Low-Energy Housing as a Means of Improved Social Housing: Benefits, Challenges and Opportunities

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Abstract Rising energy costs are significantly impacting low-income households. These households can struggle to pay their utility bills, and/or self-ration how much energy they consume which impacts on liveability within the home, such as the provision of appropriate thermal comfort. While incremental progress is being made in terms of improving the energy efficiency of housing in many developed countries, such improvements are typically inaccessible to low-income or social housing tenants. This chapter presents outcomes of a multi-year evaluation of a cohort of low-energy social housing from Horsham in regional Victoria, Australia. The analysis includes technical performance data and is supplemented with the occupants' own stories about improved liveability outcomes. It is clear that the evidence supports aspirations by the state housing agency, which owns and maintains the housing, to move beyond their current minimum housing standards for new construction. A combination approach, whereby the thermal performance of the dwelling is improved, in addition to including renewable energy generation, will address several goals of social (or public) housing providers—namely improving quality of life, health outcomes, finances and poverty. In addition, such housing will help them achieve organisational or broader government sustainability goals such as reducing greenhouse gas emissions and fossil fuel energy consumption.

1 Introduction

The unsustainable energy performance of housing in Australia, and many developed countries, is not just an issue for the environment (see Chapters "The Built Environment in Australia", "An End-User Focused Building Energy Audit: A High-Density Multi-Residential Development in Melbourne, Australia", "Are we Living with Our Heads in the Clouds? Perceptions of Liveability in the Melbourne High-Rise

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P. Rajagopalan et al. (eds.), *Energy Performance in the Australian Built Environment*, Green Energy and Technology, https://doi.org/10.1007/978-981-10-7880-4_7

Apartment Market" and "The Way Forward-Moving Towards Net Zero Energy Standards" from this book). Sustainable housing is increasingly also about improving outcomes for occupants in the dwelling, by improving thermal comfort, liveability and reducing costs of living [8, 9, 28]. This last point is of increasing concern in many countries with the cost of energy rising significantly in recent years. In Australia, from 2007 to 2017 the price of electricity rose by 62% and gas 71% (both inflation adjusted) [5]. Other countries have experienced varied rises (and falls) in the price of energy, for example in the 10 years to 2016 the price of electricity rose by almost 21% in the USA [14] but rose by 65% in England [12].

It is low-income households who are most at risk from increasing energy prices. For this chapter, low-income households refer to those households who are in the lowest equivalised disposable household income quintile as defined and measured by the Australian Bureau of Statistics [1]. These households typically have limited ability to absorb additional costs which can result in disconnection of utilities when payments are not made on time [2, 6, 10, 11]. In 2015–16, there were more than 135,000 energy disconnections in Australia demonstrating the size of the problem [4, 15]. There is evidence that some low-income households reduce their energy costs by self-rationing their energy consumption which can lead to other issues such as compromising appropriate thermal comfort levels [10, 16, 18, 23]. Research has found that some low-income households will make trade-offs from other areas of their life (e.g. healthy eating, healthcare, education) to ensure they can pay their energy bills [10].

While some progress is being made in terms of improving the energy efficiency across the residential sector in Australia (e.g. the 6 star National House Energy Rating Scheme (NatHERS) requirement for new housing or retrofit of existing housing, see Chapter "The Built Environment and Energy Efficiency in Australia: Current State of Play and Where to Next"), such improvements are typically inaccessible to low-income social housing tenants who have limited control over what dwelling they live. Social housing can be a mix of age and quality as government and not-for-profit social housing providers juggle the need to provide more housing as well as upgrading their existing housing stock with challenges including capital costs, split incentives and conflicting or complex information [2, 6]. Occupants in social housing generally have limited means to make improvements themselves and often have older, less energy efficient appliances (e.g. fridge, washing machine) [2].

While there are increasing numbers of sustainable housing projects occurring around the world, there are less which are specifically targeted at social housing [17, 19, 25, 26, 29]. This chapter presents a case study of a multi-year evaluation of a cohort of low-energy social housing from Horsham, Victoria.

2 Social Housing in Australia

This section provides a brief overview of social housing in Australia. As defined by the lead social housing provider in Victoria, Australia, social housing is made up of two types of housing, public housing (state owned/managed) and community housing (not-for-profit owned/managed) [13]. It is for people on low incomes who need housing, including those who have recently experienced homelessness, family violence or have other special needs and can be for short- or long-term accommodation.

