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Article

Increasing Energy-Saving Actions in Low Income Households to Achieve Sustainability

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Abstract: Residential energy consumption contributes up to one-fifth of total greenhouse gas emissions in Australia. Low-income households could benefit from energy efficiency behaviour change programs with anticipated "bridge sustainability" outcomes of environmental and financial benefits and increased well-being, but participation rates from this demographic are often low. The EnergySavers energy behaviour change program was designed for Australian low-income households. A variety of information materials were delivered in structured discussions over a five month period in 2012, with 139 low-income participants in two Australian cities in different climate zones. This article identifies which energy-saving actions low income households are already undertaking and, after completing the program, which actions were most commonly adopted. Participants reported that their participation in the program increased their energy-saving actions, increased their control over energy consumption, and that they disseminated their new knowledge through their social networks. Findings identified the importance of group discussion within demographic groups for information uptake and adoption of new energy behaviours. The housing situation, home population and language background were found to have a significant influence on the uptake of new behaviours. The results also suggest that the program would benefit from amendments to the actions and assessment prior to national roll-out to ensure that effective and long term bridge sustainability can be achieved.

Keywords: energy consumption; behaviour change; low-income; Australia; bridge sustainability

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1. Introduction

Residential energy consumption in households ranges between 15 and 20 percent of total energy consumption in the Organisation for Economic Co-operation and Development (OECD) countries [1]. Although modern households use energy more efficiently than in the past, household energy consumption has been steadily increasing [1]. Residential energy consumption is affected by a range of factors, including heating and cooling devices (and expectations of resulting comfort), household population and occupancy patterns, cultural habits, standards of living and use of appliances [1]. The household sector has considerable energy conservation potential, with behaviour of building occupants one major contributor in the building's energy consumption even if technological and economic factors remain constant [2–4]. In Australia, households are currently responsible for 21% of Australia's annual carbon pollution [5].

There are a range of environmental and socio-economic benefits as a result of adopting energy efficient behaviour. Environmentally, benefits include achieving reduced greenhouse gas emissions, and reduced reliance on non-renewable fossil fuels, resulting in benefits for the physical environment. From a socio-economic perspective, energy efficiency behaviour can improve energy security and bring benefits that include improved household wellbeing through efficient heating and cooling, and reduced household financial strain from energy bills.

For low income households, energy consumption is a significant cost as a high proportion of income is spent on energy, and there is often limited access to capital or ability to change the housing infrastructure, especially in rental accommodation [2,6]. This situation exists despite low income households, in general, consuming less energy than higher income households [7]. In addition, around 19% of Australian residents live in low economic resource households [8]. These low income households identified as being at risk of energy poverty include those living in energy inefficient housing, relying on old or energy inefficient appliances, with health and disability issues, located in remote indigenous communities, with large family households and with high energy consumption or residing in areas not served by many or cheaper energy options [9].

Despite the significant spending on energy by these households, an international review of energy behaviour change programs by [10] found that most energy behaviour programs are delivered to households with higher than average incomes and education. A similar review in Australia led by [11] found that only 10 percent of the programs involving households were targeted at low-income households [11]. It is recognised that this particular demographic would benefit greatly from programs that target their specific needs and context in regards to energy efficiency and behaviour change [12].

This article investigates an energy efficiency pilot program for its impact on low-income participants' knowledge of, and actions on, energy saving. It also investigates participants' sense of control over their energy use, and on the dissemination of the information beyond participants to social networks. The article initially provides the current context of energy efficiency programs for low-income households, and then describes the CSIRO energy program developed for this target audience. The methods of the program development and evaluation are detailed. The results are presented and discussed for the program's impact on participant knowledge of energy-saving behaviours, energy-saving actions undertaken, dissemination of program information within their social networks, and remaining barriers to energy actions. The findings of this assessment outline future research opportunities, and these

will inform a larger-scale roll-out of the program in Australia. This article contributes to the literature on energy behavior change as well as the specific energy information needs of low-income participants.

