



LOW CARBON LIVING  
CRC

## RP3016: EnergyFit Home Initiative

### Working paper 1: Literature Review and Gap Analysis



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## Executive Summary

The EnergyFit Homes Project aims to explore the key information and behavioural factors as well as the market structures that influence the purchase and leasing of new and existing low-carbon homes. This report presents a review of the literature on publicly available information, research reports and papers within this domain. The review has considered 94 articles and reports, published both in Australia and overseas. Most literature has been published in the past five years.

This review highlighted the factors that play a key role in influencing homebuyers and lessees when making decisions about purchasing and/or renting a home. The key factors could be explored in this research are:

- Individuals' knowledge, awareness and level of interest in information about low-carbon products/homes
- Householders' notion of home comfort and its relationship to low-carbon products/homes
- Individuals' perception of the costs of low-carbon products/homes and its effect on home affordability: upfront versus operational costs
- Perceptions of low-carbon products/homes by householders in different life stages
- Individuals' perceptions of the value of low-carbon products/homes in relation to other valued home improvements such as increased floor space, new kitchen and bathrooms
- Individuals' perceptions of 'moments of change' and the reasons why it might facilitate the adoption of new technology and/or practices
- Householders' perceptions about potential restriction of low-carbon products/homes on their preferred choices of designs.

This review also identifies the social actors involved in the market for low-carbon housing that are either a potential adopter of such technology or an influencing stakeholder. Aspects of this review which remain to be explored are:

- Homeowners versus investors' perceptions and priorities about low-carbon products/homes and how upfront versus operation costs influence decision making
- Tenants' perceptions, priorities and interaction with landlords regarding low-carbon products/homes
- Real estate agents' perceptions, experience and interactions with homeowners and tenants about low-carbon housing market
- The perceptions and experience of builders/architects/tradespeople in facilitating the adoption of low-carbon products/homes.

The next stage of the project includes conducting focus groups and a national survey with homeowners and renters in both urban and regional Australia to further investigate their perceptions of low-carbon homes as well as existing rating tools. Telephone-based interviews or online surveys with builders, developers and real estate agents will also be undertaken to further investigate the gaps in information and skills to support increased sales and rentals of low-carbon homes. These activities aim to establish the baseline understanding and attitudes towards the idea of voluntary rating and disclosure by homebuyers and lessees, sales and rentals staff and real estate agents across Australia.

## Introduction

### Aim of the literature review and gap analysis

The EnergyFit Homes Project aims to explore the key information and behavioural factors as well as the market structures that influence the purchase and leasing of new and existing low-carbon homes. In doing so, this project aims to better understand the motivations and information needs of homebuyers and lessees, and sales intermediaries around the point of sale and lease. The project also aims to identify the information content and presentation that is most likely to affect purchase decisions for low-carbon homes.

The first step to achieve such aims is to conduct a literature review on publicly available information, research reports and papers to summarise the existing information within this domain. In doing so, this review highlights the factors that play a key role in influencing homebuyers and lessees when making decisions about purchasing and/or renting a home. This review also identifies the social actors involved in the market for low-carbon housing that are either potential adopters of such technology or an influencing stakeholder and highlight the gaps that remain to be explored in this and future research.

The review has considered 94 articles and reports, published both in Australia and overseas. Most literature has been published in the past five years.

## Factors

This section will describe the main factors identified in the literature that affect homebuyers and lessees' decisions specifically with regards to low-carbon homes. The impact of those factors in influencing decisions at the point of sale and lease will be further explored in the next phase of the project which will aim to engage homebuyers, lessees and other stakeholders in focus groups, interviews and surveys.