There are gross income thresholds set to qualify for social housing which differs between states and organisations around Australia. For example, in Victoria for 2017 the state government housing provider has a threshold range of $981 gross weekly income for a single occupant household to $2025 gross weekly income for a family with dependent children. There are also asset limits which also apply. Households which qualify for social housing are provided access to housing at below-market rental rate value and may be provided with additional financial or other assistance to help them meet minimum quality of life requirements. In Victoria, where this chapter is focused, the state government housing provider sets the rent cap for low-income households at 25% of their gross income.

Information by the Australian Institute of Health and Welfare [3] reported that in 2016 there were more than 845,000 tenants living in 394,000 social housing dwellings across Australia. Almost 80% of these were through state government housing provision (i.e. public housing). Tenants are more likely to be older persons over the age of 55 years or children under the age of 15 years. Almost two-thirds of tenants are women and just over half of all households are single adult households. Approximately 41% of households in public social housing have been in their tenancies for more than 10 years. Social housing covers a range of housing types from apartments through to detached housing.

The providers of social housing often face complex and sometimes competing objectives which must be balanced out. For example, one typical objective is to provide housing for all those in need. In Australia, there is a need for more social housing and so there is an ongoing requirement to add additional houses to keep up with demand. Developing new housing, or purchasing existing housing, is a costly exercise and so due consideration must be given to ensure that the best value for money is achieved.

3 Pushing Design and Sustainability Boundaries

The Department of Health and Human Services (the Department) is a Victorian State Government Department which provides, amongst other services, housing to low-income households in Victoria. The Department currently has a portfolio of more than 84,000 dwellings which they own and manage. Their portfolio of housing includes different dwelling types (e.g. detached housing, apartments), locations (urban and regional) and cater for a range of different living arrangements (e.g. single occupants, family living, special needs, elderly), highlighting the complexity they face in providing housing for those in need.

Within the broader context of the government's requirements for improved sustainability outcomes, the Department has been exploring how to improve the sustainability and performance of their dwellings (both the physical building and how they are being used by tenants) and what impacts on social and health outcomes are likely to be for their tenants, as well as contributing to the governments broader sustainability improvement goals. For example, the Department has been involved in developing higher density apartments such as K2 which included passive design features, rainwater harvesting, grey water reuse, solar hot water and photovoltaics for renewable energy generation [30]. The K2 apartments were designed to have improved performance compared to standard apartments at the time of its construction. This included using 55% less mains electricity, 46% less mains gas and 53% less mains water.

However, the Department recognised that this was just the beginning and more needed to be done in relation to improving the performance and sustainability of their building stock, including developing a plan for lower density housing [24]. The Department made a strategic decision to develop an innovative and leading sustainable social housing exemplar project which went significantly beyond minimum standards to explore what the costs and benefits were for both the Department and for the tenants, and how the development could inform future departmental housing developments and standards.

Horsham, in regional Victoria, was selected as the location for the development as it offered extreme summer and winter climatic conditions (climate zone 27 in NatHERS—hot, dry summer, cool winter). This allowed for comprehensive analysis of how such housing performs in the context of a changing physical climate, with the predictions that Victoria (like other locations) will be facing more frequent and severe weather events.

The result was the construction of four two-bedroom, single storey, sustainably designed units with a NatHERS rating of 8.9 stars (referred to herein as low-energy houses or LEH). These low-energy houses have a predicted heating and cooling energy load of 25 MJ/m^2/year and utilised a number of key design and technology features to achieve the low-energy outcome such as improved insulation, glazing and thermal mass (see Table 1; Figs. 1 and 2). Seven control dwellings and households were also included in the research. The control houses were all located in Horsham and built at a similar time to the low-energy houses; however, they were built to the Department standard requirements at that time; a 6 star NatHERS rating with a predicted heating and cooling energy load of 108 MJ/m^2/year, but going beyond this minimum requirement by also including solar hot water and a rainwater tank not plumbed into the house (see Fig. 3). The design elements for both the low-energy and control houses are listed in Table 2.

The additional capital cost for the sustainability elements of the low-energy houses was calculated to be $75,800 per dwelling (see Sect. 4.3). The Department also provided each low-energy household with a manual on how to maximise the performance of their new dwellings and conducted a 2-hour hands-on house tour to show tenants how the houses operated before they moved in to ensure that all residents understood the various sustainability design elements and technologies included in the dwelling.