2. Conceptual Framework and Methodologies

Efforts to achieve bio-physical environmental goals through behaviour change has been termed by Vallance *et al.* [13] as "bridge sustainability"; it describes a branch of sustainable development that considers social impacts while identifying economic and bio-physical challenges. Additionally, it addresses how to prompt environmentally-beneficial behavior. Such behaviour change can be achieved through a combination of non-transformative intervention or efficiency behaviour, such as providing supportive infrastructure and information, as well as transformative intervention or curtailment behaviour, where new behaviours have to be introduced, prompted and repeated until they become habitual [13]. It is to address this gap and create bridge sustainability for which the "EnergySavers" program was designed, developed through a collaboration between energy efficiency experts and social scientists within and beyond Australia's government science agency, the Commonwealth Scientific and Industrial Research Organisation (CSIRO) [13].

The EnergySavers program was designed based on the social-psychological model, outlined by Costanzo *et al.* [14] for use in energy behavior change programs. Energy consumption strategies developed using this model focus on two types of behaviour change: one-off ("efficiency", such as the installation of an efficient appliance) or repetitive behaviours ("curtailment", such as changing long term habits) [10]. McMakin *et al.* [3] and later Dietz *et al.* [15] recommended behavior change through actions that are convenient and easy to perform if individuals are provided with the skills and knowledge to undertake the behaviour. Further to this, if these behaviours are repeated consistently, this ensures they can more easily become long-term habits.

Sutterlin *et al*. [16] identified that financial savings are often the main driver for energy-saving behaviour for low income householders, while other researchers, including Steg [17], argue that normative and environmental concerns are important in promoting energy conservation, as energy-saving behaviour that is solely based in cost or hedonic savings is less likely to be sustained. Similarly, Niemeyer [18] found that householders least likely to act to reduce greenhouse gas emissions hold lower pro-environmental attitudes and less concerns about, and knowledge of, environmental issues. Due to these financial constraints and motivations, low income householders are more likely to adopt curtailment behaviour, involving repetitive efforts to reduce energy use [19].

The communication and delivery mode for EnergySavers' design is also drawn from the social-psychology model. For a more in-depth analysis of these aspects of the program, a qualitative case study approach of the EnergySavers' program has also been published [20]. Stern [2] documented that communication of messages are best received when delivered by a credible source that ideally has expertise in energy use and also holds the trust of the individual, and this is emphasised in more recent work on Community-Based Social Marketing by McKenzie-Mohr [21]. Delivering the behaviour change program through face-to-face group discussion can encourage participants to develop a more complete understanding of a complex issue [22,23]. In addition, delivering the program within existing social networks can assist a change of behaviour through mutual learning and peer support. This builds on Lave and Wenger's observations that the nature of the situation can significantly influence the

process of learning, where they stated, "this social process, includes, indeed it subsumes, the learning of knowledgeable skills". ([24], p. 29). Stern's early work [2], and later research by [25], documents that messages about the benefits of the behaviour change are received with greater salience within social networks as it comes from known and trusted social connections.

Such face-to-face peer support groups have been found to be effective in other community actions when barriers to behaviour change are high or the requested behaviour actions are numerous or complex [26], and the "norming" effect occurs among participants as they adopt a new behaviour. McMakin *et al.* [3] notes that more permanent changes in energy consumption behaviour have been noted when social norms develop to support the behaviour, such as family and friends undertaking the same behaviour as the participant. Public goal-setting has also been found to increase the likelihood of achieving behavior change [21].

3. Background: EnergySavers Program

EnergySavers is a residential energy efficiency program for low-income Australians, with the pilot conducted in 2011–2012 by the CSIRO. EnergySavers was designed based on the conceptual model outlined in Section 2. Focus groups were initially conducted with low-income householders to investigate the type and format of information participants would be interested in receiving regarding energy efficiency. The program sought to increase participants' energy-saving actions and sense of control over their energy consumption, in order to meet financial and well-being needs, and to reduce greenhouse gas emissions from residential energy use. It was promoted for the dual environmental and economic benefits.