### Level of awareness, knowledge and the role of information

Previous studies have indicated that buyers as well as builders are generally unaware and lack information about energy efficiency schemes, measures for adoption and/or associated costs and benefits of such technologies (Bryant and Eves, 2011; Crabtree and Hes, 2009; Dzidic and Green, 2012; Häkkinen and Belloni, 2011). Riedy et al. (2012) argues that awareness of the energy costs, comfort and lifestyle benefits of low-carbon homes are essential to motivate consumers to acquire such homes. Research has also argued that individuals might lack, not only specific technical knowledge, but also interest in retrofitting (Gabriel and Watson, 2013) to achieve such aspirations. Dzidic and Green (2012) also stress that individuals perceive that it takes too much time to find appropriate information about new technologies. Entrenched building practices and the lack of knowledge of alternative construction systems has also been identified as a barrier for the adoption of low-carbon technology (Berry et al., 2014).

Research conducted by Winton Sustainable Research Strategies (2010) in Queensland has indicated that over 90% of participants in their research agreed that it would be useful to have information available about a house's sustainability when purchasing a property. Furthermore, participants agreed that it would be useful to have standardised information so they could compare the sustainability of houses they may be looking to buy. However, despite participants (sellers and buyers) in the research stating that they would use such information, Bryant and Eves (2012) found that the sustainability of a house was not a priority for homebuyers. For example, from 2010 to 2012, in Queensland, it was mandatory for information to be provided on the energy and water use of properties that were on the market. However, Bryant and Eves (2012) found that there was limited interest and/or awareness from homebuyers in requesting a property's Sustainability Declaration during a home purchase process. It was unclear whether homebuyers were unaware or lacked interest in such information.

However, while information plays a key role in underpinning behaviour, information alone is unlikely to motivate behaviour (Moloney et al., 2010). Increased knowledge of energy efficiency benefits has to be coupled with the availability of attractive products and reliable advice on renovation solutions in order to facilitate adoption of energy efficiency technology during home renovations (Risholt and Berker, 2013).

How information about low-carbon homes is framed and communicated to potential buyers and renters should also be carefully considered. For example, according to MacKillop (2012) the 'Land Matters' development at Currumbin Valley in Queensland has put great emphasis on the community vision and aspects of living in such a development. While this approach might be appealing to a section of the community, it also can be seen as 'overbearing' for many people due to some residents feeling pressure for social interaction and participation.

Knowledge and information are important factors not only before but also after the technology is adopted. This is because the ability to understand and have control over the operation of appliances is key to technology acceptance. In this regard, the ease of operation of the energy efficiency technologies adopted as well as the level of information provided to the building occupier are essential for the technology users to establish control over the technology and achieve their needs, such as a comfortable home (Willand et al., 2012).

### Home comfort

The concept of comfort is constructed according to what individuals perceive as the norm for 'comfortable', which is dependent on social practices that evolve across time and place (Shove, 2003). Previous research has identified four aspects related to building occupants' perception of comfort: visual, acoustic, thermal conditions, and air quality (Frontczak et al., 2012).

Research has shown that individuals' perceptions of comfort can either hinder or facilitate the adoption of energy efficiency technology. For example, in a study by Dzidic and Green (2012) about non-potable groundwater use in sustainable households, participants who were reluctant to change justified their views by arguing that they felt comfortable with their homes and did not see a need to change.

On the other hand, heating and cooling can account for more than 40% of a household's annual energy consumption (Australian Bureau of Statistics, 2009). Of the four types of comfort mentioned, thermal comfort seems to be seen as a

key driver for low-carbon products, as low-carbon homes include a range of aspects that relate to thermal comfort such as solar passive design, indoor temperatures, seasonal differences and heating and cooling (Berry et al., 2014). For example, according to the Australian Bureau of Statistics, the majority of Australian households (69%) have some form of insulation, with the main reason for installing insulation being to 'achieve comfort' rather than to 'save energy' (Australian Bureau of Statistics, 2011). Furthermore, a review conducted by Organ et al. (2013) found increased comfort to be one of the primary motivations for carrying out home improvements.