Table 1 Design and technology inclusions for the low-energy and control houses

Low-energy house	Control house
8.9 Stars—25 MJ/m^2/year predicted heating and cooling energy load	6.0 Stars—108 MJ/m^2/year predicted heating and cooling energy load
Solar hot water systems (gas boosted)	Solar hot water systems (gas boosted)
Two 5000L rainwater tanks shared between the houses and plumbed into toilets	Basic rainwater tanks (not plumbed into the house)
Passive solar design	
Optimum orientation	
Advanced roof design	
Improved levels of ceiling/wall/floor insulation	
External window shading	
Access to natural ventilation	
Increased thermal mass	
Reverse brick veneer construction on back half of housing	
Improved glazing	
1.5 kW solar photovoltaics (PV) system per house, with a 60c/kWh feed-in tariff	

Fig. 1 Picture of one of the low-energy houses in 2012. *Source* Trivess Moore

RMIT University was engaged to conduct a post-occupancy evaluation which began at the end of the first year of the low-energy houses being occupied in April 2013 and went until October 2015. The methods included:

- Three separate rounds of in-home interviews with householders across three years;

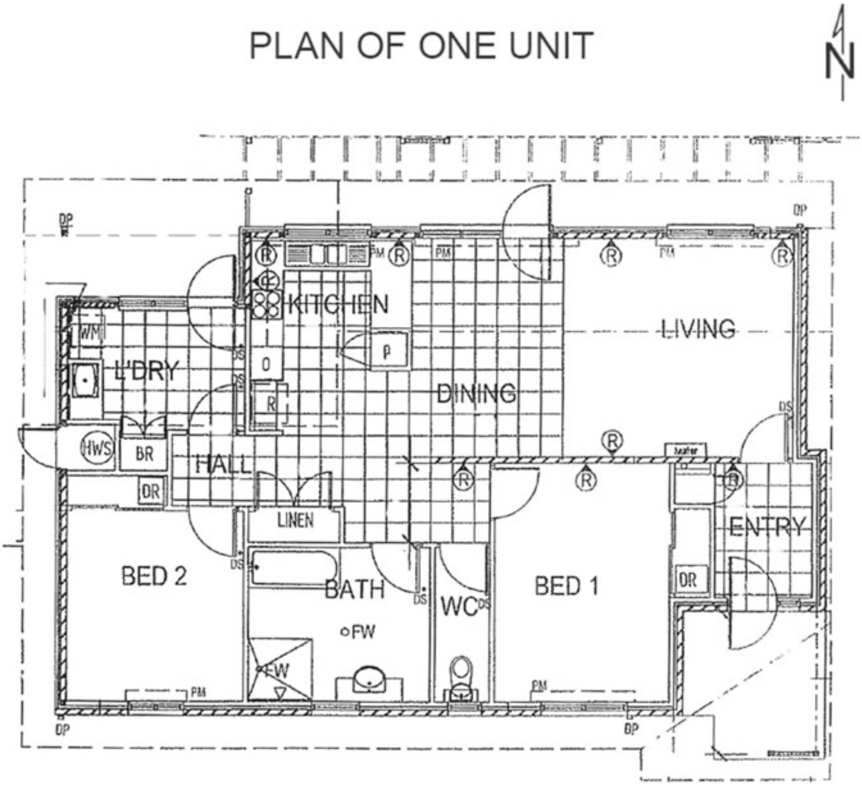

Fig. 2 Floor plan for one of the low-energy houses (while the low-energy house plans were almost identical, there were significant differences between the layout of the control houses so no example floor plan has been included.) *Source* Department of Health and Human Services

- Two rounds of interviews with key stakeholders involved in the conception, design, construction and ongoing management of the low-energy houses. This included the architect, building, electrician as well as key regional and head office Department stakeholders;
- A housing performance and cost–benefit analysis.

For both sets of houses, utility consumption (electricity, gas and water) and renewable energy generation data (where relevant) were monitored at 15-minute intervals via in-home monitoring equipment. This monitored data was cross-checked with utility billing data to improve accuracy. Hobo loggers were also used to measure temperature and humidity data throughout the study for the main living area and main bedroom in the dwellings.

A third-party engineer engaged by the Department to set up the data monitoring and initial utility consumption models, Organica Engineering, developed a Department "standard" performance scenario assuming a two person "average" occupancy

Fig. 3 Picture of one of the control houses in 2012. *Source* Trivess Moore

living in housing meeting the current Department standards at that time. This scenario was applied for comparison to the 11 case study dwellings (four low-energy houses and seven control houses).

Further, details of the methods and outcomes can be found in the detailed project report [24].

