homeowners in this study. Homeowners have a lot of ideas about their needs and expectations but have limited knowledge of renovation. For homeowners interviewed, the main areas of knowledge deficit were around the rules and procedures, strategies for improving environmental performance and managing heritage impacts, and selecting appropriate products.

*Our brief to the architect was more to make it as energy efficient as is possible and use their knowledge to do that ... we had to trust their knowledge of what was going to work in terms of energy efficiency* (Jeremy)

*How to make the old bit, how to bring that up to standard without detracting from the features ... ideally we would like a house that had double glazed windows through it, but these windows are just the old glass windows and they are beautiful and I wouldn’t want to touch them, so that’s an issue. ... Inability to insulate the walls for example, ... because there are problems with the solid plaster too, ... but of course you can insulate the ceiling. So those, yeah, trying not to detract from what makes it special in the first place.* (Rachel)

*Is it better to do aluminium or PVC? So we’re still grappling with that* (Jessica)

As indicated above, architects are seen as a principal authority and in most cases the architect steered the renovation. In others, it was the homeowner who took the lead; one couple, both qualified architects, designed the extension, submitted the permit applications, negotiated with the local planning and building officers, and project managed the renovations themselves. Some homeowners were able to contribute specialist knowledge and/or skills, gained from their education or profession:

*Thermal efficiency of the house is important ... I’m acutely aware of thermal efficiency in most things so I was educating [the architect] on that.* (Gareth)
An experienced renovator and qualified planner, Cass employed an architect to do the design work but led the planning and building permit application process herself, although she admitted that she was unfamiliar with the building permit process which lead to some glitches:

*I just lodged the [planning permit] ... I did all the report for it so that the town planner could basically just check it off and make sure it complied ... I knew more than the planners that were dealing with the provisions on a day-to-day basis.*

... we did deal with [the building permit] actually, it was a little difficult. (Cass)

As a qualified services engineer, Max used his knowledge and practical skills to install photovoltaic panels on the roof of his house at no cost:

*I was an installer and it wasn’t going to cost anything to put it all in, so [with the] government rebate. ... there was no installation cost.* (Max)

Elsewhere, Matt was able to contribute through his knowledge of ESD:

*A lot of the ESD aspects and everything, we already knew what we wanted because my wife and I are both in the field, so we had a pretty good idea about what we wanted and what we didn’t want. ... It’s been [a] conversation with our architect and she’s brought some useful stuff to the table. It’s been a collaborative association.* (Matt)

The evidence from homeowners in this study is that renovation is produced or created through collaboration. However, as Guy (2006) has articulated in a social-technical perspective, the ‘consumer’ is embedded in a network of social relations that limit and control the choices he or she is capable of making.

For minor projects, where an architect could not be justified, home-renovators demonstrated their resourcefulness, drawing on their own knowledge, the
Internet and contractors or friends. For larger or more complex renovations, several homeowners selected an architect experienced in renovating heritage buildings or with expertise in ecologically sustainable design (ESD), and drew on knowledge from other advisers where necessary. The interaction of several ‘expert-practitioners’ sometimes gave rise to strained relations due to dissonance between different interests. In one account the engagement of an ESD consultant and a designer led to tensions between aesthetic and environmental objectives: ‘Okay, we actually had a few advisors and we were quite lucky to get away with it’ (Justine)

Justine goes on to explain how the ESD consultant placed windows on an angle to make the most of a through breeze, but this arrangement was not in keeping with her own aesthetic taste. Also, the range of colours available in ecological paints was purportedly too limited for the designer and did not accord with the homeowner’s ideas for a colour scheme so she disregarded that advice too: ‘we drew the line there, yeah.’ (Justine)

The design was modified to align with the homeowner’s own understandings.

Another homeowner narrated during the interview how contention arose over certain products that she thought were unsuitable, and attempts to substitute with more environmentally acceptable alternatives, which led to a ‘kind of happy combative situation’ with the contractor as the renovation proceeded. Homeowners did not always follow the advice given by ‘expert-practitioners’, and rationalised their decision in a way that makes sense to them in accordance with their own knowledge and know-how, together with guidance from friends and family. One explanation could be that the homeowner sensed that the ‘expert practitioner’ was perhaps more focused on design and

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11 The Institute of Australian Architects (AIA) online directory currently lists 50 architectural practices in Victoria with experience in heritage building work (http://www.findanarchitect.com.au). Whilst the Consultants & Contractors Directory (Heritage Council of Victoria, DPCD 2010) includes 29 practices specialising in heritage building conservation, only 3 practices are listed as having expertise in both heritage buildings and ESD. There are few architects and building surveyors that are recognised as having qualifications in both conservation of heritage buildings and environmental performance.
environmental considerations, or compliance with explicit rules, rather than how the dwelling would function as a home and impacts on everyday life.

*We get why [the architect] wanted to put louvre windows in for the ventilation but we kind of feel like we can get the ventilation with opening windows and have them double-glazed.* (Jessica)

In balancing environmental and other objectives, the homeowner’s concerns about functionality and own knowledge about maintenance, how to achieve comfort, and ease of operation outweighed the architect’s advice. In this way homeowners put together their own solutions based on their experience of what works for them, and which aligns with their own understandings and expectations. Appropriation of technologies as part of renovation involves bringing together of formal knowledge (of rules and theoretical-abstract knowledge) and householders routines, competences and knowledge, which is acquired and transacted in their social groups and entrenched in everyday life (Elzen et al., 2004); this alignment of different interests and knowledge of professionals and occupants is referred to by Glad (2012) in the context of renovation to reduce energy consumption in social housing. Using the concept of *social learning*, Aune and Bye (2005) argue that energy efficiency is more than technical improvement, but also involves learning within a system that implies co-operation, communication and reflexivity. They emphasise the importance of sharing knowledge, communication alongside improving technological systems.

Discussion with home-renovators revealed the importance of informal networks of knowledge and advice, and the extent to which homeowners make use of their social networks and social capital. Guidance is often sought from trusted friends, neighbours or family members in the industry. Keen to install a solar hot water system on the roof, one homeowner was not satisfied with the recommendations received from an engineer, and despite paying
$800 for the consultant’s advice, Tim then contacted a trusted friend, a retired civil engineer:

*I’ve got a mate, ... he was a civil engineer and he’s about 9, 10 years older than me and he’s a bit like me in the sense he can make a judgment. I said, “Bruce, come over and have a look at this roof and as a friend, just tell me whether it will be okay or not to put 400kg up here and spread it”* (Tim)

This homeowner is ‘high income’ (see section 8.1.2) and cost is unlikely to have been a significant factor in taking a second opinion; the main consideration seems to be the existence of a level of trust based on shared ways of thinking and doing, which confirmed his reasoning.

Use of informal networks is consistent with the study of home-renovations in four European countries by Bartiaux et al. (2011) where most renovators sought help from friends and family members in relation to the decision process as well as carrying out renovations. Darby (2006) draws attention to the importance of social networks in householders’ actions to improve energy efficiency and conserve energy, and the various sources of advice and information.

A social practices approach, as used in this study, sheds light on the range of competences involved in renovation, and how the alignment of formal knowledge and know-how is necessary to produce the desired outcome. Examined from the perspective of the homeowner, the analysis indicates that competence within renovation practice is spread across a number of people, each having a level of knowledge and proficiency, the configuration of which influences the environmental and heritage outcomes. In home-renovation, knowledge is assembled from various sources; alongside local, contextualised knowledge of their own environment and how things are done, homeowners’ draw on the advice of ‘expert-practitioners’—including professional advisors, contractors and specialist tradesmen, and other people—which is readjusted.
where it makes sense to the homeowner’s own understanding. In this way, renovation emerges from the interaction of people and competences, and is consistent with the view that competence is scattered across various humans and material artefacts including products and instructions about how to use them (Watson and Shove, 2008). The next section considers the material component and how this shapes renovation practices.

8.2 Material infrastructures shaping practices

This section explores the ways in which material elements shape renovation and associated practices in heritage dwellings, based on analysis of interviews with homeowners. First, the role of physical things in mediating renovations is considered and how they interact with daily practices, followed by non-physical elements.

8.2.1 Physical things, renovation and associated practices: co-dependency

It is evident that physical things are implicated in renovation, constraining or enabling certain strategies. Participants in the study described how the building fabric, technological configurations, spatial arrangements and larger infrastructural systems have shaped their renovation which, in turn, had an impact on what they were seeking to achieve in terms of improving thermal performance, comfort or other objectives:

[I]t’s [the] lath and plaster, so you can’t insulate in between (Heidi)

[W]e haven’t insulated I guess the walls that are still lath and plaster ... because we’d have to pull out it all, it’s just an expense and ... you know when you pull that lath and plaster off you’re in a dust storm ... (Cass)

There’s no insulation in the walls. And the chimneys are all open. So any heat goes straight up the chimney. ...You can’t [insulate the walls] because they’re solid plaster, plaster and lath so you can’t get into them. (Joy)
There’s no space between the bricks for us to put insulation in. (Matt)

The sub-floor space is not insulated at all and there’s no way you’re ever going to be able to do that. (Jeremy)

We’ve looked at the possibility of putting in ducted heating systems or hydraulic or something, that sort, but we know that underneath, we can’t get in underneath the floor without actually lifting the floor of the house. (Paul)

From the above comments, the focus of homeowners is on improving energy or thermal performance and comfort, and the existing construction is highlighted as presenting insuperable difficulties in some instances, particularly for insulating solid or timber walls and under suspended floors. Even so, all homeowners reported having installed insulation in the roof—sometimes with unexpected effects on thermal comfort (as observed in section 7.4.6) indicating the existence of conflict over thermal performance and comfort. Attention to efficiency is symptomatic of the dominant technological approach where the focus is on technical performance of the envelope and systems, standards and conventional comfort provisioning.

In addition to difficulties, several homeowners drew attention to advantages provided by the material structure and how certain elements of the building—whether the fabric or spaces—assist in optimising thermal performance by, for instance, moderating summer temperatures and avoiding a build up of heat:

Well, we can actually appreciate the way it was built, because it was – the high ceilings are brilliant. The bluestones are brilliant. ... The verandah at the front really serves a purpose to keep it cool as well. (Justine)
Recalling the discussion in section 5.6, where it was noted that non-human objects both constrain and enable practices (Reckwitz, 2002), and are important in constituting new practices (Shove and Pantzar, 2005). A combination of different material infrastructures may be ‘recruited’ in renovations. In this recently extended and renovated terraced dwelling the internal temperature is mediated by the double brick construction along with shading and a concrete slab floor, in addition to a thermal chimney which enables heat to be dispelled:

... hot hair rising up through a thermal chimney and the [new] staircase doubles as a thermal chimney. (Gareth)

The design of the dwelling and housing infrastructures, such as incorporation of wide eaves, verandahs, window openings and shading, are seen as ‘passive’ elements in managing thermal performance, but can play an active role by shaping what people do. With regards to their household heating and cooling (which was a primary concern to homeowners in this study and accounts for the most significant proportion of energy use in dwellings), it was observed during interviews that the housing infrastructure is instrumental in enabling certain practices, including active forms of heating and cooling as part of daily routines:

On a cold day what we would generally do is put the heater on and shut all the doors and just stay in here the whole day. (Joy)

A verandah on part of the east side of the house, the north and a little bit of this western side that’s made a major, what I think is a brilliant design from the way the house was put together in the first place. And as well as that every room you can open the windows across the house or lengthways in the house and quite often get a cross flow of air so that you can cool the house down overnight with the cross flow. And then close up first thing in the morning for,
keep the heat out and generally the house is pretty liveable, even tonight it’s not all that bad.\textsuperscript{12} (Paul)

Here, these homeowners describe how through careful design, such as partitioning of spaces, shading and window openings, they are able to manage the building to optimise heating and cooling. The material infrastructure plays a part in comfort practices, including adaptive forms of cooling. Although not all, some homeowners routinely enacted cooling practices, for instance, by manually opening and closing windows at certain times using their know-how to increase ventilation through the building, as an alternative to air-conditioning:

\textit{[W]e can open all the windows at night \ldots And so at night in summer we leave the front door open and the side door open, so we have the cold breeze coming through at night to cool the house down and then in the morning we just shut everything back down again. So we find we can use the house, we can operate the house manually \ldots so we don’t have any air conditioning, and we just maintain the temperature by operating the house manually.} (Heidi)

Although having a split level air-conditioner in the kitchen/family room which she used on occasions, Frida explained how she reproduced practices that she had learned for keeping the house cool:

\textit{I try and do it, moderate things by, you know, opening and closing windows and things like that as far as I can and keeping the, particularly those rooms on the west, keeping them with the doors closed so that this side of the house where my bedroom is doesn’t get quite so hot. \ldots closing up the house in the mornings and letting it go, open it up at night. Well, I’ve done that since I was}

\textsuperscript{12} The interview was conducted on 31 January 2011, the hottest day of the month. According to Bureau of Meteorology records, the maximum air temperature was 38.9 degrees celsius (recorded at the nearest weather station), not untypical for the time of year. It was 30 degrees outside between 8.15-9.30pm. An electric fan was operating in the living room and the temperature was estimated to be around 26-27 degrees during the interview.
a child. My mother was a great one for doing that, and she lived in the country and it was part of the routine. (Frida)

The indications are that these houses, although not conforming to conventional comfort standards, provide thermally comfortable homes for most of the year. During extremes, some homeowners including Heidi, were able to draw on know-how in their practices to adapt to heat, by interacting with the building (to increase ventilation) and other objects to achieve cooling:

[W]e have one fan that we use at night, so one of the children will go to bed and we’ll put the fan in their room until they go to sleep, and they’ll sometimes have a water spray if it’s been 40 degrees for a few days in a row or it’s been very hot. So they’ll have a cold flannel next to their bed and a water spray to use if they need it: they might dampen their hair off before they get into bed to keep them cool. (Heidi)

Whilst a number of homeowners interviewed followed the adaptive model of comfort (Humphreys and Nicol, 1998) which is discussed in section 4.6.3, through on-going interaction with the housing infrastructure, others tended to rely on mechanical forms of cooling such as air-conditioning and fans to manage comfort. Nine homeowners had already installed air-conditioning, and retained or extended it during the current renovations.

Other material or spatial constraints relating to integrating new infrastructure and technological appliances in conjunction with the existing structure were observed, and seen as a frustration by homeowners in achieving environmental and other goals:

It would have been nice to put solar hot water in at some stage but then we’re back to that question of where does it go We would not want a structure consuming what little garden we have. No. Definitely not. It’d have to go on the roof. ...Well, north facing happens to be highly visible. ... you could put it on a
west facing roof. In our instance we’ve got a chimney there so it’d be subject to shading and not quite as visible from the street. (Max)

We were going to originally look at putting in PV panels. Yeah, it was part of our original plan. ... we didn’t have much roof space. (Justine)

We did try to have solar hot water installed, but ... the unit was going to be too far away from where the bathroom was so they suggested that it really couldn’t be done at this house. And it couldn’t be put on the slate [roof]. (Heidi)

In addition to housing infrastructures, wider systems of provision shape renovation and everyday live. The homeowners interviewed in metropolitan Melbourne were all connected to the gas network, however, interviewees in regional Victoria drew attention to the lack of natural gas supply which limited the options available in terms of space heating, hot water and cooking; these households are reliant predominantly on electricity, and to a lesser extent bottled gas and wood, for domestic heating, hot water and cooking (as noted earlier in Figures 2.5 and 2.6). Of these, two had installed a solar hot water system and this was boosted by electricity; another homeowner had considered retrofitting solar hot water as an option but was concerned that it would compromise the heritage significance:

[W]e have two hot water services in the house, both electric. Gas is not really an option here and I don’t want to get into carting bottles and stuff around we looked at putting in solar [hot water] ... but both of them would, in both locations  It just would compromise what’s there. (Paul)

Paul installed PV panels on the shed roof (not the house) to generate electricity for household use—demonstrating a level of resourcefulness. In the absence of a mains gas supply, another homeowner told how she was investigating installing a wood burning range to provide hot water for washing and heating as well as for cooking, in addition to a solar hot water system with an electric back-up. Investment in multiple systems or fuel types was observed
during interviews and tours; this is seen as offering greater flexibility in delivering household services that are dependent on energy, and ‘building in’ a safeguard against breakdown or failure of large scale infrastructures, for example disruption of electricity supply, which interferes with household everyday routines. This indicates the existence of links between renovation, existing systems of provision and daily practices; previously the connections between systems of provision and everyday life has been demonstrated by socio-technical researchers (for example, Sofoulis, 2005; Southerton et al., 2004; Strengers and Maller, 2012). In renovation, the range or diversity of energy resources available and the way it is provided, through for example, alternative technologies, offers both opportunities and challenges for homeowners in this study, in terms of expectations and shaping household practices (Judson et al., 2013).

It is suggested that material infrastructures moderate renovation strategies in two main ways: through continued existence (as in the case of a heritage dwelling, where there is a requirement to retain heritage significance, which is often linked to the physical fabric); and through availability—or absence—of a particular resource, thereby encouraging diversity or innovation in provision of household services and potential to change household practices.

As well as mediating the renovation strategies adopted, as illustrated in the above mentioned examples, material infrastructures are viewed as essential ingredients in the effective accomplishment of everyday life (Watson and Shove, 2008: Gram-Hanssen, 2009). The majority of renovations in this study involve changes to the spatial layout, mostly the living spaces and kitchens, the creation of additional bathrooms, acquisition of new appliances and systems, such as a new heating or cooling system, and in some cases a supplementary solar electricity system (which also feeds into the electricity infrastructure), which shape homeowners’ everyday practices. Homeowners described their interactions with the different technologies to maintain a
comfortable and homely environment, before and after renovation, whether splitting logs and having to feed the wood burning stove during the night, programming the controls on the central heating, adjusting the thermostat, or turning individual thermostatic control valves on or off. Where existing systems, such as electric storage heaters, did not deliver adequate comfort, old practices were swiftly discarded in favour of new. However, other comfort practices were more resistant to change. In one example, Jill could not adjust to the GCH, preferring the previous system where she could control heating simply on an individual room basis.

*I've never lived with this sort of whole house heating before and I'm not a very good sleeper and so in our old house, I just got up in the night and just put on the heater, you know, in the lounge room and that was okay. But now, if I get up at night, I can't turn on the hydronic, because the whole house will heat up and everyone who's asleep will get hot and wake up, so I find that a bit difficult* (Jill)

New systems with different components, controls and modes of operation, such as passive cooling, sometimes forcefully challenged routines and enabled the development of new competences around control of heating and cooling.

If, as suggested above, practices are established and modified through changing configuration of practice components, it follows that different material infrastructures can change how a practice is enacted. Using the example of installation of domestic solar generation, a common retrofit for households in this study, effected some perceptible shifts in timing and participation in certain electricity-consuming practices. Several participants with *in situ* solar power generation talked about changes to their household practices; Debbie and her husband reorganised their dishwashing and laundering practices, putting the washing machine and dishwasher on in the middle of the day if the weather
was sunny to make use of the PV generated electricity, assisted by appliances that are fitted with timers:

[M]y husband in particular has been good trying to make a conscious effort of when you’re using electricity as well. So he’s a really good one for putting all the washing and the dishwasher run at night, and I’m like “Put them on in the day, it’s cheaper”, and so I’ve shown him the bills because the problem now with the smart meters is that they charge you for the maximum amount of electricity, when you’re using it at the peak time. (Debbie)

These homeowners became aware that after PV was installed they had to change their established daily routine of setting the dishwasher and washing machine to run during the night using off-peak electricity, as cheaper electricity and hot water became available during the middle of the day.

Changes in infrastructures and systems as part of renovations also caused other homeowners to re-examine their domestic practices and material constituents:

[N]ow that we’re generating too much electricity we’re we’ve got to think about things like that. I think actually we should get the electric oven, because we were buying a new oven, we had to go through this thinking, “Actually we shouldn’t get the gas oven now. Now we’ve got [solar] electricity, too much electricity, I need to get the electric oven.” (Heidi)

Here, changes in how energy is provided to the household influences a change in material infrastructure and cooking practices to make use of solar electricity. Thus what people do in their homes shape and are shaped by technologies, modifying particular practice configurations, with accompanying implications for and energy use – whether reducing or increasing energy use.
The effects of technologies, once in place, may run counter to expert and policy expectations. Empirical evidence indicates that established routines can, inadvertently or deliberately, disrupt new technical measures to improve performance through, for example, the retention of air-conditioned cooling or a secondary heating appliance with low efficiency after renovation (and as observed in previous studies including Bell and Lowe, 2000; Hong et al., 2006; Judson et al., 2013). This may be related not only to habits/know-how but to the earlier point about multiple systems, and safeguarding against disruption of electricity supply.

The configuration of material infrastructures appears to be crucial in the changing composition of household practices, and how more or less energy intensive practices become more frequently incorporated into the home. Using the example of heating and cooling practices of homeowners in this study by way of illustration, Table 8.3 shows the interface between the components of practice, and how practices may be shaped through material infrastructures and technologies involved in heating and cooling. The building, technology, and the infrastructure systems that support household activities through renovation play an active role in reproducing and modifying current practices, establishing new practices (such as air-conditioned cooling, or passive cooling), and discontinuing existing practices (as discussed by Shove and Pantzar, 2005b).
<table>
<thead>
<tr>
<th>When &amp; why</th>
<th>Meanings/understandings</th>
<th>Know-how</th>
<th>Knowledge (formal)</th>
<th>Technology</th>
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<tbody>
<tr>
<td>Cooling</td>
<td>Homes should be comfortable, not uncomfortable&lt;br&gt;Discomfort/sweatiness is not acceptable&lt;br&gt;A constant temperature is desirable</td>
<td>Installing A/C will keep the house cool during extremes&lt;br&gt;Switching on the A/C to cool down</td>
<td>Insulation will improve comfort in extremes&lt;br&gt;Climate change dictates weather is getting warmer&lt;br&gt;A higher star rating standard provides better quality, more comfortable homes that consume less energy</td>
<td>Range of insulation products/materials available&lt;br&gt;Single unit or whole house/ducted A/C system</td>
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<td>Less energy intensive</td>
<td>A/C is not healthful&lt;br&gt;Expect variation in temperature&lt;br&gt;Natural methods are widely adopted and acceptable&lt;br&gt;Opening and closing windows to allow through air-flow is beneficial</td>
<td>Passive cooling involves active interaction with housing infrastructure at certain junctures&lt;br&gt;Techniques for cooling may be passed on from others</td>
<td>Indoor temperature range increased to 25ºC in summer and 19ºC in winter&lt;br&gt;Dress according to the season e.g. loose clothing</td>
<td>Passive design features e.g. orientation, carefully placed shading, natural ventilation</td>
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<td>How</td>
<td>More energy intensive</td>
<td>Less energy intensive</td>
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<td>Fans are not as effective for keeping cool</td>
<td>Recommendations from friends who have A/C</td>
<td>The manual states that the temperature should be set at 24°C</td>
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<td>A/C is good for vulnerable people, children and pets to avoid heat stress</td>
<td>A/C availability/affordability</td>
<td>Appliances that that have a high star rating are more efficient</td>
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<td>A/C is a desirable and necessary feature</td>
<td>Marketing and advertising of A/C</td>
<td>A/C keeps temperature steady when it is hot outdoors</td>
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<td>Modifying activities and dressing according to the conditions</td>
<td>Guidance on levels of insulation in renovation</td>
<td>Depends on setting/instructions for appliances</td>
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<td>Natural cooling techniques such as water mist spray or damp cloth</td>
<td>High performance glazing reduces heat gain</td>
<td>Temperature settings and fan speeds</td>
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<td>Cold drinks/ice</td>
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<td>When &amp; why</td>
<td>Heating</td>
<td>More energy intensive</td>
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<tr>
<td>More energy intensive</td>
<td>Homes should be warm and cosy</td>
<td>Hydronic heating is best for comfort</td>
<td>Keeping the thermostat at 21-25°C</td>
<td>Install minimum levels of insulation to reduce heat loss</td>
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<tr>
<td>More energy intensive</td>
<td>Hydronic heating is healthy, clean, convenient and ‘luxurious’</td>
<td>Hydronic heating is efficient and low cost to run</td>
<td>Hydronic heating is best for comfort</td>
<td>Programable heating timers and thermostatic control valves save energy</td>
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<td>More energy intensive</td>
<td>Heating unused rooms is ‘wasteful’</td>
<td>Change in habits/flexibility to take advantage of opportunities available e.g. when solar energy is being generated</td>
<td>Change in habits/flexibility to take advantage of opportunities available e.g. when solar energy is being generated</td>
<td>Articles featuring home-renovations in magazines, and on popular TV</td>
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<td>Less energy intensive</td>
<td>Splitting wood requires effort</td>
<td>Using materials with high R values reduces heat loss through the building fabric</td>
<td>Using materials with high R values reduces heat loss through the building fabric</td>
<td>Advice from product manufacturers, contractors and installers</td>
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<td>Less energy intensive</td>
<td>Energy saving is associated with low incomes/hardship</td>
<td>High performance glazing reduces heat loss</td>
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<td>Install minimum levels of insulation to reduce heat loss</td>
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<td>Less energy intensive</td>
<td>Shared knowledge/learning from other home-renovators e.g. online forums</td>
<td>Change to heating regimes (heat individual occupied rooms rather than whole house) Making use of a range of available techniques e.g. hot food/drinks and physical activity; appropriate textiles and layering of clothing; personal mobility to maximise passive solar energy</td>
<td>Increase thermostat to 25°C in summer, and reduce to 19°C in winter Dress according to the season Draught stopping prevents uncontrolled ventilation and heat loss</td>
<td>Orientate living rooms to maximise heating from winter sun Clothing Opening windows/controlled ventilation Low energy appliances</td>
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8.2.2 Non-physical infrastructures: Institutional arrangements and regimes