The characteristics of the building as well as occupants' actions play a key role in maintaining the level of comfort. Depending on the building conditions, individuals can control their level of comfort by dressing according to the ambient temperature, changing the natural conditions in that space such as opening or closing of windows and/or doors and use of cooling or heating devices such as fans and heaters (Nicol and Humphreys, 2002; Soebarto and Bennetts, 2014). For example, a study in a low to middle income housing development in South Australia has shown that those householders avoided the use of high cost measures such as air-conditioners and preferred adopting other low-cost actions such as opening windows and using ceiling-fans (Soebarto and Bennetts, 2014). However, individuals' perception of comfort is highly subjective and depends on a range of psychological, social and cultural factors (Organ et al., 2013; Willand et al., 2012; Williamson et al., 2010). In addition, Tweed (2013) stresses that household energy and comfort concerns are dependent on other concerns which can vary in both time and space. For instance, as householders adjust to their new home environment resulting from retrofits. Residents of a near net zero emissions estate in South Australia involved in a study, reported a relatively high level of comfort across the climate seasons and were mostly comfortable with the operational aspects of the energy efficiency technology installed (Berry et al., 2014).

In addition, comfort can also lead to other benefits to households. For example, a review of the literature suggests that increased thermal and acoustic comfort, as well as air quality in buildings might lead to direct health benefit for its occupants (Willand et al., 2012). This view is supported by studies conducted in New Zealand which found that retrofitting insulation resulted in significant self-reported health benefits as well as reduced hospitalisation for respiratory and coronary conditions, and a significant reduction in children's absences from school (Howden-Chapman and Chapman, 2012). This view is supported by Berry et al. (2014) who argue that building thermal comfort has a direct impact on occupants' health especially during extreme weather events such as heatwaves.

## Home location, affordability and preferences

The location of a house plays a key role in an individuals' decision to buy a home, with an Australian study stressing that respondents prefer to live in a safe neighbourhood, close to family, friends, shopping, and public transport (Kelly et al., 2011b). In addition, a pre-requisite for renovations is the homeowners' satisfaction with the location of the home (Willand et al., 2012).

While preferred location is not likely to be associated with low-carbon homes, research suggests that there is an association between the geographical location of a home and the uptake of low-carbon energy technology such as solar photovoltaic (PV) panels. For example, Willand et al. (2012) draws attention to international research which has shown that the likelihood of homeowners adopting energy saving measures was influenced by the geographical location of the home. This view is supported by Bollinger and Gillingham (2012) who investigated peer effects in the adoption of solar PV systems in California, and found that each PV installation within a postcode area increases the probability of further adoption in the same postcode location. The findings suggest that both the visibility of the panels and word-of-mouth lead to further adoption of PV panels within the postcode area. In addition, Willand et al. (2012) argues that greater awareness in some regions, individuals' lifestyle and local construction methods may facilitate the uptake of low or zero carbon refurbishments.

Regardless of whether a home is low-carbon or not, individuals' choices for buying, renting and/or renovating a home are restricted by what they can financially afford. Bryant and Eves (2011) cite international research which found that buyers in residential property markets are more concerned about the price of the property, its location and number of bedrooms, than the energy efficiency or the green rating of the property. However, as stressed by MacKillop (2012), while sustainability products such as solar panels can be costly initially, sustainable houses are more affordable to run due to lower operational costs. The debate about home affordability (especially for rental properties) should increase its focus on the operational costs of such properties, as affordable homes are not necessarily economical to run.

Individuals' choices are also restricted to the availability of homes for purchase and/or lease. Lack of choice means that some households cannot always live in their preferred type of home and or/location (Kelly et al., 2011b). Further and according to Kelly et al. (2011a), housing preferences are much more varied and mixed than Australian cities currently provide, and there are shortfalls in semi-detached housing and apartments in established areas of some of Australia's capital cities. The likelihood for renovations and moving homes depend on a range of demographic factors, including age, gender, educational level, income and household composition. For example, older householders might be less inclined to renovate their homes due to the uncertainty over the payback period of such investment (Willand et al., 2012). Households in different life stages also have different housing preferences (Weidmann and Kelly, 2011). For example, a study by Kelly et al. (2011b) found that while large dwellings are preferred by Australian households, the size of internal space was particularly valued by middle-age families with children, while older households (60+ years) found it difficult to

maintain a large home. Households in this study associated space with freedom, flexibility and privacy. In addition, the study found that in choosing dwellings, people give priority to the number of bedrooms, having a detached house with a garage, and ample living space (Kelly et al., 2011b).