4 Analysis

This section provides analysis on how the low-energy houses performed across their first three years of occupation. While there are broader elements of sustainability included in these dwellings (e.g. water efficiency measures), the focus of this chapter is on the energy performance (and by association the thermal performance).

4.1 Energy and Environmental Performance

The low-energy houses improved energy performance through the inclusion of renewable energy technology as well as improving the thermal performance of the

Table 2 Characteristics of each household and house

Code	Household makeup and approximate age at first interview	Dwelling star rating	Thermal performance (heating and cooling MJ/m^2 annum)	Total internal area (m^2)	Total internal area conditioned (m^2)	Cooling technologies used in house
Low-energy houses						
LEH-A	Couple (early 20s) with two children (aged 3 and under)	8.9	26	100	74	Two ceiling fans in living area
LEH-B	Older couple husband and wife (60+ years)	8.9	25	99	72	Two ceiling fans and split-system reverse cycle air conditioner in living area
LEH-C	Single woman (60+ years)	8.9	26	100	74	Two ceiling fans in living area
LEH-D	Single woman (55+ years)	8.7	33	99	73	Two ceiling fans in living area
Control houses						
ConA	Husband and wife (60+ years)	6.0	108	82	73	Split-system reverse cycle air conditioner
ConB	Single mother (mid 20s) and child (3 years old)	6.0	108	97	84	None
ConC	Single male (45 years)	6.4	98	52	40	Pedestal fans
ConD	Husband and wife (55+ years) and teenage boy	6.0	108	97	84	Portable air conditioner
ConE	Single mother (50+ years) and teenage daughter	6.0	110	88	75	Wall unit air conditioner
ConF	Husband and wife (65+ years)	6.0	108	85	76	Split-system reverse cycle air conditioner
ConG	Householder information unknown, monitored performance data only					

Table 3 Summary of average annual utilities consumed/generated from each dwelling from June 2012 to May 2015

	Electricity consumed (kWh)	Total electricity consumed per m^2 of dwelling (kWh)	Electricity bought (kWh)	Total electricity bought per m^2 of dwelling (kWh)	Renewable energy generated (kWh)	Gas consumed (MJ)	Total gas consumed per m^2 of dwelling (kWh)	Total energy consumed (kWh)	Total energy consumed per m^2 of dwelling (kWh)	Total energy bought (kWh)	Total energy bought per m^2 of dwelling (kWh)	Number of occupants
Department standard	4587	36	4587	36	0	21,786	172	10,639	84	10,639	84	1.7
LEH-A	3305	33	1605	16	2916	13,977	140	7188	72	5488	55	3
LEH-B	3495	35	1890	19	2497	26,044	263	10,140	102	9124	92	2
LEH-C	3978	40	1756	18	3257	16,614	166	8593	86	6371	64	1
LEH-D	3285	33	1604	16	2853	27,463	277	10,914	110	9233	93	1.5
ConA	4584	56	4584	56	0	32,776	400	13,688	167	13,688	167	2
ConB	2259	23	2259	23	0	55,864	576	17,777	183	17,777	183	2
ConC	1510	29	1510	29	0	14,827	285	5629	108	5629	108	1
ConD	5860	60	5860	60	0	32,776	338	14,964	154	14,964	154	3
ConE	2223	25	2223	25	0	30,491	346	10,693	122	10,693	122	2
ConF	2172	26	2172	26	0	24,618	290	9010	106	9010	106	2
ConG	3118	NA	3118	NA	0	14,008	NA	7009	NA	7009	NA	2

dwelling. Table 3 presents the monitored energy performance of the low-energy houses (LEH) and control houses (Con) in comparison to the design of the Department standards. The control households consumed less electricity (3104 kWh) when compared to the low-energy households (3516 kWh). When adjusted to include the solar generation, the low-energy households purchased 45% less electricity compared to the control households and 62% less electricity compared to the Department standards. The low-energy households were also found to consume 15% less gas when compared to the control households and 3% less gas than the Department standards.

Figure 4 presents the preceding electricity and gas data in a single graph for comparison. Overall, the low-energy houses used an average 12% less energy than the Department standards and 7% less energy than the control households. When solar generation is factored in, overall the low-energy houses purchased 29% less energy than the Department standards and 24% less energy than the Control households. This translated to the low-energy houses achieving 50% less environmental impact (CO_2^{-e}) compared to the Department standard and 40% less environmental impact compared to the control houses.