Home-renovation takes place within the organisation of energy supply and distribution, planning and building regulations, the markets for products and government policies and initiatives. Such ‘socio-technical regimes’, are the ‘rule-set’—which includes skills and procedures, expectations, ways of defining problems, etc. all embedded in institutions and infrastructures (Shove, 2003b: 196). Elsewhere, Dean (1999: 211) refers to ‘regimes of practices’, the organised and systematized ways of doing things, and which give rise to and are informed and re-shaped by various forms of knowledge and expertise. For most of the homeowners interviewed, the practice of renovating centred on the regulations governing renovation and procedures associated with obtaining the various permits. The broad term ‘institutional arrangements’ is used here to refer to the institutions, planning and building regimes, rules and regulatory procedures, guidance and programmes put in place to govern renovation.

Improving the energy performance of existing dwellings can be challenging for homeowners; even more so where an existing dwelling is heritage listed, and interventions are subject to additional policy and regulation, thereby adding a further layer of complexity. Homeowners are required to obtain planning approval for alterations affecting a local heritage place. A heritage permit may be required for works to a place on the Victorian Heritage Register. Renovation of heritage buildings is framed by State and local policies, which are guided by national and international charters. These require knowledge of cultural significance, and how to comply with rules and procedures relating to the planning policy framework and building code requirements. Although some problems might be expected due to homeowners’ unfamiliarity with the procedures, 21 of the 26 homeowners interviewed reported varying degrees of difficulty in seeking to obtain either/both planning and/or building permits, even though 14 homeowners engaged an architect to assist. The regulatory regime had a significant influence on homeowners’ experience of renovation. Homeowners would often take the path of least resistance, to avoid being embroiled in a long, drawn-out appeal against the responsible authority.
To get the planning permit, [we] dropped the solar bit. The builder said, “Fight your battles further on down the track because we want the permit”. So [we] got the permit, then the builder said, “What about this?”, and that's when [the Council] said, “No you can put it on the south side or you can put a frame on the side of the wall, on the south side and get it” and that's when the builder said, “It's all too hard, it's stupid, let's just not do it”. (Jeanette)

We'll just have to put in what they want which will be more expensive – but we can't be bothered, we don't want to slow the process down by having to go to VCAT with the Council ... so we've just sort of sucked it up basically. (Jessica)

In the following extract, Jessica describes her frustration and, ultimately stoicism, at planning policy that requires the front section of the building to be retained, the implications for the design and how this affected the way she intended to use the space:

It probably would have been great if we would have been allowed to just say keep the façade and then build behind that. I read in a Sanctuary magazine about this place in Adelaide and they just kept the façade, they kept sort of the walls around it and then built within in and they sort of made the front a kind of a courtyard ... we are constrained by having to keep the front of the house (Jessica)

Jessica’s dreams to demolish almost the entire house, leaving only the façade is a stark example of the tension between functional objectives and heritage policy requirements, as discussed earlier in section 3.3.2. Some homeowners, including Bridget and Martin who wished to demolish the unrenovated dwelling they purchased in December 2010, view the heritage requirements imposed by local councils as a constraint on their lifestyle aspirations, and their goals to improve energy performance:
It has just dictated some real limitations on what we can do, in terms of the design. (Bridget)

Heritage guidelines, and how these are interpreted, were held by homeowners to be responsible for the inability to incorporate technology such as solar installations. Even though neighbours had erected solar panels, the homeowners of this corner property were not permitted to install solar hot water, as the north (side) elevation, although not the principal façade, faced onto the street.

What we did want to do was put in solar hot water and the Council wouldn't let us. They wanted us to put it on the south side. And why would you put solar [water] heating, solar panels on a south side roof 'cause you get no benefit. (Jeanette)

Others reported difficulties in negotiating the planning permit process:

What we ended up with is, largely, what we put in but that was because we persisted. The message we were given from council was that they had issues, right? So it wasn’t that the Council said, “Yeah, that’s all fine”, all the way along, and then we got what we wanted. We got what we wanted despite Council saying, “Oh, no. We’ve got issues with this and you need this.” But we kind of persevered (Bridget)

In another instance, after negotiation with the Council and a third party appeal, which took two and a half years to resolve, the proposal was approved at VCAT [Benjamin & Ors v Yarra CC [2009] VCAT 1747] with some modification:

I think for heritage reasons we took out one bank of solar panels at the front, it's neither here nor there to us, and you could say that was a compromise (Gareth)
These findings suggest that practices are influenced by ‘structural’ arrangements, which are perceived as limiting aspirations, with homeowners’ confounded by rules and procedures and their application.

As might be expected, rules and procedures have a significant impact on home-renovation, with homeowners remarking on the uncertainty in understanding requirements, the length of time taken to process permits, and difficulties associated with making changes. Most homeowners have a limited grasp of regulatory processes and how to meet requirements for energy or environmental performance, and rely heavily on ‘expert-practitioners’ who tend to adopt prescribed procedures and methods, even though these are generic, and not devised for heritage dwellings.

Table 8.4 Key findings: how competences and material elements shape home-renovation practice in heritage dwellings

<table>
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<th>Competences: knowledge and skills</th>
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- Within home-renovation practice, competence is spread across a number of people; different forms of knowledge is balanced and resolved—and this shapes outcomes.

- Alongside knowledge and expertise from ‘expert practitioners’, homeowners make use of their own knowledge and know-how around renovation and energy use within the home, and also seek advice from other trusted sources, in seeking to reconcile cultural heritage significance with objectives for environmental performance and other changing priorities for home improvements.

- There remains a lack of knowledge amongst homeowners of the effects of renovation and household daily practices on building performance and energy consumption, thus preventing the evaluation of strategies that could inform future design and guide policy.
• Measures such as retrofitting insulation to solid walls and under floors are often left undone or only partially complete. This suggests that homeowners are reluctant to undertake work that is dirty or disruptive, and may lack the knowledge and practical skills, or capability. A greater range of solutions may need to be developed that are able to meet the demands of heritage dwelling contexts than are currently available. Complementary ways to reducing energy consumption could focus on changing everyday practices.

Material elements

• Homeowners and practitioners are seeking to modify the building fabric in order to achieve a specific star rating, through technical ‘solutions’. However, these technical solutions are not always effective in meeting homeowners’ expectations for thermal performance.

• Although rules and procedures are significant in shaping practices, they do not determine renovation practice. Homeowners seek alternative views and proceed to do what makes most sense to them.

• Policy measures are having some effect on renovation practice. Whilst financial incentives have encouraged take up of renewable energy technologies in some cases, it was not the primary reason: homeowners incorporated technologies to improve energy efficiency or environmental performance where these did not detract from their living standards and expectations for their home, aligned with their aspirations, could be integrated into their established everyday routines, and where there was some financial benefit to them.

• Heritage buildings both constrain and enable practices; it is suggested that combinations of different material infrastructures may be ‘recruited’ into new, low energy practices. The material structure and certain elements of the building—whether the fabric or spaces—can assist in optimising thermal performance.
- Energy infrastructure provision is implicated in renovation, with homeowner practices linked to the possibilities afforded by existing infrastructures and systems of provision. The range or diversity of energy resources available and the way energy is provided, through for example, alternative technologies, offers both opportunities and challenges for home-renovation in heritage dwellings, in terms of expectations and shaping household practices.

- The configuration of material infrastructures appears to be crucial in the changing the composition of household practices, and how more or less energy intensive practices become more frequently incorporated into the home.

- Improving the energy performance of a heritage dwelling may be counterbalanced by material changes such as large extensions to accommodate household changing daily practices. Future longitudinal research with renovating households would reveal further insight into the long-term environmental impact of the renovation and the households’ changing practices.

- Variations in renovation and comfort practices observed between urban and rural locations could be related to differences in ‘energy culture’ or how people talk about, relate to and their expectations about energy.

### 8.3 Digest: renovation of heritage dwellings

These findings indicate that far from being a straightforward process of the insertion of technology, renovation is negotiated between the different actors whose interactions shape the renovation. A social practices approach sheds light on the competences involved in renovation, the intersection of knowledge and how the alignment of formal knowledge and know-how is necessary to produce the desired outcome. Within home-renovation practice, competence
is spread across a number of people, and different forms of knowledge are balanced and resolved. Analysis of data collected during interviews indicates that alongside knowledge and expertise from ‘expert practitioners’, homeowners make use of their own knowledge and know-how around renovation and energy use within the home, and also seek advice from other trusted sources. It is suggested that renovation emerges from the interaction of people and competences, as a ‘collective of practice’.

Renovation practices are mediated between the fabric of the heritage dwelling, technology, and wider socio-technical systems (including institutional arrangements). Material infrastructures, the building fabric and technologies play a critical role in renovation of heritage dwellings—although the nature of their influence varies across the case studies. Rules and procedures—the institutional arrangements that are thought of as the ‘context of action’ within which renovation takes place—are significant in steering the practice of renovation, and can enable and constrain householders’ practices. How these institutional arrangements are incorporated into and shape renovation practice is discussed further in the following chapter.
9 Discussion of key findings

Following the results reported in Chapters 7 and 8, this chapter discusses the key findings. The chapter is structured so as to respond to the second-level research questions as set out in section 1.4 (page 13). In addressing each question, the discussion links the findings to the wider contextual setting of the research, and to the review of relevant literature from earlier chapters, and places these into a policy context.

9.1 Home-renovation practice: incorporating notions of heritage

The second-level research question (i) seeks to relate meaning and significance of cultural heritage to homeowner renovation practices. In responding to this question this section draws on the analysis in Chapter 7 of common understandings. Findings indicate that meanings associated with heritage influenced renovation practices, and this is considered in the following section.

The research has identified and defined various meanings of cultural heritage, how built heritage is valued by participants, and the ways in which these understandings inform renovation practice. For the first time, notions of heritage are incorporated into a social practice of renovation. Consistent with the literature in Chapter 5, the research indicates that renovation is reproduced through social practice. It also extends knowledge by identifying how meanings and understandings around heritage are an element of
renovation practice, and elaborates on how these understandings are manifest in the practice of renovation in owner-occupied dwellings.