## Monetary costs

Previous research has indicated that Australia has one of the highest transaction costs of moving homes and that therefore homeowners avoid moving homes to avoid the high costs associated with it (Kelly et al., 2011b). Indeed, weighting the costs of renovation against the costs of moving houses seems to play a key role in householders' decisions in Australia. Willand et al. (2012) argue that owner-occupiers might only be motivated to renovate their existing home if the cost of renovation is not higher than the cost of finding their preferred home as well as moving to it. However, the authors also note that there is currently limited stock of low-carbon homes in Australia which might motivate homeowners aspiring for a low-carbon home to renovate their existing home regardless of other costs. In addition, Willand et al. (2012) note that the inclusion of energy efficiency measures is most cost effective when incorporated into general renovation work undertaken for building maintenance.

Dowson et al. (2012) argues that the return of investment of some energy efficiency technologies is never realised and therefore can be a barrier for its adoption. Furthermore, due to the large payback timeframe of recovering the costs of energy efficiency measures, research by Riedy et al. (2012) suggests that households that intend to stay longer in their homes are more likely to invest in sustainable retrofits. In addition, the authors argue that few homebuyers are willing to accept a payback of more than 5 years. The large upfront costs is a barrier especially for improvements in investment homes, as while the landlord is responsible for the initial capital outlay of the home improvement, it is the tenant who benefits from the improvements in home comfort and lower energy bills (Gabriel and Watson, 2012). Similar findings were reported by McGee et al. (2008), who found consumers perceived cost to be the greatest barrier to the implementation of sustainable features.

The adoption of low-carbon products can lead to considerable operational costs savings (MacKillop, 2012), so it is no surprise that saving money is seen as the most compelling reason for homeowners to improve the energy efficiency of their homes (U.S. Department of Energy, 2010). However, the potential for such savings depend on the initial thermal efficiency of the building shell as well as the appliances that are currently in use for space cooling and heating as well as hot water consumption (Willand et al., 2012). In addition, while the adoption of energy efficiency should result in lower energy bills, householders need to perceive and value such benefits in order to influence the adoption of such measures (Willand et al., 2012). The net zero emissions estate study undertaken in South Australia found that households achieved large energy savings (Berry et al., 2014). However, Riedy et al. (2012) argue that low and zero carbon homes are not yet seen as good value for money in most markets, while MacKillop (2012) found that the perception is that low-carbon homes are mostly suitable for those on higher incomes. Häkkinen and Belloni (2011) found the fear of high investment costs for sustainable buildings are higher when compared to traditional buildings, with the risks of unforeseen costs often perceived as barriers for investing in sustainable buildings. In addition, there is research showing that sustainability features are less valued than other more visible features such as new kitchens and bathrooms and/or features that bring 'status to homes', such as central heating, spa baths and marble bench tops (Crabtree and Hes, 2009; Dowson et al., 2012).

Research about the effectiveness of low-carbon homes to achieve costs savings has shown that low-carbon homes use significantly less energy per unit floor when compared to homes in similar climates (Berry et al., 2014). However, despite the potential for lower operational costs, valuations of homes do not seem to take energy efficiency technology into account (Willand et al., 2012). While some research found a relationship about house prices and energy ratings in the Australian Capital Territory (where there is a mandatory energy efficiency disclosure scheme), research on the effect of energy efficiency improvements on home value seem inconclusive, with sustainability yet to be proven to be a criterion for relevance to homebuyers (Bryant and Eves, 2012). Häkkinen and Belloni (2011) argue that the market value of energy efficiency retrofits is also negatively impacted by the lack of visibility for energy efficiency features. Some authors argue that in order to increase the homeowners' interest in low-carbon renovations, it is important to better understand how lifestyle choices affect real-world renovation decisions as opposed to relying on an approach that is based mainly on technical and economic analysis (Fawcett and Killip, 2014).