4.2 *Improved Thermal Performance in Summer*

While the direct performance of energy consumption and generation discussed above points to more sustainable housing, there was also the benefit of addressing energy efficiency with respect to the thermal performance of the dwellings, especially over the summer months. The low-energy houses were built to not require air conditioning.[1] Analysis of the summer time temperature data from the low-energy dwellings

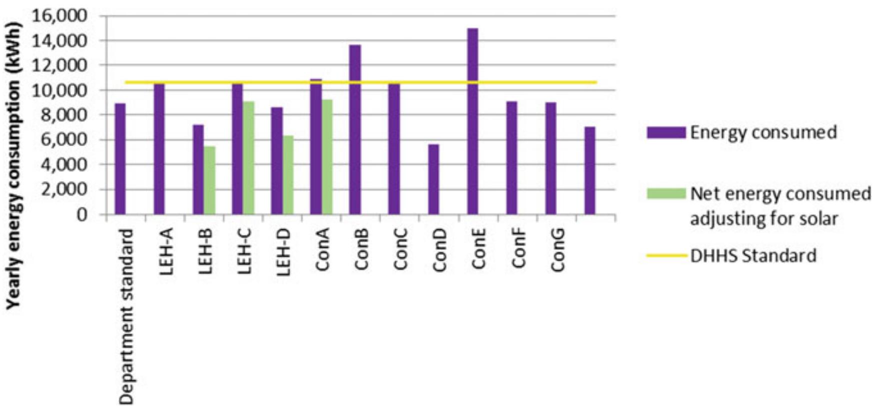

Fig. 4 Yearly energy consumption for each of the dwellings

[1]One of the low-energy houses installed air conditioning during the evaluation period due to perceived health issues (they believed they were more susceptible to pneumonia due to their age and

found that they had better thermal comfort compared to the control households and particularly during extreme weather even though the control houses had various types of air-conditioning systems. For example, during the summer period the average temperatures inside the low-energy houses (23.8 °C) and control houses (24.0 °C) were similar for the living area, but the low-energy houses had an average mean temperature of 1.2 °C lower for the bedrooms. However, the average maximum temperature in the living areas of the control houses was significantly higher (2.7 °C) compared with the low-energy houses.

The assessment of the adaptive comfort criteria against the European thermal adaptive comfort standard, BS EN 15251 using monitored temperature and humidity data shows that the low-energy houses were comfortable for 10% more of the time in summer for the living areas and 7% more of the time for the bedrooms compared with the control houses; this was all achieved without the use of additional air conditioning. The biggest benefit for thermal comfort was during extreme weather conditions such as heatwaves (with temperatures reaching upwards of 45 °C during the study period), when the low-energy houses were significantly cooler than the control houses which were using air conditioning, reflecting the improved design and thermal performance of the dwellings. Figure 5 shows that on the second day of a heat wave, the best low-energy house was 16.6 °C cooler compared to the worst control house (with air conditioning). At least one of the control households (without fixed air conditioning) found it too hot to stay in their dwelling during heatwaves and spoke about the negative impact of having to find other places to stay during such periods. He stated (ConB):

> One of my friends had a device and walked in here one day and it was like 51 degrees… if you're expecting a week of 40's…most of all my friends have got air conditioning so I normally sleep there…

This improved comfort particularly during the more extreme weather periods was something the low-energy residents spoke about during the interviews. For example, LEH-B stated:

> Well we both feel the heat pretty well but when it was 42 degrees outside, it only got to 29 in here…when it was 3 degrees below zero this was 15 degrees inside on that morning, that's without any heaters being on, 15 degrees. So that's good.

This improved thermal performance of the low-energy houses was noticed by the occupants in relation to self-reported health improvements. For example, one occupant used to get pneumonia regularly during winter in their previous accommodation, but had not had a case of it over the first three years in the low-energy houses; an outcome they relate directly to the improved, and consistent, thermal performance. Another occupant reported that they would get cramps in their legs when it got too cold, which made sleeping in winter difficult unless they were next to a heater. Again this had seen a dramatic improvement in the low-energy house due to the improved thermal comfort.

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previous health issues). The monitored data before they installed the air conditioning suggested the dwelling remained comfortable over summer.