The research identifies a range of common understandings and meanings associated with heritage dwellings that are significant in configuring home-renovation practice, and these are summarised in Figure 9.1. In particular, the findings indicate that ideas relating to aesthetic appearance, distinctiveness, attachment, and continuity are evident amongst homeowners participating in this study. In enacting renovation, these meanings and understandings are combined with other understandings, knowledge and skills, technologies and infrastructures in shaping home-renovation practice.

The meanings and understandings identified from the qualitative interviews are narrower in scope than the heritage values as defined in the conservation literature (and as synthesized in Table 3.1), and include alternative conceptions of heritage, although there are commonalities. The importance of physical fabric and material authenticity was evident in some homeowner’s renovation practices, but not in others. The way in which meaning attributed to heritage dwellings differed between homeowners indicates the subjective nature of heritage. This finding accords with contemporary conservation theory in that heritage is interpreted in various ways, incorporates people’s experience, and is often linked to contemporary purposes and needs (Gibson and Pendlebury, 2009). There is some evidence that alternative conceptions of heritage and environmental understandings are challenging established understandings of heritage (Rodwell, 2007; Smith, 2006). The meanings identified in this study were not confined to a particular group, but were shared across home-renovators of different ages and socio-economic backgrounds, although the relevance varied between participants.

The research indicates the different ways in which these understandings are manifest in renovations. For example, where continuity is salient, homeowners
were less likely to make material changes where these were perceived to jeopardize the integrity of the heritage building. The results also show evidence of participants being recruited to alternative (less energy intensive) household comfort practices. These home-renovators tended to be largely within the upper age range, although not exclusively. Where aesthetic appearance is a key element, renovation practices involved minimal changes to the exterior but were more likely to engage in extensive internal interventions. Distinctiveness related to the external appearance or particular features of the building, such as original windows, wooden floors or even a plaster cornice. For some homeowners, attachment to the dwelling (or feature of the dwelling) was immediate, whilst for others it developed over a period of time. Nevertheless, the evidence from interviews and home tours indicates that this attachment was discernible in the types of renovations enacted. It was observed that extensive alteration or demolition occurred where other considerations had greater relevance over heritage. This research, therefore, contributes to the literature by identifying those meanings of heritage that are considered important elements, namely, aesthetic appearance, distinctiveness, attachment and continuity, and the ways in which these shape renovation practices.
Figure 9.1 Components and elements of renovation practice

Notes: The term ‘institutional arrangements’ is used here to refer to the institutions, planning and building regimes, rules and procedures, and programmes put in place to govern renovation.
Looking at the ways in which renovation practices vary and are shared amongst homeowners, and implications, Table 9.1 depicts the types of renovation strategies pursued in this study and understandings expressed, which are then arranged by group profiles. The evidence suggests that most homeowners in the study sought to adapt the dwelling to suit their everyday practices and implicit understandings, thereby exerting demands on the heritage dwelling, with attendant consequences for consumption of energy and other resources. Although some physical modifications were carried out by all participants, those where continuity or attachment was prioritised over other considerations, (deemed ‘heritage stewards’ in Table 9.1 and representing less than a third of those interviewed), were least likely to undertake interventions that would compromise the heritage building. They also demonstrated readiness to adapt their everyday practices by engaging in thermal comfort practices that accommodated the constraints of the building. Thus, the findings demonstrate that renovation practices are shaped by different meanings and understandings about heritage. Whilst not seeking to generalise, the data suggests there are different discernible practices or ‘practice variants’. When considering how to develop policy, this thesis argues that account should be taken of renovation practices and how these may be configured.

The research has demonstrated that home-renovators can be classified into three broad groups according to their renovation practices. Results indicate that homeowners are not a homogenous group. This finding lends substance to the claim that ‘[s]ome home buyers may prefer to have a less energy-efficient home if that is what is required to obtain certain highly-valued characteristics’ (Productivity Commission, 2005: 236). Whilst these categorisations are not fixed, and the boundaries between them may be blurred, the distinctions revealed from the study indicate variations in renovation practices as well as signalling the potential for shifting household practices for different groups. By identifying groups that reproduce and share practices, it is argued that practices may be redefined by introducing new
ideas and variants that are less energy intensive to specific cohorts (Hitchings, 2013: 111).

Table 9.1 Practice variants within renovation of heritage dwellings

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<th>Practice variant</th>
<th>Practices</th>
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| 'Liveability'    | - Functional aspects are important  
                  |   - Economic considerations may be important  
                  |   - Significant alterations internally and externally to meet contemporary performance requirements  
                  |   - Building is adapted to suit household practices |
| 'Face value'     | - External appearance is important  
                  |   - Retains elements/symbols that are meaningful  
                  |   - Façade is retained  
                  |   - Makes changes /upgrades to improve functionality but seeks to limit impact on appearance |
| 'Heritage steward' | - Authenticity is important  
                    |   - Minimal intervention to preserve integrity of heritage building  
                    |   - Restoration of missing features  
                    |   - Household practices are adapted to building |

Previous research on renovations is limited, and the renovation practices of owner-occupiers of heritage dwellings are not well understood. A survey by BIS Shrapnel (1994) has indicated that the type of renovation is influenced by life stage and age of dwelling, along with property market conditions, and government policies. However, the findings demonstrate that the nature of renovation in heritage dwellings is shaped by homeowners’ understandings of heritage. As such the thesis adds to previous knowledge and extends understanding of social and cultural aspects of renovation.
9.2 Policy and renovation: institutional arrangements

In responding to the second-level research question (ii) this section discusses institutional arrangements as a constituent of the practice and how these intervene in home-renovation practice in heritage dwellings. The following discussion of the relations between policy measures and renovation practice is restricted to the Melbourne and rural Victoria case study context presented in this thesis.

Institutional arrangements are deliberate attempts by government and other institutional bodies to influence what people do and how they do it. Others have acknowledged the importance of rules and procedures in constituting practices (Gram-Hanssen, 2010b; Schatzki, 2002; Strengers, 2009; Warde, 2005, 2013). Nonetheless, there is a lack of studies on how rules and procedures shape renovation practices in the context of a heritage setting.

This thesis has shown that renovation of existing dwellings has become a key element of federal and state government strategies to achieve targets for reducing both energy consumption and CO₂ generation. The findings demonstrate that government clearly has a hand in homeowners’ renovation practice—through urban planning and building regimes, investment in technologies and infrastructures, and systems of provision. Amongst the participants in this study, there is evidence of awareness of energy efficiency amongst homeowners, which suggest that policy measures are having some effect on renovation practice. This could be explained by media coverage on household energy costs and the Australian Carbon Tax, alongside information campaigns and schemes such as the federal government’s Green Loans programme and home insulation rebates, as well as other government initiatives (Australian Bureau of Statistics, 2012b; McColl, 2012). The findings from this small sample also indicate that financial incentives have encouraged take up of renewable technologies in some instances, with just over half the homeowners receiving some form of government subsidy. Recent data shows
that uptake of solar heating/hot water systems in Australia has increased 167 per cent since 2005, with a peak of around 180,000 units in 2009, reducing to 80,000 in 2010 as rebates reduced (Clean Energy Council, 2011: 17). Between 2007 and 2012, 7 per cent of households in Victoria purchased a solar hot water system, and 9 per cent purchased a heat pump. The number of Renewable Energy Bonus rebates given for solar hot water in Victoria was 7,470, an uptake of 0.35 per cent (AECOM, 2012). The apparent low rate compared with other states and territories is thought to be due in part to the high proportion of households with gas hot water systems (see Figure 2.6) and overlap with other State-funded programmes, although data was not available on take up of Victorian rebate programmes for comparison. This study suggests that the availability of a rebate coincided with homeowners’ aspirations in some instances, but it was not the primary reason for installing renewable technologies.

It was observed that current policy is manifest in the material infrastructure of renovation practice through rules and procedures. Homeowners frequently referred to these rules and procedures, as embodied within the building code, HER rating assessment, permits, appliance standards, and guidance. Indeed, except for those undertaking only minor changes, rules and procedures associated with regulations figured prominently in homeowner discussions about renovation practices. The findings show that homeowners are preoccupied with processes associated with planning and building regimes, and will often take the ‘path of least resistance’ to achieve aims. Thus the findings support the proposition by Warde (2013) that rules and procedures are an essential component of the ordering, or organisation of certain practices. Other socio-technical studies of energy and water have shown that institutional arrangements and systems of governance are significant in shaping social practices (Moloney et al., 2010; Sofoulis, 2005). The data gathered here supports the idea that social structures are part of renovation practice, as contended by Spaargaren (2003), insofar as homeowners identified that their ability to engage in certain practices was constrained (or
enabled) by existing institutional arrangements, infrastructures and systems of provision. However, the evidence also suggests that rules and procedures do not determine renovation practices, as observed by others including Chappells et al. (2000) and Randles and Warde (2006). There are several instances in this study where policy driven advice about how things should be done was disregarded. Homeowners sought alternative views and proceeded to do what made most sense to them, which did not necessarily accord with the ‘expert’ advice received. This reaction may be due to recommendations from professional advisers not corresponding with homeowners’ own understandings, or because official information is not—and cannot be—tailored to individual circumstances. This suggests that homeowners do ignore guidance or lose interest in information that does not bear direct relevance to the ways they carry out daily activities (Strengers, 2011), implying that current policy measures focused predominantly on providing generalized information and technical efficiency are likely to have limited reach.

Rules and procedures intervene significantly in homeowners’ experiences in this study through particular rationalities, ways of thinking, procedures and standards. One example is the requirement to comply with thermal performance as part of building code compliance. This is normally obtained through assessment of heating and cooling loads or star rating, using HER software. These instruments and systems of governance are important in determining compliance. The findings indicate that these new standards and procedures inflect homeowner’s understandings of energy performance. The use of the HER software appears to be redefining renovation practices in heritage dwellings, in that homeowners and practitioners are seeking to modify the building fabric in order to achieve a specific star rating, through technical ‘solutions’. There is evidence, however, that these technical solutions are not always effective in meeting homeowners’ expectations for performance; some homeowners complained of overheating and discomfort resulting from increasing insulation and reduced air-flow. At the same time, insufficient attention is given to inhabitants’ (possibly unrealistic) expectations,
conventions, daily routines and practices including how people use and engage with the dwelling.

Compliance with energy performance and heritage requirements, as well as wider regulatory issues affecting energy prices and flows, feed through into the data. Even so, the findings suggest that rules are not a reliable predictor for actual renovation practice, or ensure particular outcomes. Rules are often interpreted and incorporated into home-renovation practices in different ways than originally intended. For example, most homeowners participating in this research had switched to more energy efficient light globes amidst various initiatives to phase out incandescent globes and save energy. This practice concurs with survey data showing that the proportion of Australian households using energy saving light globes has increased (Australian Bureau of Statistics, 2008; 2010b). However, renovations often included more light fittings, particularly in kitchens and bathrooms, thereby contributing to increased energy consumption on lighting (Sandu and Petchey, 2009). Suggested explanations include changing preferences, and aspirations—linked to social and cultural practices (Aune, 2007; Wilhite et al., 1996; Wilhite and Lutzenhiser, 1996; Crosbie and Guy, 2008). Likewise, efforts to improve thermal performance via building codes has coincided with an increase in size of many dwellings, and extension of space conditioning (Australian Bureau of Statistics, 2011b)—as reflected in this study. The findings support the proposition that codification of a practice cannot be assumed to achieve a particular course of action (Warde, 2013). It would appear that even carefully scripted policy and programmes to govern renovation do not necessarily have the intended effects, as institutional attempts to improve environmental performance may be confounded by homeowners’ practices, as observed elsewhere (Moloney et al., 2009; Sunikka, 2006; Tweed, 2013).

In this study, there was evidence that institutional arrangements have enabled some practices, such as micro-generation, with 15 of the 20 households in this
study either having had PV panels installed, or including solar PV as part of current renovations, through federal, state and local government-supported initiatives. Even so, these initiatives are not associated directly with reducing overall consumption, but with sustaining household amenities and services. Survey and other data (Australian Bureau of Statistics, 2008, 2011b; Energy Efficient Strategies and Department of the Environment Heritage and the Arts, 2008; Sandhu and Petchey, 2009) indicates growth in the acquisition of household equipment such as larger refrigerators and more energy-intensive household practices including whole house heating, incidence and use of air-conditioners, home entertainment and personal computers—and many of these were observed in this study. Further, the increased size of dwellings—a feature of many of the renovations in this study—is linked to number of appliances and increased domestic energy use (Hand et al., 2007; Wyatt, 2013). This suggests that existing comfort and consumption practices are reinforced and maintained, or being reconfigured in more energy intensive ways.