While energy savings are often cited as a principal motivation of householders when adopting energy efficiency technology (McGee et al., 2008; Organ et al., 2013), the adoption of the technology is also dependent on other household needs such as comfort, convenience, aesthetics and size of living space (Horne et al., 2014; Zundel and Stieß, 2011). In addition, research undertaken in the U.K. indicates that environmental concern can also drive low-carbon retrofits, with householders who participated in the study listing concerns about climate change and future generations ahead of costs savings (Fawcett and Killip, 2014).

## Household energy behaviour

Recent research has recognised that the energy efficiency of buildings designed for low energy consumption do not always meet their intended goal; therefore, attention has shifted to the behaviour of the occupants and the need to better understand it (Stern, 2011). This is because technical solutions aimed at reducing carbon emissions depend not only on the household uptake of such technology, but also on how individuals use such technology to achieve the expected savings (Dowson et al., 2012; Tweed, 2013), and how household practices and norms of comfort change over time (Gram-Hanssen, 2014). Therefore, there is a clear need for research to understand both the determinants of technology adoption, as well as the factors that shape how individuals interact with such technology. For example, Kierstead's (2007) research into the behaviour of households living with solar PV indicated that installation of rooftop solar PV combined with system performance monitors encouraged households to reduce their peak and overall electricity consumption. Other studies also suggest that evolving industry arrangements for combining smart metering with distributed energy technologies such as rooftop solar PV will be central in engaging consumers in both supply and demand side technologies (Abi-Ghanem and Haggett, 2011; Keirstead, 2007).

There is also concern that focusing solely on the potential savings from adopting energy efficiency technology may detract from the need to engage the wider society in the debate about lifestyle change (Reid and Houston, 2013). While technology efficiency might improve householders' operational costs, it might also encourage wasteful practice with everyday habits that can undermine the benefits of such technology (MacKillop, 2012). For example, a household may replace an air-conditioner with a more efficient model; however, due to its greater efficiency, the air conditioner is used on a more frequent basis, which then offsets potential energy and cost savings. This is known as the rebound effect.

In addition, the outcomes of domestic retrofits can benefit from happening during a 'moment of change' (Karvonen, 2013), as people undergoing a life change or transition, such as moving homes, are more likely to change their behaviour. This situation allows habits to be broken as people become 'susceptible to new information and advice in order to find satisfactory replacement of their old habits (Verplanken, 2011 p. 25). Karvonen (2013) points to emerging evidence that 'moments of change' serve as windows of opportunity to reconfigure the dynamics of the relationships between individuals and the built environment.

## Building age, condition, type and ownership

The age and condition of the building might be a driver for the adoption of low-carbon products, as a building in decay might require extensive reconstruction works to rehabilitate living conditions (Willand et al., 2012). On the other hand, Dowson et al. (2012) stresses that some dwelling types and locations might inhibit low-carbon refurbishments due to the existing structure of the dwelling (i.e. solid walls, no loft space for insulation) and/or no alternative energy types possible (such as gas or solar energy). Gabriel and Watson (2012) argue that two major issues inhibit the uptake of sustainable technologies within multi-unit, strata-titled rental properties. First, the governance of those properties in which landlords reported difficulties in negotiating permission with managers and/or other owners for sustainable upgrades of their individual unit or common areas. Second, the under-developed role of real estate agents in supporting sustainable property upgrades.

## Aesthetic qualities

Previous research has indicated that aesthetic qualities can both inhibit and facilitate the adoption of low-carbon products. For example, Crosbie and Baker (2009) found that some householders rejected energy efficiency measures such as compact fluorescent lamp (CFL) light bulbs due to their aesthetic and light quality. Gabriel and Watson (2012) also found that energy efficiency measures with any significant visual feature (such as solar panels and water tanks) were objected in multi-unit, strata-titled rental properties, as managers or body corporate viewed the visibility of those measures as potentially detracting from the value of the property. The Crosbie and Baker (2009) study recommends that increased adoption of energy-efficiency measures are dependent on the technology being aesthetically pleasing for building occupiers, as well as style and fit with current lifestyles and practices of residents.