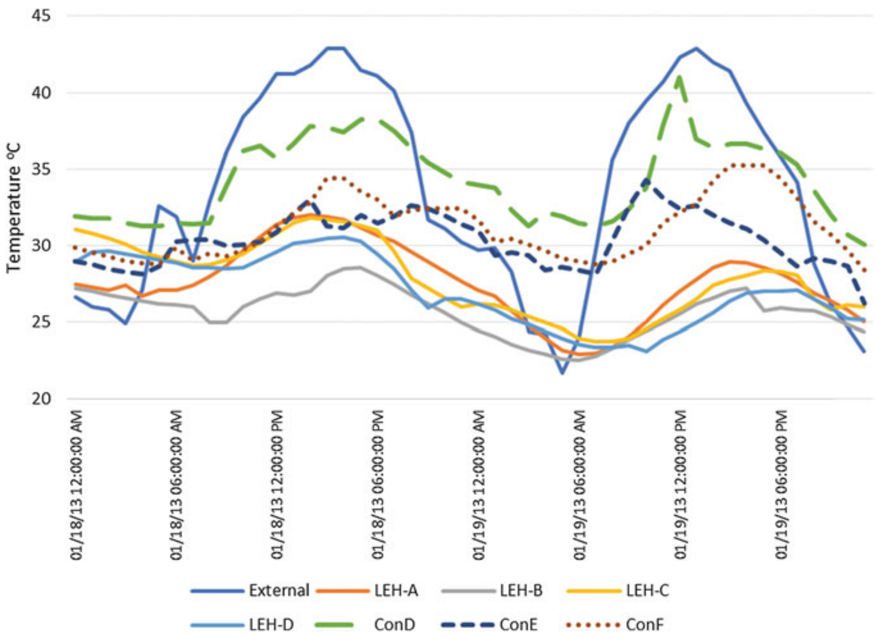

Fig. 5 Temperature in living rooms of monitored houses and external temperature for 18–19 January 2013

Despite the improved thermal performance of the low-energy houses, it was also evident to the researchers that the occupants in the low-energy houses were not always using the design and sustainability features as intended to help with the thermal comfort and overall sustainability of the dwellings. For example, one household was not using the celestial windows to help vent excess heat inside during summer as they believed the architect placed them on the wrong orientation, meaning the occupant believed they let heat in, rather than vented it out.

4.3 Costs

While the above energy, environmental and thermal comfort data all suggest a significant improvement from the low-energy houses, this must be all considered within the context of the cost to achieve such an outcome, especially for social housing providers who must balance the need for more overall housing with the need to improve outcomes from those in the housing. So, what were the costs for the project and is it feasible to be repeating?

The additional upfront cost for the low-energy houses was calculated to be $75,780 per dwelling (Table 4), which was found to be higher than for other similar sustainable

Table 4 Additional upfront costs of low-energy houses compared to standard department houses

Element	Cost per unit	Additional maintenance cost per year per unit ($)	Total cost for replacement across 40 years (includes inflation)
Building envelope	$55,322	$553	
Solar photovoltaic system	$9625	$96	$13,531
Rainwater tank plumbing and pump	$10,833	$23	$1673
Total	$75,780	$672	$15,204

Table 5 Summary of additional costs to the department

Element	Initial cost	Accumulated cost after 5 years	Accumulated cost after 40 years
Additional building envelope, solar photovoltaic, rainwater tank plumbed into house	$75,780	NA	NA
Additional maintenance	NA	$3570	$50,705
Additional solar photovoltaic and rainwater tank elements replacement	NA	NA	$15,204
Change to rent received	$0	$0	$0
Total additional cost to the department	$75,780	$79,350	$141,689

housing projects in Australia [24]. The majority of this cost was for the improved thermal performance of the building envelope. A maintenance costs and cost for technology replacement were also considered. At both a high- and low-energy price future, and for a discount rate of 3.5 or 7.0%, the low-energy houses do not achieve a positive payback within a traditional cost–benefit framing.[2]

While there are substantial costs to the Department over 40 years ($141,689 of which $75,780 is capital cost and $65,909 is additional maintenance and replacement of technologies—see Table 5), there are significant financial benefits to the households. The low-energy households saved an average of $1050 per household from the improved design. They also deliver significant contributions to environment, comfort and broader society benefits that are not costed in this study.

The low-energy households spoke about being better off financially in the low-energy dwellings. This was noticeable for them as it allowed them to do things they had been unable to do previously like buy presents for family members, go shopping without having to use lay-by and even go on a holiday. For example, LEH-D states:

[2]If assuming the Department received the solar feed-in tariff rates.