Rules and procedures appear to be favouring some paths in shaping renovation in heritage dwellings whilst disregarding others. The methods for compliance with the BCA are closely specified. In giving particular attention to DTS and HER software, this reinforces understandings around energy performance and renovation which are tied to the building, and maintains particular ideas about occupant comfort, as prescribed in Australian building standards through The American Society of Heating, Refrigeration and Air-Conditioning Engineers’ (ASHRAE 2010) standard for ‘Thermal Environmental Conditions for Human Occupancy’. Alternative approaches and methods of compliance are available but were not employed for any of the dwellings in this study; reluctance to depart from standard methods and solutions as observed in section 8.1.2, may be because homeowners (or ‘expert practitioners’) fear getting ‘stuck’ in the approval process, as suggested in the data. Observations made elsewhere in connection with construction of new dwellings claim that the prevalence of DTS provisions and HER software is due to difficulties with
the Alternative Solution approach (Wallis and Dewsury, 2009). No examples were uncovered of renovations that used an Alternative Solution and further investigation would be required to substantiate this.

This study does include examples of renovations that incorporated passive design strategies, although the effectiveness of such strategies could not evaluated in relation to actual energy consumption before and after renovation. Whilst the efforts of participants in this study was on the building fabric and systems, in some instances upgrading the energy efficiency of the dwelling was difficult due to the dwelling having solid walls, or damage to external weatherboard and internal lath and plaster construction. In these cases, homeowners opted for other measures to improve energy performance such as installing ceiling insulation and/or PV panels. Although not recognised in the performance assessment methodology, several homeowners adopted adaptive comfort practices; this strategy, which integrates material interventions with user interaction, assisted two families in the study to manage comfort without air-conditioning, whilst keeping electricity consumption low, although both used gas as the main energy source for heating, hot water, and for cooking. Actual gas and electricity consumption could not be confirmed for these dwellings but other studies (for example, Karol and McMinn, 2008; Miller et al., 2012; Williamson et al., 2010) have shown that combining different design strategies with householder engagement can assist in lowering energy consumption as well as enabling occupants to manage thermal comfort without air conditioning. Currently the assessment methodology aimed at confirming regulatory compliance does not credit homeowners’ practices that reproduce adaptive approaches to comfort. However, the data suggests that there is potential for the study of homeowner practices to reshape rules and procedures to enable more creative solutions which integrate physical components, together with active engagement and interaction of occupants to deliver low energy consumption.
9.3 Heritage in contention: the materialisation of the ‘comfort culture’

In responding to the second level research question (iii) this section considers the ways in which retention of heritage is in contention with concerns about environmental performance.

Within the realm of renovation, the literature and policy context, and review of VCAT planning appeal decisions in section 6.2.2, suggest that the environment and heritage are in contention. However, the findings of this study indicate otherwise. In reality, homeowners are realizing aspirations of comfort, cleanliness and convenience in renovations. Although homeowners articulated heritage and environmental concerns as important in interviews, the most common reasons communicated by individual participants for undertaking renovations relate to expectations of thermal comfort and better living standards within the home, and this is reflected in renovation practices. As an example, 16 out of the 20 renovations involved heating or cooling more rooms in the house, either installing a new heating system or extending an existing system. The evidence points to comfort being predominant in shaping renovation practices, and on this point the findings agree with Shove (2003) and others.

All participants demonstrated a level of environmental awareness, and most expressed a desire to reduce their environmental impact. However, the connection between environmental concern and renovation practice appeared to be weak, with the findings showing this concern tended to be of secondary importance in comparison to expectations of thermal comfort, which featured repeatedly in the interviews, and was manifested in appropriation of heating and cooling appliances, such as hydronic and underfloor heating systems. Whilst homeowners acknowledged environmental performance as being an
important objective, this did not figure prominently in discussions about renovations or in the organisation of everyday life, as might be anticipated. The only exceptions to this was the homeowner who insisted on low energy intensity materials in the new extension, and use of re-cycled materials in five renovations). Although 11 homeowners had installed solar PV panels, the findings suggest that this was for reasons other than environmental concern. Homeowners talked of taking advantage of financial subsidies, organising their household routines to make use of solar energy and/or exporting excess electricity generated to the grid, off-setting credit from renewable electricity supply against conventional grid power consumption, and at the same time seeking to demonstrate their environmental credentials or achieve self-sufficiency. One suggestion is that homeowners may be willing to act according to environmental principles where it is easy to do and does not take much time and effort (Aune et al., 2011). In analysing the different renovations, the evidence indicates that homeowners incorporated technologies to improve energy efficiency or environmental performance where these did not detract from their living standards and expectations for their home, aligned with their particular images and needs, could be integrated into their established everyday routines, and where there was some benefit to them.

Although most participants agreed that retaining heritage is important this was perceived as distant from everyday concerns and of secondary importance to immediate needs for many homeowners in this study. The desire for a comfortable home took precedence over aesthetic appearance or other values associated with conserving a heritage dwelling. It is acknowledged that not all of the homeowners taking part in this study set out to purchase a heritage dwelling, with other factors such as size, location and affordability having a greater influence on their decision. Even so, retaining heritage significance may be regarded as an important consideration in renovating, but one that is ‘trumped’ by expectations for meeting new standards of comfort, cleanliness and convenience. The findings show that heritage features were more likely to be retained in renovations where these corresponded with homeowners’ own
understandings of what is meaningful, and that upheld their comfort expectations or prevailing ideas of what a home should be.

The academic literature highlights several significant impulses associated with home renovation, with a previous study (Dalton et al., 2008) pointing to a variety of linked and negotiated motivations including environmental concerns, cost and desire to achieve standards of comfort. However, the findings indicate that the main reasons for renovation of heritage dwellings are related to conventions and expectations around improved comfort. This corresponds with research by Maller et al., (2012) which found the practicalities and contingencies of everyday life predominate over concerns for the environment. Thus, this research accords with previous research, which found that some retrofitting has occurred in parallel with rising environmental concern, but the link between environmental concern and action is weak, with efforts to change hampered by shifting household practices relating to comfort, cleanliness and convenience (Maller and Horne, 2011; Shove, 2003).

Comparison with a previous study of home improvements (Maller and Horne, 2011) shows marked similarities between the kinds of home-renovation projects undertaken in this research despite the differences in households and range of dwellings. As the pattern of renovations was consistent across the two studies this suggests that renovation practices do not arise from the physical condition of dwellings, as presupposed in the literature on renovation and obsolescence, but are related to other social practices around the creation and maintenance of standards and conventions of daily life.

The predominance of comfort over environmental concerns and heritage considerations supports the existence of a ‘comfort-orientated energy culture’ (Aune, 2011; Heidenstrøm et al., 2013). In this regard, it is interesting to note that some differences in renovation practices were observed between homeowners in metropolitan Melbourne, and those in rural Victoria who were...
not connected to the mains gas network. Despite being in a climate zone with lower daily average winter temperatures, none of the four participants in rural Victoria had central heating (although one had installed electric underfloor heating in the bathrooms as part of the renovations). Homeowners interviewed in rural, off–gas locations talked about electricity blackouts due to bushfires or adverse weather events, and related their renovation practices and expectations to experiences of supply and reduced reliability. Differences in heating and hot water appliances indicate that energy infrastructure provision is implicated in renovation, with homeowner practices linked to the possibilities afforded by existing infrastructures and systems of provision (Evans and Abrahamse, 2009; Sofoulis, 2005; Strengers and Maller, 2012). However, the findings also suggest that variations in renovation and comfort practices could be related to differences in ‘energy culture’ or how people talk about, relate to and their expectations about energy (Heidenstrøm et al., 2013; Wilhite et al., 1996). The research supports the argument that differences in energy cultures and the existence of a ‘comfort-orientated energy culture’ shapes renovation practice.

A ‘comfort culture’ has been observed in relation to installing energy efficiency measures in domestic dwellings, documented in several studies in other countries (for example, Heidenstrøm et al., 2013; Shove, 2003). The indication is that homeowners are willing to undertake energy efficiency measures provided that these do not interfere with changing expectations of comfort. Homeowners will only accept more sustainable devices in the field of energy under the condition that the devices ‘fit’ into the overall organisation of their households and lifestyles (Spaargaren and Van Vliet, 2000; Anker-Nilssen, 2003).

It was observed that a desire for increased comfort co-existed alongside concerns about energy costs. The economic rationale had a high priority, at least in the participants’ rationalization of the reasons for undertaking renovation, with one of the main explanations given for undertaking
renovations being a wish to reduce household energy costs. Although the participants in this study are drawn from across various age groups, including families with young children (see Table 6.2), it should be noted that 11 of the 26 homeowners in the study were over 55 years of age and contemplating retirement; a circumstance that may be reflected in their declared concern to safeguard against increasing energy prices for everyday services. Rising energy costs and capacity to pay in the future were anxieties expressed frequently by homeowners in this study, reflecting wider concerns about energy hardship, an emergent policy issue in view of energy costs having risen markedly in recent years and the likelihood of further increases (Australian Bureau of Statistics, 2012b; Council on the Aging (NSW), 2011; Rolfe, 2010). It should be noted that interviews were conducted during a period of heightened public awareness and party politicisation of domestic energy prices. Paradoxically, even though reducing household energy costs were amongst the most frequent reasons cited by homeowners for undertaking renovations, there is a lack of attention to actual consumption by participants. Only two of the households in this study (one mature couple, and a family with two young children) paid close attention to their energy consumption or bills. There was little evidence amongst participants that rising costs had translated into changes to lifestyle or daily routines to reduce energy consumption to any great extent—except perhaps for reorganising some household practices to make greater use of PV generated electricity. The findings point to technical efficiency (and particularly the attainment of a high star rating for energy performance) being perceived by homeowners’ as the key pathway for achieving environmental performance targets, whilst at the same time reducing energy costs and sustaining living standards. The findings concur with Aune et al. (2011) who suggest that environment-mitigating activities are being undertaken as a type of ‘free-loading’ activity, where renovation to improve comfort and aesthetics may lead to increased energy efficiency.
In situating this research in a wider international context, this research adds to several relevant international studies that point to the importance of priorities other than energy efficiency or environmental concerns, the most widespread being: aesthetic reasons, convenience and comfort (Bartiaux et al., 2011); ideals of domestic life (Hand et al, 2007); contribution to identity creation (Gram-Hanssen and Bech-Danielsen, 2004). In these studies, which extend across Portugal, Belgium, Latvia and Denmark, and the UK, energy efficiency is included as a motivation, but alongside higher levels of comfort (Gram-Hanssen, 2011).

The research indicates that whilst homeowners appear to be justifying their renovations as energy efficient, these appear to be only tangentially related to environmental concerns. Evidence presented in this thesis shows that comfort wins out over other environmental and economic motives. The research points to the importance of comfort in renovation: the ‘comfort culture’ is not only a problem that concerns the environment, however, as the findings suggest this is also a problem for heritage, and comfort overrides both heritage values and environmental objectives in home-renovation practice.

This chapter has discussed the key findings from the research in relation to the three second-level research questions. Each of the questions has been addressed, and the findings considered in the context of contribution to knowledge. The next chapter presents the conclusions, contributions to knowledge, and limitations of the research, followed by insights from the research for the development of policy. Finally, opportunities for future research are identified.
‘[W]hat we do is in some ways wrong, in most ways imperfect, and in all ways ephemeral.’