Twenty-two energy-saving actions identified through earlier CSIRO research on residential energy efficiency were introduced in both the pre-questionnaire, which was administered prior to commencing the program, and in the post-questionnaire which was administered at the completion of the program [27]. These actions, detailed in Table 1 were identified as meeting the criteria of being convenient and easy to perform, and as likely to become long-term habits [3,15]. These actions were selected for the diversity of rooms in which they can be undertaken in the home and their "low cost or no cost" financial commitment. It is acknowledged that additional actions exist, and that, methodologically, providing such a list of actions may inadvertently prioritise or instigate such actions. However, these risks were considered manageable within the analysis and the authors have ensured transparency when reporting results.

The communication and delivery mode is also drawn from the social-psychology model. Information messages were delivered from CSIRO-endorsed scientific material, considered a "trusted advisor' to the public, with the magazines and video clips focused on low or no cost actions to achieve savings from changing energy behavior [28]. Face-to-face group discussion within similar demographic or pre-established social groups creates a supportive environment for goal-setting to ascertain new norms within the groups.

The EnergySavers groups brought participants together in discussions as equal individuals for a deliberative session each month for five months to discuss energy efficiency at home, facilitated by a non-expert convener. Commitments were sought from participants by identifying and writing several goals at the end of each session in their magazine, and revisiting this at following sessions.

Table 1. Energy-saving actions measured.

Energy-saving actions
For all areas in the home
Turning appliances and devices off at the power point when not in use
Switching off the lights in rooms that are not being used
Reducing the time the TV is on, even when people are home
Setting goals or targets for reducing energy usage and sticking to them
Checking electricity bill against the meter
Buying energy efficient appliances
Heating and cooling the house
Closing off areas that don't need to be cooled in summer or heated in winter
Shutting blinds/curtains to reduce heat getting into/out of the home
Using fans or natural ventilation for cooling the house instead of using the air-conditioner
Minimizing the use of the air conditioner
Reduced air conditioning costs by choosing the right temperature (18 °C or less in winter and 25 °C or more in summer)
In the Laundry or Bathroom
Washing clothes in cold water
Hanging clothes to dry naturally
Using a fan to help drying the clothes quicker
Minimizing the use of the clothes dryer
Only running the washing machine with a full load
Having shorter showers
In the kitchen
Cooking larger meals then freezing leftovers to be consumed in another day
Only running the dishwasher with a full load
Turning off the second fridge
Using a thermometer to make sure the temperature is in the correct range for both fridge and freezer
Maintaining the refrigerator (checking for leaks, the seals and defrosting the freezer)

The program information was delivered through five magazines, nine video clips, discussions and take-home activities (see [29]). The formats were recommended by the low-income focus group participants as media they regularly sought out and enjoyed. The printed materials were presented in a form similar to popular magazines, with large text, personal testimonials, and strong use of images, as displayed in Figure 1. Five video clips were presented in the format of a commercial "Morning" television show, with a "friendly" anchor, "handy" hints placed on the screen in text, and actors demonstrating the energy efficient behaviour. Two video clips were "testimonials" performed by actors using a script created from energy saving actions cited by focus group participants. A further two video clips were sourced from existing websites to describe climate change and to provide guidance on how to read an electricity bill. The materials were intended to be accessible for participants with lower levels of literacy and English proficiency, and to be similar in style to the media format already accessed by the this target audience. The behaviours presented were either low cost or no cost to reduce barriers to implementation.

Figure 1. CSIRO EnergySavers material: magazine cover image magazine and a video screen-shot.

4. Methods

EnergySavers was delivered as a pilot to a small portion of the target population in 2012 in Brisbane and Melbourne, two Australian cities with different climate zones and potentially different energy behaviours. Based on the Köppen system, Brisbane is a sub-tropical climate with warm winters and hot summers, while Melbourne is a temperature climate with cold winters and hot summers [30].

Participants were brought together in community groups for a deliberative session each month for five months to discuss energy efficiency at home. The majority of groups interacted in face-to-face sessions, but a small number participated instead in an online chat-room, to test the importance of the face-to-face delivery and social opportunity that this provided.