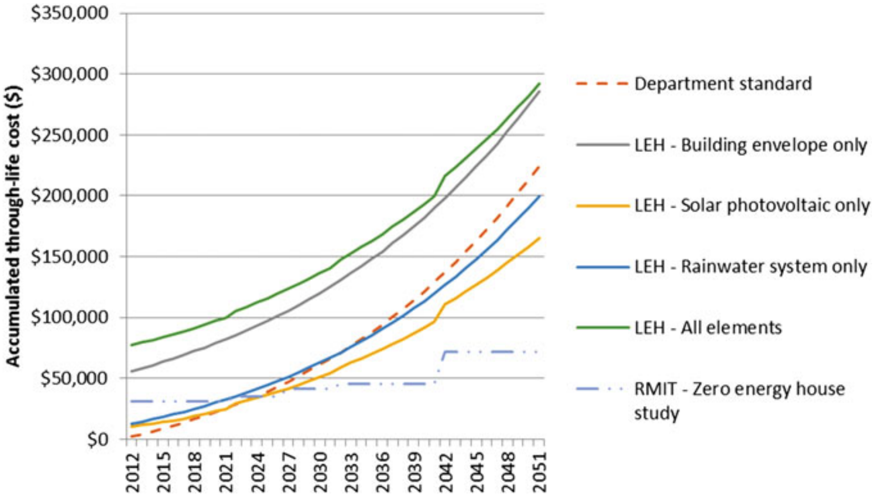

Fig. 6 Accumulated costs for various sustainability elements within the low-energy houses across time for a low-energy price future in comparison to a zero energy house study previously conducted at RMIT University [21]

> I do go clothes shopping on occasion now instead of thinking, "Oh God, I have to go and layby that.

If the additional upfront costs are broken down to their individual elements, there are some elements which are more financially viable than others (Fig. 6). What can clearly be seen is that for both a low and high energy price future, the solar photovoltaic system is the most cost-effective element, followed by the rainwater system plumbed into the house. The solar photovoltaic system has a payback period of 10–13 years, and the rainwater tank plumbed into the house has a payback period of 17–21 years. Only for the high energy price future does the building envelope only or the whole low-energy house achieve a payback (36 years) compared to the standard industry practice, and neither of these options achieve payback within the 40-year modelling against the Department standard. This indicates that it is more economically viable for the solar photovoltaic system and water elements than it is for the building envelope.

5 Discussion

The above analysis demonstrates that the low-energy houses performed significantly better than the control houses from an energy efficiency and thermal comfort perspective. This was not unexpected as the dwellings were specifically designed to be more energy efficient and to generate renewable energy to achieve a low-energy outcome. The question is how these low-energy houses impacts on social housing provision—an area which is often overlooked in the sustainable housing discussion.

5.1 Social Housing Providers

As stated in the introduction, the providers of social housing often face complex and sometimes competing objectives which must be balanced out. They are constantly balancing the need for more dwellings but also to improve occupant liveability, health, well-being and financial outcomes for low-income households, as well as contribute to broader government sustainability targets, an issue which is not just related to the Australian context [20]. Developing new housing, or purchasing existing housing, is a costly exercise and so due consideration must be given to ensure that the best value for money is achieved.

Anything that adds to these costs, as sustainability elements typically do, takes away the ability to obtain more housing. As the above study found, there was a significant cost for achieving the low-energy outcomes, which is arguably the biggest challenge the Department has to overcome if these housing are to be replicated. Broader research has found that achieving low-energy housing could be done for much less than what the Department spent [7] which means if the Department was to repeat this project, significant cost savings could be achieved. For example, the solar panels were found to be about twice the cost of average systems which was partly because of the regional location and constraint of choice in the marketplace.

An additional cost and challenge for social housing providers is not just the additional capital costs, but the ongoing maintenance costs for sustainability technologies such as solar photovoltaics and rainwater tanks. This included needing to factor in for replacement at end of life, and that there will inevitably be faults in these technologies/systems from time to time. While a regular maintenance program can be developed, without some type of remote monitoring of the systems it can be difficult to pick up on faults. One of the low-energy houses in this research spoke about how their solar photovoltaic system stopped working, and it was only when they received their utility bill which was higher than normal that they realised something was wrong. The additional challenges of maintenance and faults for social housing providers have been identified in other low-energy and social housing research [25].

Another challenge is that the Department does not have a mechanism for charging higher rent for their properties even if they have lower costs to live in. Currently, rent is set as a percentage of their total income—in Victoria where this case study is located that percentage is capped at 25% of gross income. Benefits from things such as lower energy bills or income generated through feed-in tariffs are not considered within that framework. To make sustainable housing more affordable for social housing providers, it may be that they need more innovative ways to recoup some of the sustainability costs. For example, perhaps the Department could have claimed half of the feed-in tariff, a situation which would have provided some additional money for the Department, but also ensured the tenant was better off as well.