David Lowenthal, 2008 p. 14

10. Conclusions

The research has sought to explore the ways in which cultural heritage significance is in contention with objectives for environmental performance and other changing priorities for home improvements, and how homeowners balance these potentially conflicting objectives through home-renovation practice. Three second-level questions were developed to guide the research response (see section 1.4, page 13), and these were addressed in chapter 9. An interdisciplinary approach was adopted: drawing on theories of social practice for the analytical framework and employing ethnographic methods, this thesis has examined the components shaping home-renovation activities and how these intersect in heritage dwellings. The research developed and applied a framework in which renovation of heritage dwellings could be explained by configurations of meanings and understandings, competences, and material infrastructures. This chapter summarises the contribution to knowledge made by this work in the construction and heritage disciplines and the limitations of the research. Implications for policy are outlined, as well as areas for future research.

10.1 Methodological, conceptual, and empirical contributions to knowledge

This thesis addresses a significant gap in knowledge regarding homeowner renovation activities in heritage dwellings, by providing in-depth learning about renovation practices and underlying mechanisms. This is critical to
understanding the dynamics of demand for energy and achievement of objectives for environmental performance.

10.1.1 Conceptual contribution

Prior to this research, no work in Australia had explored the range of meanings associated with renovation of heritage dwellings as experienced by homeowners. The research has revealed how meanings and understandings of heritage shape home-renovation practice. By adding a detailed understanding of the elements involved in configuring renovation in heritage dwellings, and how the practice is reproduced in an Australian context, this thesis adds to understanding of the concept and dynamics of renovation. As such, this thesis contributes to the conceptual debate on the configuration of practices. Furthermore, by identifying homeowners’ conceptualisations of heritage in home renovation, this thesis adds to the body of work on changing notions of heritage and home.

The role of rules and procedures in the context of a heritage setting has not previously been adequately studied. Although rules and regulations are acknowledged by others as a constituent in practices (Gram-Hanssen, 2010b; Schatzki, 2002; Strengers, 2009; Warde, 2005, 2013), the research highlights for the first time, how rules and regulations influence heritage renovation practices.

10.1.2 Methodology and methods

In housing renovation and energy performance domains, the emphasis has been on survey-based research, as well as a prevalence of quantitative methods. As outlined in Chapter 9, this thesis extends research methods used in energy and renovation research domains, by applying a social practices approach, not previously applied to renovation of heritage dwellings. A social practices theoretical framework was used to investigate homeowners’
experiences of renovation, and their renovation practices were explored. Theories of social practice provide the ability to incorporate social and cultural aspects of heritage and housing, along with material dimensions of housing and improvement, and gain in-depth understanding into the mechanisms underlying homeowner renovation practices. This methodology could be applied beyond the domestic context, to other groups such as SMEs, to explore the mechanisms shaping energy-intensive practices.

By illuminating the connections between homeowner understandings, practices, buildings and technology, this research provides insight to the mechanisms that produce observed material arrangements and patterns of energy use in heritage dwellings. The research adds to qualitative studies within the built environment on user-centred approaches that prioritise understanding of routines, habits, conventions and conceptions of normality (Dalton et al., 2007; Gram-Hanssen, 2008a; Maller et al., 2011; Gram-Hanssen, 2008b; Maller et al., 2011; Shove, 2003a). Further, the application of social practices to the domain of renovation and cultural heritage contributes to interdisciplinary research, which can offer a different perspective in resolving problems associated with energy performance of the existing housing stock.

This thesis has demonstrated that a social practice theoretical approach is powerful in explaining renovation practices in owner-occupied heritage dwellings. The social practices theoretical framework in Figure 9.1, has identified the key mechanisms for configuring homeowner renovation, and illustrates how practice varies through the different arrangement of elements, and specifically homeowner understanding relating to heritage. It contributes to more detailed understanding of the dynamics of renovation through deconstructing the components involved in renovating existing dwellings with cultural heritage significance. Prior to this research no other studies have been undertaken to explore the elements of renovation practice for heritage
dwellings from the homeowner perspective, and how these is implicated in shaping renovation and energy performance. By using a social practice theoretical perspective as an alternative to the dominant technical and behavioural approaches discussed in Chapter 4, this thesis reveals new insights into homeowners’ renovation practices. The research reveals the complexity of renovation in heritage dwellings and how it is interrelated with the dynamics of everyday life, and related social and cultural understandings.

10.1.3 Empirical contribution

In applying a social practice conceptual framework to renovation of heritage dwellings, this research has extended the scope of previous empirical studies. Although there have been some limited investigation of the experiences and understandings of households undertaking home improvement and retrofitting (for example, Goodsell, 2008; Maller et al., 2012; Shove and Hand, 2005), the extent, diversity and complexity of renovation has generally been overlooked across both technical and social sciences, with little attention given to heritage dwellings. This research contributes to understanding of the lived experience of homeowners undertaking renovation in heritage housing, and the various motivations, adding to previous studies on implications for sustainable consumption (Shove, 2003; Soebarto et al., 2004; Wilhite and Lutzenhiser, 1999; Wilhite, 2008). In analysing this particular sub-sector of the housing stock, this thesis provides deeper understanding of how social and cultural aspects shape renovation practices. The additional consideration of heritage has shed new light on the established renovation practice debate by showing how practice is shaped by certain notions of heritage, and how this interfaces with other common understandings.

Building on previous research on social and cultural influences on energy consumption and environmental performance, the findings illuminate the contest between cultural preferences to retain heritage elements and the need to address perceived problems of performance associated with emerging
environmental concerns. However, the empirical evidence points to the importance of comfort in renovation of heritage dwellings.

The findings of the research extend the empirical literature by identifying a comprehensive set of elements experienced by homeowners. These are identified, explained and validated. They also reveal configurations of elements and how these shape practices for different home-renovator groups.

10.2 Limitations of this study
Diligence was taken in the research design and methodology to ensure the rigour and validity of the approach applied, and these measures have been discussed in Chapter 6. This section summarises additional limitations arising from the research.

This thesis has analysed home-renovation practices of twenty ethnographic case studies in Australia, focusing on a small sample in the State of Victoria. It has been shown that qualitative, ethnographic approaches have an important role to play in research to reduce domestic energy consumption (Crosbie, 2006; Henning, 2005; Pink, 2011; Wilk & Wilhite, 1985). Whilst providing detailed knowledge that could not otherwise be obtained, the preferences and practices of homeowners and dwelling types reflect their particular regional and cultural context; the findings should only be generalised with caution and due regard to context. Nevertheless, the conceptual framework presented here offers a different perspective and interpretation of the renovation of the existing housing stock, and how this intersects with environmental objectives, and conservation of heritage significance—an issue common to other countries. Thus, it has potential for broader application, informing a more in-depth understanding for the development of policy. Further case studies are now needed that systematically apply and critically examine this conceptual framework across other contexts, with a view to informing a more in-depth
understanding of social and cultural aspects of renovation for the development of policy.

In collecting data for this research, the cooperation of homeowners undertaking renovation of their heritage dwellings was necessary. Whilst the research strategy envisaged that the case study examples would include dwellings of differing levels of cultural heritage significance, most of the dwellings included in the study are of local heritage significance. While this bias towards dwellings with local heritage significance was not a serious problem given the interpretive nature of the research design and consequent absence of any claims to representativeness, it does influence the conclusions that can be drawn. As buildings of local significance predominate, the findings more closely reflect the constitution of heritage dwellings across the state of Victoria, but the conclusions should be treated as tentative in respect of dwellings of state significance until further research is carried out. Nevertheless, it is anticipated that further research would confirm that the social practices conceptual framework is relevant to dwellings having varying levels of significance, although the relative importance of the various components may be configured differently.

Social practice theory as explored in this thesis is an emerging field and application in empirical studies within the built environment is currently limited, although interest in the social practices paradigm in interdisciplinary research is growing. This research has assumed that social practice theory is applicable to transformation of the built environment and specifically adaptation of heritage dwellings in Australia. Discussion in Chapters 4 and 5 highlights the ongoing debates within the social psychology and sociology literature, and the limitations and critiques have been considered in application of social practice theory in this research.
10.3 Implications for policy in Australia

The findings of the research are of particular importance to policy-makers and others who are interested in delivering transformation in patterns of energy consumption to realise environmental goals. This section sets out the implications of the research for future energy efficiency and heritage policy in the existing housing context in Australia.

10.3.1 Comfort driving renovation practices

Although renovations may be rationalised as improving environmental performance and energy efficiency, analysis using a social practices framework indicates they are motivated by homeowner expectations relating to standards and conventions of comfort, cleanliness and convenience. Thus, the proposition that requirements for environmental performance in existing dwellings are impacting on cultural heritage is only partially correct. Although the research illuminates the tension between cultural preferences to retain heritage elements and the need to address perceived problems of performance associated with emerging environmental concerns, analysis using a social practice lens indicates that, in fact, priorities of comfort dominate renovation. For most homeowners, the desire for a thermally comfortable home takes precedence over other considerations, and this is manifest in material alterations.

The findings suggest that continuation of existing policy approaches promoting thermal performance standards aimed at achieving constant temperature set points and standardized conditions sustaining levels of comfort are likely to reproduce current patterns of consumption.

However, there is potential for shifting practices. In around one third of the renovation case studies homeowners did not undertake works to improve energy performance where interventions would detract from the qualities of the
heritage dwelling, and almost half did not have air-conditioning but managed thermal comfort in other ways.

10.3.2 Disjunct between policy and practice

This thesis concludes that policy seeks to shape renovation in certain ways, through particular rationalities and procedures, regulating technical efficiency of the building envelope and systems, so as to achieve certain environmental objectives. However, by tracing linkages between homeowner renovation practices, the structures with which they interact, and everyday practices, this thesis has highlighted a disparity between policy intentions and renovation practices. What makes sense for homeowners’ and their everyday practices may not align with policy aims. Current approaches misconstrue how homeowners participate in, and co-shape renovation, and underestimate the extent to which such practices are related to social and cultural underpinnings, and how these determine the intensity of energy use in everyday life.

A policy shift in how renovation is conceptualised is required. Far from being a straightforward process of the insertion of technology, as assumed by existing policy approaches, the findings show that renovation is more complex than simply installing new equipment. What makes sense for homeowners emerges from their ideas about home, and how these align with understandings of the environment and heritage, along with shared knowledge and know-how; and mediation by material infrastructures and institutional arrangements.

10.3.3 Renovation: from adapting the dwelling to adopting practices

The range of strategies undertaken by homeowners in this study fall across a wide spectrum from adapting the building to accommodate certain expectations, to engaging in everyday practices that optimise building performance and/or making use of the possibilities afforded to them. However, in common with the current policy discourse the majority involved significant
technical interventions to adapt the dwelling to meet expected standards of performance. From the analysis of case studies, and insights from the wider literature, common renovation practices such as larger floor areas and increased comfort counterbalance energy efficient technologies. In trying to organise environmental change, current approaches are unlikely to realise environmental benefits required as these underrate the crucial role of homeowners and everyday practices in renovation and consumption. Analysis undertaken in this thesis and elsewhere (for example, Hargreaves, 2011; Shove and Walker, 2010) suggests that greater attention to practices would increase the likelihood of a successful outcome.

10.3.4 Policy development

Given current housing energy performance policy discourse in Australia, the research highlights the need for a shift in perspective and focus if policy limitations are to be addressed. The thesis demonstrates that renovation is not simply installing new equipment but involves a ‘complex dialogic relationship ... between the inhabitant(s) and the building where both the human and technological components have and express agency’ (Cole et al., 2008: 330). A ‘hybrid’ approach is called for, that optimises performance through the interactions between occupants, their practices and the building. A movement towards a more user-centred approach is observed internationally, with social practice theoretical approaches being employed in research to analyse the mechanics of energy consumption and how certain practices may be changed through interventions: UK examples include the Consumer Appealing Low Energy Technologies for Building Retrofitting (CALEBRE), the Customer-Led Network Revolution (CLNR) project, and Dynamics of Energy, Mobility and Demand (DEMAND) research programmes.

The systemic focus on standardized approaches to environmental performance in buildings undervalues the importance of the underlying cultural value of heritage buildings, diversity amongst individuals and buildings, and
the loss of building features that individuals value more than energy efficiency, as higher levels of energy efficiency may only be sustained through trading-off other features that homeowners’ value. Although in a minority, some homeowners prefer to have a less energy-efficient home if that is what is required to obtain certain highly valued characteristics. This research highlights the need for an approach that optimises performance through the interactions between the building, technology and occupants’ practices, and which more aligns with heritage principles. This may be achieved through a review of the Alternative Solution procedure in the BCA, which will enable ‘trade-off’ between fabric performance and everyday practices, allowing for more creative solutions encompassing cultural understandings of heritage and alternative notions of comfort.