Program participants were recruited through a variety of channels. This included individual invitations, through established community groups, and through a marketing agency. The final participant numbers are displayed in Table 2 for different treatments including face-to-face and online discussions (with and without grocery vouchers as incentives). To test the value of engagement and discussion, a group was provided with information only (without an opportunity for group discussion).

Table 2. Treatment and gender of EnergySavers pilot participants.

Treatment	Male	Female	Not stated	Total
Face to face without incentive	26	61	7	94
Face to face with incentive	2	10		12
Online without incentive	0	1		1
Online with incentive	6	14		20
Information-only	1	11		12
Total	35	97	7	139

Participants in the EnergySavers pilot program were mostly females (73%) and/or not in the work-force (68% were retired, unable to work, looking for work, conducting unpaid work or studying). Only 22% of participants were between 18 and 34 years old, with 45% of participants aged between 35 and 54 years and 33% of participants being above 55 years old. Over 75% of participants reported a household income below AUD$60,000, considered to be a low income. These participants lived in mixed housing situations: 40% of participants lived on their own properties, while 34% of participants were renters, 16% of participants lived in share accommodation and 3% lived in public housing. The household size was mainly two to four people, although 18% of participants lived in households with five or more people. Nineteen percent of participants indicated that they have a non-English speaking background (NESB) with the main language spoken at home a language other than English. Many of these participants were recently-arrived migrants.

Participants were asked to complete a questionnaire at both the start and end of the pilot, a common means of evaluating energy behaviour change programs [31]. Demographic questions were asked to profile the participants, as well as control the potential effect on relationships between variables of interest. Twenty-two energy saving actions were assessed in both questionnaires. In addition, perceived control over energy use, thermal comfort and energy efficient behaviours performed were asked. The post-questionnaire assessed whether program information was disseminated to members of the participants' personal networks. Wilcoxon matched-pair signed-rank tests were conducted to compare the participants' responses in the pre- and post-questionnaires. This is a non-parametric statistical approach to compare matched samples often employed when it is not possible to make specific assumptions about the distribution of the data in the populations from which the sample is extracted [32].

Electricity meter data was not included in this analysis due to the following reasons: the small sample of available data; the fact that NMI data was from 12 different energy retailers and thus in different formats; and the reporting period differed too greatly to allow any data comparisons. This analysis also did not included data from the control group, as their questionnaire did not include energy behavior measures explored in this paper. Furthermore, as the program was conducted over a nine month period and the NMI data was mostly provided in non-comparable quarterly periods, the effect of the two climate zones could not be assessed.

To gather in-depth views, participants were randomly chosen within each group to participate in 15 minute telephone interviews. They were asked questions regarding the perceived impact of the program, dissemination of the information and the actions undertaken since commencing the program. Of the total 139 participants who completed the program, 29 were interviewed, representing 21 percent. This constituted five from Brisbane and 24 from Melbourne. The transcripts were analysed using NVivo 9, a form of Computer Assisted Data Analysis Software (CAQDAS), to extract the recurring themes from the various discussions [33].

5. Results and Discussion

This section presents quantitative data drawn from the questionnaires, and enhanced or validated with the qualitative interview responses. Only quantitative data from matched pre- and post-questionnaires are cited here. There were no statistically significant differences in responses between those that

received and did not receive a financial incentive to participate. Given this, the findings are presented as three treatments only: face-to-face discussion, online discussion and information only.

5.1. Knowledge of Energy-Saving Behaviours

As shown on Table 3, participants self-reported their knowledge regarding how to reduce household energy use. Participants in the online group reported a significant increase in their knowledge of actions to reduce household energy costs as a result of participating in the program ($p < 0.05$).