A review by Willand et al. (2012) found that energy efficiency homes tend to be associated with contemporary design which does not reflect consumers preferred design style. Indeed, residents who participated in a study in Sydney expressed the perception that sustainable homes restricted their choices of designs and options in addition to being 'cold and didactic' (Crabtree and Hes, 2009). On the other hand, in another study reviewed in Willand et al. (2012) households living in low-carbon homes believed their homes had superior design to other homes offered and were pleased with its aesthetics. In addition, the review also suggests that the lack of visibility of some energy efficiency features might hinder its uptake, with studies suggesting that initiatives that are visible are preferred by homeowners (Willand et al., 2012). In addition, Crabtree and Hes (2009) argue that the acceptance of homes is dependent on them 'belonging' in the landscape.

## Social actors

The housing industry and market is comprised of a multitude of actors, each with their own role to play and level of influence in purchase decisions for low-carbon homes. The purchasers of this housing type and associated technologies are the home owners and they will make the ultimate decision on its adoption. However, others actors, such as real estate agents, architects and designers, engineers, building developers and tradespersons, manufacturers of low-carbon housing products and tenants may influence or provide input at different points of the decision-making process. This section will highlight issues of importance identified in the literature for each of these different actors.

### Potential adopters

#### Owner-occupiers

Individuals occupying their own property has been identified as a stronger driver for investment in low-carbon refurbishments, compared to properties in lease arrangements (Willand et al., 2012). Owner-occupiers are in a position to experience the benefits of investing in sustainable features, such as improved comfort and energy cost savings.

In addition, research has shown that housing preferences vary between homeowners and investors. In relation to low or zero carbon refurbishments, owner-occupiers seem to be more willing to invest in best practice standards than investors (Willand et al., 2012). This view is also supported in an unpublished study undertaken in New South Wales which found that home owners tend to rank home comfort and functionality alongside home location and price as the main factors for consideration when looking to purchase a property. On the other side, home investors tend to rank price and resale value as the main factors for decision-making.

However, willingness to undertake an energy efficiency renovation is also influenced by the characteristics of particular individuals. A study conducted by Risholt and Berker (2013) found that only consumers who were pro-active and had special knowledge about energy efficiency due to their professions succeeded in realising energy efficiency renovation. In addition, a study by Haines and Mitchell (2014) undertaken in the UK found that owner-occupiers could be segmented into five types of renovators according to their goals and motivations. Understanding the range of different types of renovators could assist in the development of targeted information that is of relevance to specific owner-occupiers.

#### Investors/Landlords

Investment properties are not occupied by the home-owner; generally, they are occupied by tenants under a lease arrangement. The landlord is generally responsible for purchasing major appliances and facilities, such as ovens, dishwashers and hot-water systems, and other major home improvements. The tenant however, is responsible for paying the ongoing energy costs. This means the potential benefits of refurbishing a rental property such as improved thermal efficiency and reduced energy costs are directly experienced by the tenant, not the landlord. This 'split incentive' has been identified as a barrier to upgrading rental properties (Gabriel et al., 2010; Willand et al., 2012). In interviews with private rental investors, Gabriel et al (2010) found that respondents made particular reference to this issue in regards to items of greater cost such as solar panels and hot water systems. In addition, a landlord may decide to prolong a refurbishment or opt for a cheap solution when the decision is based upon the upfront cost (Willand et al., 2012). Furthermore, the cost and lack of financial incentive for landlords were significant barriers, even amongst those supportive of environmental measures (Gabriel et al., 2010).

Furthermore, Willand et al. (2012) review of the drivers for retrofitting existing dwellings to a zero emissions standard also points to research which shows that landlords were twice as likely to discard the building structure and build something new as opposed to homeowners which might hold stronger emotional attachment to the building structure than investors.