This thesis has argued that more sustainable patterns of consumption depends on transforming practices (see Southerton et al., 2004). As Warde observes, ‘the principal implication of a theory of practice is that the sources of change behaviour lie in the development of practices themselves’ (Warde, 2005 in Hargreaves, 2011: 82). If, as argued in this thesis, renovation practices unfold from interactions between practices, people, and socio-material settings, from this conceptual position it follows that policy needs to focus on practices and their constituents to investigate how renovation practices might change.

In translating the findings into a policy approach within the built environment, this section proposes that the way forward lies in the alignment of interventions to households and contexts, and the development of strategies that account for, and potentially reconfigure, certain household practices. As a starting point, the social practices framework developed opens up the possibilities for reorienting policy and programmes towards how practices and conventions around energy consumption and renovation might be changed, alongside material interventions and other approaches that would assist in
shifting practice elements. Analysis undertaken in this thesis and elsewhere (for example, Hargreaves, 2011; Shove and Walker, 2010) suggests that inclusion in policy would increase the likelihood of a successful outcome. This would necessitate studying practices requiring change and their connections; identifying the range of interventions and approaches; engaging with agencies and actors involved in shaping or influencing those elements; and then implementing a coordinated programme of change, followed by monitoring.

In investigating how renovation and associated practices might be changed, one suggestion is to give attention to the nature of the intersection between practices (as in this research). Another tactic is to examine the conventions around certain practices such as comfort. If the reconfiguring of social practices depends on the alignment of new ‘things’ with existing practices, as proposed elsewhere (Judson et al., 2013), a further suggestion for optimising future interventions is studying how household practices respond to and evolve with infrastructural interventions. A worthwhile endeavour would be to trial the use of alternative material arrangements and explore how existing practices react to, appropriate, and ‘hybridize’ with them (Schatzki, 2013: 44).

10.4 Suggestions for further research

This thesis has addressed a significant gap in knowledge regarding homeowner renovation practices, how they are constituted and reproduced in the Victorian context. Clear evidence and analysis of renovation practices is presented, and there is now potential for further future research to build upon this new foundation.

There is scope for extension of the social practices conceptual framework to heritage case studies in other jurisdictions in Australia, and internationally, to include other dwelling types, climates and socio-technical regimes. Future
research could include investigation of the dynamics of heritage renovation practice in different contexts.

There is advantage in studying social practices in tandem with monitoring of environmental conditions. Technical measurement of temperature and humidity within the dwellings, and comparison with outdoor conditions, in conjunction with occupant comfort, would lend a further dimension to understanding how the existing stock of heritage dwellings performs—which is largely unexplored. This would also assist in validating homeowners’ comments about how older dwellings perform in terms of thermal comfort.

This study has identified a need for improved data on the existing built stock in Victoria, in particular relating to information on (and changes to) buildings over time. The influence of home renovation on patterns of energy use on a larger scale requires further research. Although beyond the scope of this thesis, and not without challenges, one possibility would be to develop a buildings and renovation database using the ‘data framework’ model (cf. Hamilton et al., 2011; Wyatt, 2013) for the domestic sector that brings together property data and data on energy-related improvements. The starting point could be the VGV dataset referred to in Chapter 2, which is a record of all dwellings in Victoria maintained by the Valuer General for property rating purposes. This could be extended to incorporate additional property characteristics, heating systems, insulation measures, and micro-generation technologies installed. Information in interventions could be collected through government sponsored programmes, trade associations and registered building practitioners, along with survey data collected by BIS Shrapnel, data gathered from the Housing Industry Association, the Building Commission and the ABS, along with qualitative data on renovations. Collating data from existing administrative data sources would enable this rich data source to be constructed at relatively low cost, and which otherwise would have to be obtained by fieldwork and physical inspection. As domestic energy data becomes available through the
smart meter programme, this could be added. In addition to monitoring changes in the housing stock, the data framework would provide an evidence base for evaluating the impact of energy efficiency measures on energy consumption. Data on energy efficiency renovation and housing characteristics at the individual property level would provide the basis for empirical study, in combination with qualitative data collection, analysis and interpretation.

It is evident from the findings that material transformations to dwellings through renovation practices have implications for present and future patterns of materials and energy use. Dwellings are often enlarged as part of renovations. The energy associated with the increase in the size of Australian homes is of immediate significance for future policy and programme development on environmental performance, and warrants further attention.

Returning to the on-going tension between heritage, comfort and environment, and the dilemma about how to address its consequences:

‘... a major issue is lifestyle and how it has changed over time. ... Shifting the population back to a less comfortable, less convenient lifestyle will be difficult if not impossible’ (Lowe in Taylor et al., 2011)

In attending to the challenge of transforming practices, further research could take the form of a field trial to evaluate occupants’ practices within heritage dwellings that have been upgraded using passive thermal design principles, and are natural ventilated, with a comparable study of occupant’s practices in typical 6 star rated dwellings. The study would use quantitative and qualitative methods to collate and examine multiple data sets within a defined climatic and social context. Such a real-world approach of building evaluation would enable comparison of building attributes alongside occupant’s perceptions and what they do. This contextual enquiry would involve semi-structured interviews with participants in their own home, and observation of participants ‘operating’
their homes. Thermal performance data would be collected using temperature and humidity sensors. Data on electricity, and gas consumption could be collected in each home using advanced metering. Analysis of the transcribed interviews, observation notes, building and performance data would enable evaluation of the relationships between thermal comfort expectations and experiences of the participants, and the translation of their expectations into daily practices. The aim of the study would be to feedback to participants in a collaborative context and, with assistance from a ‘practice coach’, examine ways of transforming practices. Occupants’ practices would be followed, and further monitoring carried out to evaluate implications for thermal comfort and energy performance.

The research has identified the challenge, encapsulated by one homeowner:

‘[W]e want to make it comfortable for, as we get older. We want to make it more environmentally sustainable but we also want to maintain the integrity of it ’ (Joy)

Rather than being a straightforward matter of inserting energy efficient technologies, it is necessary to deconstruct practices, their constituents, and focus on how these could be changed.
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Building Research & Information, 38, 5: 509 - 529.


Appendix 1: Buildings and floor plans
<table>
<thead>
<tr>
<th>No.</th>
<th>Front view</th>
<th>House type/description</th>
<th>Floor plan (not to scale)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td>Detached, brick workers’ cottage</td>
<td>No tour</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Mid Victorian</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>Detached, brick and weatherboard homestead</td>
<td>No floor plan</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>c. 1850</td>
</tr>
<tr>
<td>3</td>
<td></td>
<td>Terraced, brick workers’ cottage</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Late Victorian</td>
</tr>
</tbody>
</table>
Detached, brick cottage

Queen Anne/Federation
5 Detached, weatherboard cottage Edwardian

6 End terrace, brick townhouse Late Victorian

7 Detached, weatherboard cottage Edwardian No tour
Detached, weatherboard cottage
Edwardian

Terraced, brick cottage
Edwardian
Detached, weatherboard
Californian bungalow

Detached, weatherboard
cottage
Edwardian

No tour
Detached, weatherboard cottage
Edwardian
13 Attached, brick cottage
Edwardian

14 Detached, weatherboard villa
Queen Anne/Federation

No tour
15 Detached, weatherboard cottage
Late Victorian

16 Detached, weatherboard cottage
Edwardian
17 Detached, weatherboard villa
Mid Victorian

18 Detached, stone cottage
Edwardian
Detached, stone villa
Mid Victorian
c.1872
Detached, stone and weatherboard villa

Late Victorian

No tour
Appendix 2: Homeowner energy data
### Daily/Monthly/Annual - Electricity Usage (Peak & Off-Peak)

**ID No. 15**  
**Climate zone 6**

<table>
<thead>
<tr>
<th>Bill Ended</th>
<th>Days</th>
<th>Previous Reading</th>
<th>Current Reading</th>
<th>Total Usage kWh</th>
<th>Average daily kWh</th>
<th>Average daily kWh</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>17-Dec-09</td>
<td>29</td>
<td>87060</td>
<td>87369</td>
<td>809</td>
<td>8.70</td>
<td></td>
<td></td>
</tr>
<tr>
<td>19-Feb-10</td>
<td>65</td>
<td>0</td>
<td>500</td>
<td>720</td>
<td>7.66</td>
<td></td>
<td></td>
</tr>
<tr>
<td>24-Aug-10</td>
<td>92</td>
<td>1220</td>
<td>2170</td>
<td>950</td>
<td>10.33</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20-Nov-10</td>
<td>87</td>
<td></td>
<td>630</td>
<td>7.24</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>21-Feb-11</td>
<td>94</td>
<td>2800</td>
<td>3550</td>
<td>750</td>
<td>7.98</td>
<td>8.31</td>
<td>Household reduced from 2 persons to 1 on 01/02/2011</td>
</tr>
<tr>
<td>25-Aug-11</td>
<td>92</td>
<td>538</td>
<td></td>
<td>5.85</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>25-Nov-11</td>
<td>92</td>
<td>586</td>
<td></td>
<td>6.37</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>25-Feb-12</td>
<td>92</td>
<td>627</td>
<td></td>
<td>6.82</td>
<td>6.77</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Total Days**  
831  
6,362  
7.66
Additional person in household from 01/05/2010 to 01/02/2011
### Daily/Monthly/Annual - Electricity Usage (Peak & Off-Peak)

**ID No.16**  
**Climate zone 6**

<table>
<thead>
<tr>
<th>Bill Ended</th>
<th>Days</th>
<th>Previous Reading</th>
<th>Current Reading</th>
<th>Units usage kWh</th>
<th>Daily Average kWh</th>
<th>Supplier/retailer</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>14-Oct-02</td>
<td>90</td>
<td>17870</td>
<td>19230</td>
<td>1,360</td>
<td>15.11</td>
<td>AGL</td>
<td></td>
</tr>
<tr>
<td>15-Jan-03</td>
<td>93</td>
<td>19230</td>
<td>20360</td>
<td>1,130</td>
<td>12.15</td>
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<td></td>
</tr>
<tr>
<td>15-Apr-03</td>
<td>90</td>
<td>20360</td>
<td>21390</td>
<td>1,030</td>
<td>11.44</td>
<td></td>
<td></td>
</tr>
<tr>
<td>16-Jul-03</td>
<td>92</td>
<td>21390</td>
<td>22840</td>
<td>1,450</td>
<td>15.76</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Total Days** | 365 | 4,970 | 13.62 |

<table>
<thead>
<tr>
<th>Bill Ended</th>
<th>Days</th>
<th>Previous Reading</th>
<th>Current Reading</th>
<th>Units usage kWh</th>
<th>Daily Average kWh</th>
<th>Supplier/retailer</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>30-Jun-10</td>
<td>90</td>
<td>1940.7</td>
<td>2804.2</td>
<td>864</td>
<td>9.59</td>
<td>Country Energy</td>
<td></td>
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<tr>
<td>24-Sep-10</td>
<td>86</td>
<td>2804.2</td>
<td>3450.6</td>
<td>646</td>
<td>7.52</td>
<td></td>
<td></td>
</tr>
<tr>
<td>18-Jan-11</td>
<td>89</td>
<td>3450.6</td>
<td>3963.7</td>
<td>513</td>
<td>7.24</td>
<td></td>
<td></td>
</tr>
<tr>
<td>25-Mar-11</td>
<td>93</td>
<td>3963.7</td>
<td>4550</td>
<td>586</td>
<td>6.30</td>
<td></td>
<td></td>
</tr>
<tr>
<td>28-Jun-11</td>
<td>95</td>
<td>4550</td>
<td>5390.2</td>
<td>840</td>
<td>8.84</td>
<td></td>
<td></td>
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<tr>
<td>23-Sep-11</td>
<td>87</td>
<td>5390.2</td>
<td>6174.4</td>
<td>784</td>
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<td>Final bill from Country Energy</td>
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<td>6789.1</td>
<td>615</td>
<td>7.15</td>
<td>Energy Australia</td>
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</table>