Interviewees reflected on the knowledge they gained from the program to reduce their energy consumption. One described how his initial expectations were changed:

> *When I started it, to be honest, I thought I'll just do it for the money and I can just zoom through the answers and things, but I learnt a lot. MPDO2, Melbourne (online).*

Three interviewees mentioned their surprise at the cost of down-lights, refrigerators, dryers and washing machines, including one interviewee who applied this new knowledge when reading his bill:

> *The knowledge of how to read your bills and how to watch what I get when it comes to energy consumption was the biggest thing for me. BPSF1, Brisbane (single parent; face-to-face).*

For some interviewees, the knowledge provided by the discussions created a sense of empowerment, with the added awareness of how to pro-actively influence their household's energy consumption. This included an interviewee who was a recent migrant and expressed that this knowledge improved her experience as she settled into Australian life:

> *We [are] refugees coming from other country. We didn't know anything about a lot of things in Australia. Still we have to know a lot [more]. BUNF1, Brisbane (NESB; face-to-face).*

Table 3. Participants' self-reported knowledge to reduce household energy costs.

	Face-to-face group (n = 50)		**Online group* (n = 18)**		**Information only (n = 11)**	
	Pre (%)	**Post (%)**	**Pre (%)**	**Post (%)**	**Pre (%)**	**Post (%)**
I'm familiar with many tips and techniques that I am now using to reduce energy costs	42	54	33	89	27	73
I'm familiar with many tips and techniques, but I'm not sure about how to use them effectively to reduce costs	20	18	33	6	55	18
I'm not sure what I can do that will make a meaningful difference to my energy costs	34	16	22	0	9	0
I don't think there is anything more that I can do to reduce energy use and reduce my bills	4	12	11	6		9

Wilcoxon matched-pair signed-ranks test statistically significant at $*p < 0.05$; includes participants with matched responses only.

5.2. Energy-Saving Actions

Table 4 outlines the 22 energy-saving actions measured for participants both at the start and at the end of the EnergySavers program. Wilcoxon matched-pair signed-rank tests show that most participants involved in the face-to-face group sessions reported changes to their energy behaviour as a result of the participation in the pilot program. Of these actions, the greatest significance was shown in turning off appliances, reducing television viewing time, setting and maintaining energy reduction goals, closing off areas in the home and closing window covering to conserve heating and cooling, and ensuring refrigerators are working efficiently. For the online group participants, Wilcoxon matched-pair signed-rank tests showed statistically significant differences in only two actions: reducing the time television viewing ($p < 0.01$) and checking the energy bill against their meter ($p < 0.05$). There were no statistically significant differences in behavior for the information only group.

To give greater clarity, paired sample t-tests were undertaken comparing the number of actions participants indicated they undertake at home at the pre (session 1) and post (session 5) surveys. Results presented in Table 5 show that participants in both the face-to-face ($\chi^2 = -8.00$, df = 52, $p < 0.001$) and online groups ($\chi^2 = -2.37$, df = 14, $p < 0.05$) have significantly increased the number of energy saving actions undertaken at home. There were no statistically significant differences in the number of energy saving actions undertaken at home at the pre (session 1) and post (session 5) surveys for the information only group ($\chi^2 = -1.55$, df = 10, $p = 0.15$).

Table 4. Energy saving actions performed before and after the program to reduce electricity costs.

Energy-saving actions	Face-to-face group (n = 53)		Online group (n = 15)		Information only (n = 11)	
	Pre (%)	Post (%)	Pre (%)	Post (%)	Pre (%)	Post (%)
For all areas in the home						
Turning appliances and devices off at the power point when not in use	57	94***	80	93	91	91
Switching off the lights in rooms that are not being used	87	96	93	87	100	82
Reducing the time the TV is on, even when people are home	36	83***	13	80**	9	27
Setting goals or targets for reducing energy usage and sticking to them	13	47***	13	33	0	18
Checking electricity bill against the meter	19	38*	20	60**	0	36
Buying energy efficient appliances	43	57	60	60	45	36
Heating and cooling the house						
Closing off areas that don't need to be cooled in summer or heated in winter	47	81***	53	80	36	45
Shutting blinds/curtains to reduce heat getting into/out of the home	60	91***	73	80	82	73
Using fans or natural ventilation for cooling the house instead of using the air-conditioner	51	72*	80	93	27	64
Minimizing the use of the air conditioner	58	66	60	73	36	45
Reduced air conditioning costs by choosing the right temperature (18 °C or less in winter and 25 °C or more in summer)	34	47	47	53	36	55