The financial risk associated with investment in sustainable improvements has also been identified by property investors as a major concern (Gabriel and Watson, 2012). Concerns identified included: the costs of leading energy and water technologies; potential maintenance and property damage costs; and lack of demand for sustainable properties. While landlords may not experience cheaper energy bills or improved household comfort, potential benefits from refurbishing a rental property include "higher rental charges, increased occupancy rates and stronger reputations" (Gabriel et al., 2010, p.7).

## Influencing stakeholders

### Tenants

Tenant actions to minimise energy and water use are mostly constrained by existing building infrastructure (Gabriel and Watson, 2012). This is because the conditions of private lease agreements generally restrict tenants' abilities to modify or improve their rental property (Palmer et al., 2014). Tenancy agreements in Australia tend to be short in duration, ranging from 6-12 months, therefore, a tenant is unlikely to invest financially in modifications (Palmer et al., 2014). In addition, requests for any modifications or improvements must be made to the landlord or property manager, such requests may be perceived as risking eviction or increases in rent (Palmer et al., 2014). This view is also supported by Willand et al. (2012) review which found that the greatest barriers to retrofitting facing tenants were persuading landlords of property upgrades as well as the limited scope of retrofits allowed. In addition, as it is the investor who bears the cost of any substantive improvements (Gabriel and Watson, 2012), tenants are generally concerned that the capital investment spend on retrofits may be passed on to them through higher rents (Willand et al., 2012). Although studies have identified tenants with ideals of living sustainably, their choice of housing can also be restricted due to shortage of rental properties (Palmer et al., 2014). This shortage greatly reduces the influence of tenants on the market. However, a greater supply of rental housing could potentially rebalance the market and allow tenants to exert greater influence in the low-carbon housing (Palmer et al., 2014).

### Real estate agents

As property managers and marketers, real estate agents have the potential to significantly influence decisions around the uptake of low-carbon housing and refurbishments.

Private rental investors participating in Gabriel and Watson (2012) Australian study would like real estate agents managing rental properties to facilitate sustainable improvements to these properties. More specifically, investors participating in the study would like real estate agents to play a greater role in:

- Disseminating information about sustainable energy and water options
- Raising awareness among landlords about the state of their property in terms of energy and water performance
- Providing incoming tenants with green rental guides
- Assisting and coordinating landlords and tenants to undertake energy and water efficiency improvements
- Assisting with the management and servicing of major works such as solar hot water systems, solar panels and space heating and cooling systems (Gabriel and Watson, 2012).

### Builders/architects/Tradespeople

These stakeholders are often viewed as sources of innovation; propelled by their own interest or identification of a market, they can be drivers and researchers of sustainable options (Crabtree and Hes, 2009). For example, the main perceived benefit for adopting sustainable design and construction processes by small residential building firms in Queensland was improving the industry's reputation (Thorpe and Ryan, 2007).

In addition, due to homeowners low knowledge about energy efficiency retrofits, tradesmen could potentially be an important mediator in the supply chain, identifying the most suitable low-carbon products for specific renovations (Risholt and Berker, 2013). For example, improving thermal insulation has been identified as a preferred approach by architects.

However, these stakeholders may also pose a barrier. This is because the practices of the industry are also driven by their perceptions of consumer demand, and the cost and/or risk of a particular action (McGee et al., 2008; Miller and Buys, 2012). Industry perceives there to be little demand from consumers for sustainable housing (Miller and Buys, 2013). In addition, research by McGee et al. (2008) found that decisions around low-carbon housing were driven by profit and advantage over competitors and the industry was found to relate sustainability negatively to both drivers. Research by Risholt and Berker (2013) also identifies bad advice from tradesman as a barrier for homeowners implementing energy efficiency technology.

In addition, other barriers identified for these stakeholders groups include a lack of legislation to drive low-carbon fittings/designs in housing retrofits (Osmani and Davies, 2013) as well as industry preferences to supply to the minimum standards/guidelines (Miller and Buys, 2013). Similarly, other research reported the frustrations of some householders who had dealt with architects or builders who refused to go beyond the minimum guidelines (Berry et al., 2014). Thorpe and Ryan (2007) argue that the main drivers for smaller residential firms to engage in sustainable building practices are the notion that 'it was good practice' and responds to legislative requirements.