**Total Days** | 626 | 4,848 | 7.75 |
Electricity consumption after renovations, no. 16
## Daily/Monthly/Annual - Electricity Usage (Peak & Off-Peak)

**No. 20**  
**Climate zone 7**

<table>
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<tr>
<th>Bill Ended</th>
<th>Days</th>
<th>Total Peak Usage kWh</th>
<th>Daily Average Peak Use kWh</th>
<th>Total Off-Peak Usage kWh</th>
<th>Daily Average Off-Peak Use kWh</th>
<th>Average Daily kWh</th>
<th>Green %</th>
<th>Total Usage kWh</th>
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<tbody>
<tr>
<td>11-Dec-06</td>
<td>69</td>
<td>1,610</td>
<td>23.33</td>
<td>400</td>
<td>5.80</td>
<td>29.13</td>
<td>20.00%</td>
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<tr>
<td>13-Mar-07</td>
<td>92</td>
<td>1,362</td>
<td>14.80</td>
<td>430</td>
<td>4.67</td>
<td>19.48</td>
<td>20.00%</td>
<td>1,792</td>
</tr>
<tr>
<td>13-Jun-07</td>
<td>92</td>
<td>3,680</td>
<td>40.00</td>
<td>530</td>
<td>5.76</td>
<td>45.76</td>
<td>20.00%</td>
<td>4,210</td>
</tr>
<tr>
<td>7-Sep-07</td>
<td>86</td>
<td>6,970</td>
<td>81.05</td>
<td>660</td>
<td>7.67</td>
<td>88.72</td>
<td>20.00%</td>
<td>7,630</td>
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<tr>
<td>6-Dec-07</td>
<td>90</td>
<td>2,630</td>
<td>29.22</td>
<td>580</td>
<td>6.44</td>
<td>35.67</td>
<td>20.00%</td>
<td>3,210</td>
</tr>
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<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12-Mar-08</td>
<td>97</td>
<td>1,200</td>
<td>12.37</td>
<td>500</td>
<td>5.15</td>
<td>17.52</td>
<td>20.00%</td>
<td>1,700</td>
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<tr>
<td>16-Jun-08</td>
<td>96</td>
<td>3,380</td>
<td>35.21</td>
<td>600</td>
<td>6.25</td>
<td>41.46</td>
<td>20.00%</td>
<td>3,930</td>
</tr>
<tr>
<td>9-Sep-08</td>
<td>55</td>
<td>3,949</td>
<td>71.80</td>
<td>500</td>
<td>9.09</td>
<td>80.89</td>
<td>20.00%</td>
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<tr>
<td>8-Dec-08</td>
<td>120</td>
<td>4,351</td>
<td>36.26</td>
<td>850</td>
<td>7.08</td>
<td>43.34</td>
<td>20.00%</td>
<td>5,049</td>
</tr>
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</tr>
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<td>1,480</td>
<td>15.58</td>
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<tr>
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<td>3,620</td>
<td>37.70</td>
<td>780</td>
<td>8.12</td>
<td>45.82</td>
<td>80.00%</td>
<td>4,400</td>
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<tr>
<td>11-Sep-09</td>
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<td>5,380</td>
<td>62.56</td>
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<td>9.30</td>
<td>71.86</td>
<td>100.00%</td>
<td>6,180</td>
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<tr>
<td>11-Dec-09</td>
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<td>2,730</td>
<td>30.00</td>
<td>720</td>
<td>7.91</td>
<td>37.91</td>
<td>100.00%</td>
<td>3,450</td>
</tr>
<tr>
<td></td>
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<td></td>
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<td></td>
</tr>
<tr>
<td>15-Mar-10</td>
<td>94</td>
<td>1,300</td>
<td>13.83</td>
<td>660</td>
<td>7.02</td>
<td>20.95</td>
<td>100.00%</td>
<td>1,960</td>
</tr>
<tr>
<td>11-Jun-10</td>
<td>88</td>
<td>2,860</td>
<td>32.50</td>
<td>900</td>
<td>10.23</td>
<td>42.73</td>
<td>100.00%</td>
<td>3,760</td>
</tr>
<tr>
<td>15-Sep-10</td>
<td>96</td>
<td>6,920</td>
<td>72.08</td>
<td>1040</td>
<td>10.83</td>
<td>82.91</td>
<td>100.00%</td>
<td>7,960</td>
</tr>
<tr>
<td>14-Dec-10</td>
<td>90</td>
<td>2,890</td>
<td>32.11</td>
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<td>5.44</td>
<td>37.55</td>
<td>100.00%</td>
<td>3,380</td>
</tr>
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<td></td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>21-Mar-11</td>
<td>94</td>
<td>1,390</td>
<td>14.88</td>
<td>180</td>
<td>1.91</td>
<td>16.79</td>
<td>100.00%</td>
<td>1,570</td>
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<td>17-Jun-11</td>
<td>91</td>
<td>4,060</td>
<td>44.61</td>
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<td>48.46</td>
<td>100.00%</td>
<td>4,410</td>
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<tr>
<td>Date</td>
<td>Days</td>
<td>Total Peak Usage kWh</td>
<td>Daily Average Peak Use kWh</td>
<td>Total Off-Peak Usage kWh</td>
<td>Daily Average Off-Peak Use kWh</td>
<td>Average Daily Use kWh</td>
<td>Green %</td>
<td>Total Usage kWh</td>
</tr>
<tr>
<td>---------</td>
<td>------</td>
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<td>---------------------------</td>
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</tr>
<tr>
<td>13-Sep-11</td>
<td>88</td>
<td>5,820</td>
<td>66.14</td>
<td>430</td>
<td>4.89</td>
<td>71.03</td>
<td>100.00%</td>
<td>6,250</td>
</tr>
<tr>
<td>9-Dec-11</td>
<td>87</td>
<td>2,260</td>
<td>25.98</td>
<td>210</td>
<td>2.41</td>
<td>28.39</td>
<td>100.00%</td>
<td>2,470</td>
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<tr>
<td>Total Days</td>
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<td>1,893</td>
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<td>69,842</td>
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<td>12,160</td>
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<td>14,700</td>
</tr>
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</table>

**Daily/Monthly/Annual - Electricity Usage (Peak & Off-Peak)**

<table>
<thead>
<tr>
<th>Bill Ended</th>
<th>Days</th>
<th>Total Peak Usage kWh</th>
<th>Daily Average Peak Use kWh</th>
<th>Total Off-Peak Usage kWh</th>
<th>Daily Average Off-Peak Use kWh</th>
<th>Average Daily Use kWh</th>
<th>Green %</th>
<th>Total Usage kWh</th>
</tr>
</thead>
<tbody>
<tr>
<td>16-Mar-12</td>
<td>98</td>
<td>1,500</td>
<td>15.31</td>
<td>280</td>
<td>2.86</td>
<td>18.16</td>
<td>100.00%</td>
<td>1,780</td>
</tr>
<tr>
<td>Total Days</td>
<td>1,991</td>
<td>71,342</td>
<td></td>
<td>12,440</td>
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<td></td>
<td></td>
<td>83,732</td>
</tr>
<tr>
<td>Average all days</td>
<td></td>
<td>42.08</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Wood purchase**
First wood was purchased in winter of 2008 as didn't use the wood heater until then.

1-2 cubic metres per year - recovered from trees felled in own garden

**LPG Purchase**
1 x 40kg cylinder per year - used for cooking only

**List of energy use related works done:**
- 2006 Dec - window draught stopper seals applied in lounge room
- 2007 May - kitchen chimney capped
- 2007 May - ceiling insulation and main building draught stopping done
- 2007 May - under floor insulation and downstairs draught stopping done
- 2007 May - extra room heaters (x 3) installed and reverse cycle air-con installed
- 2007 Jun - fireplace covers in JW office and lounge room installed
- 2007 Jul - second meter removed so overall cost reduced by $40 per quarter for supply
2007 Dec - bedroom chimney capped
2008 May - drapes installed in studies and bedroom
2008 Jul - bedroom chimney blocked @ room level
2008 Jul - guest lounge room west side part insulated
2008 Jul - second bathroom west wall and floor insulated
2008 Aug - further window draught stopping done in all rooms
2008 Nov - guest lounge room chimney capped
2010 Nov - install solar HWS

Notes from interview:

2010 was a colder than average year
2011 was a warmer than average year
Electric heating required for much of the year with the cold inland nights
Total electricity usage, no. 20

kWh


0 1,000 2,000 3,000 4,000 5,000 6,000 7,000 8,000 9,000
Average daily electricity use, no. 20

kWh

Peak and Off-peak electricity usage, no. 20

May 2007 kitchen chimney capped, underfloor and ceiling insulation, main draught sealing, extra room heaters (x 3), reverse cycle air-con installed

Jul 2008 fireplace cover (1) installed, part insulation west wall and floor
Aug 2008 window draught stopping in all rooms

Dec 2007 bedroom chimney capped

Jun 2007 fireplace covers (2) installed

Nov 2008 lounge chimney capped

Nov 2010 install solar HWS

Wood heater

Total consumption (Peak plus Off peak)

Peak
Appendix 3: Interview schedule
INTERVIEW TOPICS/QUESTIONS FOR SEMI-STRUCTURED INTERVIEWS

Householder background
Examples:
Q. How long have you lived in this house?
Q. How many people live in the house, besides yourself?
Q. I am interested to know the reasons why you purchased this house—can you tell me a little bit about that? (e.g. location/price/size/heritage/other)

The house construction/services, and renovations
Examples:
Q. What is the construction of the house? Walls? Roof?
Q. How many bedrooms/bathrooms are there?
Q. Can you tell me what changes you have made to the house?

Theme: heritage/other understandings and significance
Examples:
Q. What things do you like/dislike about the house?
Q. What features/aspects are most important to you?
Q. How important is retaining heritage features in the renovation? [Prompt using a scale of 1-5—with 5 being ‘heritage is very important’; 1 being ‘heritage is not important’]
Q. Are there any other things that you consider important?
Q. Do you think energy efficiency/reducing emissions is more/less important that retaining heritage? Why?

Theme: improving energy performance
Examples:
Q. What changes have you made to improve energy performance?
Q. What prompted you to improve energy performance of the house? (e.g. subsidies)
Q. In what ways has heritage affected your plans for upgrading?
Q. Were any household appliances replaced, or new appliances acquired during the renovation?
Q. Have you made any changes to what you do or how you do things in the home to reduce energy consumption? [e.g. change in the way rooms are used/use of certain appliances/managing thermal comfort]
Q. What kinds of changes have you noticed in your electricity/gas bills?
Q. Do you think energy consumption has gone up or down since the renovation? Why do you think this might be?

Theme: thermal comfort and practices
Examples:
Q. Can you tell me what temperature you normally have the house at?
Q. How do you heat/cool the house? [if not already covered]? Is the heating/cooling on a timer?
Q. Have you changed the way that you heat/cool the house?
Q. [If relevant] How often do you use the air-conditioning?
Q. Are there any other things that you do apart from using the heating/air conditioner to stay warm/cool/ (e.g. put on warm clothes when cold, open windows, close blinds)?
Q. On a really hot/cold day, what kinds of things do you do to stay cool/warm?

**Theme: knowledge about renovation**

Examples:
Q. Where did you source information for the products/appliances/technologies for the renovation?
Q. Did you have any assistance during the renovation process? (e.g. architect/building surveyor/ builder/family member/discussion forum/other)?
Q. Is there anything you would do differently now?

**Theme: issues/conflicts**

Examples:
Q. Have you applied for a planning or building permit? If so, from which municipality?
Q. Did you encounter any difficulties in seeking to improve energy performance? How was this resolved?
Q. How long ago were works completed? Have there been any issues or problems since?

**Other:**
Q. Do you have any further comments or remarks that you think are relevant to the topic that you would like to add?

**House tour:**
Ask interviewee/s to point out the changes they have made.
Ask about different appliances/technologies (e.g. PV) and how these are used.
Find out how different rooms are used, and by whom.