Table 4. *Cont.*

Energy-saving actions	Face-to-face group (n = 53)		Online group (n = 15)		Information only (n = 11)	
	Pre (%)	Post (%)	Pre (%)	Post (%)	Pre (%)	Post (%)
In the Laundry or Bathroom						
Washing clothes in cold water	58	83**	80	93	55	64
Hanging clothes to dry naturally	79	96*	67	93	91	82
Using a fan to help drying the clothes quicker	4	17*	13	27	0	9
Minimizing the use of the clothes dryer	26	42	53	67	27	45
Only running the washing machine with a full load	53	79**	67	87	73	83
Having shorter showers	72	85	40	60	36	45
In the kitchen						
Cooking larger meals then freezing leftovers to be consumed in another day	49	51	33	53	36	55
Only running the dishwasher with a full load	40	55*	73	53	45	55
Turning off the second fridge	13	18	20	20	9	9
Using a thermometer to make sure the temperature is in the correct range for both fridge and freezer	21	36*	13	20	9	9
Maintaining the refrigerator (checking for leaks, the seals and defrosting the freezer)	28	70***	33	40	45	55

Statistically significant at *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$; includes all responses received excluding information-only and control groups.

Table 5. Energy-saving actions by participants pre- and post-program.

t-test	Pre			Post		
	N	Mean	SD	N	Mean	SD
Face-to-face***	53	9.49	3.90	53	14.04	0.52
Online*	15	10.87	0.84	15	14.07	1.30
Information only	11	8.91	0.94	11	10.82	0.77

Note: The surveys included 22 actions. SD = standard deviation.

This suggests that the discussion activity was critical in increasing the energy saving actions of participants. This is in line with Lave and Wenger's earlier finding that knowledge acquisition is facilitated better through social participation, ideally in pre-existing social groups or in groups of those from similar backgrounds as the discussion groups become potential "communities of practice", where it is observed that "learning as increasing participation in communities of practice concerns the whole person acting in the world' ([24], p. 49). The value of the participatory discussions was a feature mentioned in the interviews. Interviewees reflected on the way information was delivered in a manner that encouraged discussion and sharing of skills, knowledge and questions among participants from similar demographic groups. This interactive manner was mentioned by participants as helping to maintain motivation and interest, and they valued hearing from each other. Furthermore, being with others from a similar background was likely to have ensured a comfortable learning environment. The structure encouraged participants to re-visit information several times during the program to establish this knowledge. One interviewee detailed this approach:

[By] raising the issue again, you become a little bit more aware each time, you know? Each time you participate in anything like that, it just highlights things and you know where to look. I think it makes people more responsible in the sense that they don't really-they pay a lot of these [bills] without a great deal of thought. MUNF6, Melbourne (NESB; face-to-face).

This suggests that the information alone was not sufficient to motivate action, but the action of discussing it within a familiar group added meaning, focus and value to ensure knowledge uptake but also motivate action.

To explore the influence of demographic characteristics on the performance of energy-saving actions, all demographics were analysed. Only the housing situation, home population and language were found to have a significant influence on the number of energy actions undertaken at the start and end of the program. An ANOVA test with housing situation as the fixed factor and energy saving actions as a dependent variable suggest that public housing occupants were performing less energy saving actions than those living in shared accommodation ($F_{4,77} = 3.40$, $p < 0.05$) at the start of the program, although caution should be made due to the low number of participants in public housing accommodation (n = 3), as displayed in Table 6. There were no statistically significant differences at the end of the program in the number of energy saving actions amongst households living in different housing situations ($F_{4,75} = 0.93$, $p = 0.45$).

Table 6. Influence of housing situation on performance of energy-saving actions.