However, social housing providers typically also have objectives around improving quality of life for tenants, such as through improving health outcomes or financial circumstances. In this regard, the low-energy houses were achieving beneficial outcomes. The occupants self-reported improved health outcomes due to improved thermal comfort. While not explored in detail in this project, reducing the number of trips to the doctors, or hospital stays, due to improved health outcomes resulting from improved thermal comfort has the ability to help reduce costs and congestion across the already stretched health care system.

5.2 Tenants

The challenges for the tenants related to how they used the low-energy houses. Despite being provided with a tour of the houses and having the various sustainability elements explained to them, and being provided a manual for the house, a number of tenants in the low-energy houses refused to use some of the sustainability features as designed. The previously mentioned exampled about the misuse of the clerestory windows to help vent heat in summer is a case in point. This raises questions about if such elements should be automated, or if the households should have control. Overall though the tenants were mostly following the directions on how to use the dwellings.

Another challenge for the tenants related to knowing when the low-energy houses were not performing as they should and how to address the problem. In one instance, a solar panel had failed but the householder did not become aware of this until their energy bill came in two months later and was significantly higher than it had been previously. It was only through contacting their energy provider that the failed solar panel was identified. While it might not be suitable for in-house monitoring for all sustainability elements to alert tenants to any issues, this might be something that the housing provider (in this case the Department) could monitor remotely.

Despite these challenges, there were significant benefits for the social housing tenants in the low-energy houses. For example, the improved energy performance and inclusion of solar photovoltaic systems resulted in the households being better off by $1050 a year in direct energy savings. This in turn meant that these low-energy households were more financially secure and had more money for spending on other areas of their life. One of the households had turned their financial situation around so significantly they no longer received CentreLink[3] payments; this was partially due to improved affordability of living in the low-energy house but also because their health had improved because of the better thermal comfort.

[3]Government welfare payment.

5.3 Opportunities for Social Housing

The benefits realised by the low-energy housing in this case study are in line with what other sustainable housing developments around the world are finding [8, 9, 22, 25, 29]. These benefits include improved environmental outcomes, lower purchased energy, improved thermal comfort, improved occupant health, improved occupant liveability and financial outcomes. As found in other research into low-income sustainable social housing around the world, there is not necessarily one policy or development outcome which will suit every social housing provider [26]. However, there are some key lessons which are applicable across different organisations.

The challenge now for the Department, and other such social housing providers, is to find a way to improve sustainability at a lower capital cost. One option would be to pull back on the thermal performance (e.g. back down to 8 stars NatHERS rating), but this would then mean the housing would not perform as well during extreme weather conditions and would likely require the inclusion of air conditioning which would add additional capitals costs for the systems and ongoing operating costs for the households. There have also been other building and technology innovation in the years since these low-energy houses were built, so there would likely be cost efficiencies that could be found, for example with the solar panels. There is also a need for the way that occupants use social housing to be better integrated into the design process to ensure that the housing performs as predicted [27].

5.4 Limitations

Due to the space limitations of this chapter, some elements from the above evaluation have not been explored in detail. Further details from the study, including additional data analysis (e.g. blower door tests) can be found in the main project report [24].

6 Conclusion

This chapter has explored the performance and outcomes of a low-energy social housing development in regional Victoria, Australia. The evidence finds that the houses performed extremely well in terms of energy efficiency. The houses also provided a number of benefits of the social housing tenants such as reducing energy bills, providing an energy rebate from the feed-in-tariff from the renewable energy generation and improving health and well-being outcomes. While there were many benefits, there were also several challenges both for the Department (e.g. high upfront costs) as well as the tenants (e.g. learning to use the houses as designed). It is clear though that the evidence supports aspirations by the Department to move beyond their current minimum housing standards for new construction. A combination approach, whereby the thermal performance of the dwelling is improved, in addition to including renewable energy generation, will address several goals of housing providers—namely improving quality of life, improving health outcomes, finances and environmental impacts.

Acknowledgements The construction, research and evaluation of this project were funded by the Director of Housing, Victoria and are reproduced with permission of the Director of Housing. The author thanks the research participants (householders and stakeholders) who generously gave their time to this project, Becky Sharpe and Daniel Voronoff from the Department of Health and Human Services, Ian Adams from Organica Engineering and acknowledges the wider RMIT research team involved in the project: Yolande Strengers, Cecily Maller, Larissa Nicholls, Ian Ridley, Ralph Horne and Shae Hunter.

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