A study examining the effect of some key drivers on the construction contractors' adoption of carbon reduction strategies indicate that most carbon reduction strategies are not being adopted in construction projects. Such findings are in line with scholars' comments on the construction contractors as being apathetic to reduce carbon emissions (Wong et al., 2013)

A study by Thorpe and Ryan (2007) which investigated how smaller residential building firms in Queensland engaged in environmentally sustainable design and construction practices found that industry associations, training events, suppliers, journals, magazines and advertisements were the main sources of knowledge for small residential building firms. In addition, the study found that employees, designers and subcontractors were also important sources of information. The study also points to the need for greater integration of sustainability practices during the design stage. The builders involved in the research cited a number of reasons for not incorporating sustainable practices into their activities, including:

- Lack of testing of some sustainability practices
- Lack of tradespersons with the necessary expertise
- Higher cost and increased liability as a result of increased project complexity and competition (Thorpe and Ryan, 2007).

## Conclusion and next steps

This literature review has shown that there is a great breadth of work focused on understanding individuals' attitudes and behaviour regarding energy consumption, with a great number of studies focusing on the responsibility of individuals to lower carbon emissions through changing their individual behaviour inside and outside their homes (Shove, 2010). However, as stressed by Moloney et al. (2010), human behaviour needs to be placed within the wider context where social practices are undertaken. This means that it is essential that research goes beyond determinants such as costs, motivations and incentive to understand how social practices influence householders daily routines (Moloney et al., 2010; Shove, 2010).

This review highlighted the factors that play a key role in influencing homebuyers and lessees when making decisions about purchasing and/or renting a home. The key factors identified in this review that should be further explored in this research are:

- Individuals' knowledge, awareness and level of interest in information about low-carbon products/homes
- Householders' notion of home comfort and its relationship to low-carbon products/homes
- Individuals' perception of the costs of low-carbon products/homes and its effect on home affordability: upfront versus operational costs
- How low-carbon products/homes are seen by householders in different life stages
- Individuals' perceptions of the value of low-carbon products/homes in relation to other valued home improvements such as increased floor space, new kitchen and bathrooms
- Individuals' perceptions of 'moments of change' and the reasons why it might facilitate the adoption of new technology and/or practices
- Householders' perceptions about potential restriction of low-carbon products/homes on their preferred choices of designs.

This review also identifies the social actors involved in the market for low-carbon housing that are either a potential adopter of such technology or an influencing stakeholder. Aspects of this review which remain to be explored are:

- Homeowners versus investors' perceptions and priorities about low-carbon products/homes and how upfront versus operation costs influence decision making
- Tenants' perceptions, priorities and interaction with landlords regarding low-carbon products/homes
- Real estate agents' perceptions, experience and interactions with homeowners and tenants about low-carbon housing market
- The perceptions and experience of builders/architects/tradespeople in facilitating the adoption of low-carbon products/homes.

The next stage of the project includes conducting focus groups with individuals in both urban and regional areas to further investigate their perceptions of low-carbon home as well as existing rating tools. The objective is to establish the baseline understanding and attitudes towards the idea of voluntary rating and disclosure by homebuyers and lessees, sales and rentals staff and real estate agents across Australia.

Following the focus groups, telephone-based interviews or online surveys with builders, developers and real estate agents will be undertaken to further investigate the gaps in information and skills to support increased sales and rentals of low-carbon homes.

Concurrent with stakeholder interviews, a national survey representative of the Australian population will be conducted to investigate two key aspects:

- Individuals' perceptions to specific low-carbon features (e.g. installed PV, north-facing aspect, comfort, light exposure) to determine the influence, understanding and priority these have for homebuyers and lessees
- Stakeholders' (homebuyers; investors and lessees) perceptions of the useability and potential influence of home carbon rating regulation (voluntary or mandatory).

Findings will be compared between Australia Capital Territory (ACT) respondents, where mandatory rating disclosure is required, and other states.

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