ANOVA	Pre			Post		
	N	Mean	SD	N	Mean	SD
Own house	28	9.18	3.24	29	14.10	4.25
Public housing	3	4.67	4.16	3	12.33	0.58
Renting	28	9.96	3.91	25	14.08	3.24
Share accommodation	12	12.25	2.63	12	13.42	5.57
Other	7	9.43	3.41	7	11.14	3.08
Total	78	9.78	3.68	76	13.64	4.03

The home population was also analysed using an ANOVA test. Results are displayed in Table 7 and suggest that individuals within households comprised of couples with children undertook more energy saving actions pre-program when compared to participants living with other family members ($F_{5,79} = 3.12$, $p < 0.05$). Individuals within households comprised of couples with children undertook more energy saving actions post-program when compared to participants living in single person households or those living with friends ($F_{5,85} = 4.94$, $p < 0.001$). ANOVA tests ($F_{5,76} = 3.66$ $p < 0.01$) also suggest that those living with other family members were more likely to improve their energy saving behaviour when compared to those living with friends or alone. These findings suggest that the most receptive audience for the EnergySavers program were couples with children or adults living with other family members. This raises the possibility for exploring how a family environment can best support residential behavior change.

Table 7. Influence of home population on performance of energy-saving actions.

ANOVA	Pre			Post		
	N	Mean	SD	N	Mean	SD
Single person	13	9.08	3.33	16	10.88	3.83
One parent with children	12	10.08	3.37	12	13.50	3.90
Couples with no children	13	9.92	4.75	16	14.50	2.34
Couples with children	31	10.94	3.35	31	15.16	4.03
Living with other family members	5	4.60	2.97	5	14.20	2.86
Living with friends	6	8.33	2.42	6	8.67	5.65
Total	80	9.75	3.77	86	13.50	4.21

Finally, paired sample t-tests were undertaken exploring whether the number of actions undertaken by English speaking and non-English speaking (NESB) participants differ. Results show that there were no changes in the number of energy saving actions undertaken pre-program ($\chi^2 = 0.34$, df = 78, $p = 0.73$). However, as shown in Table 8, NESB participants were performing more actions that English-speaking participants at the end of the program ($\chi^2 = -2.28$, df = 77, $p < 0.05$), although caution must be taken with the small sample size (n = 14). In this analysis, it is presumed that it is not English proficiency that creates the difference but rather that the NESB participants were recent migrants who were adjusting and learning how to manage energy consumption and costs in their new home. Literature has indicated that people undergoing a life change or transition, such as moving home or countries, are more likely to change their behaviour as 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" [34].

Table 8. Influence of home language on performance of energy-saving actions.

t-test	Pre			Post			Difference		
	Obs	Mean	SD	Obs	Mean	SD	Obs	Mean	SD
ESB	65	9.77	3.53	65	12.86	4.19	63	3.32	4.21
NESB	15	9.40	4.67	14	15.64	3.82	14	6.57	4.73
Total	80	9.70	3.74	79	13.35	4.24	77	3.91	4.46

This segmentation analysis of energy-saving actions by different demographic features are indicative only but suggest that the approach of the program was more effective with certain demographics, such as couples with children, individuals living with other family members, and NESB migrants. It also suggests that public housing tenants have most potential for change due to their current low levels of energy-saving actions. This study has indicated that it is important to explore how different demographics respond to different program approaches so such programs can be further tailored to specific demographics for greater impact.

5.3. Dissemination

Many participants shared the program information with others, mainly with immediate family and friends. Several interviewees reflected that this new knowledge gained from the EnergySavers program has informed their conversations with members of their social networks, including family members,

neighbors and friends. Refugee participants who had recently migrated to Australia were particularly active in sharing the information and suggestions:

> *I've been able to now probably participate in those conversations have some advice and tips to give people. MPDO3, Melbourne (online).*

This post-program dissemination was likely effective due to the design of the stand-alone materials, as well as the discussion-based nature of the delivery. A number of interviewees stated that they were keeping the magazines (or the printed downloads for the online participants) for later reference and a prompt for taking action. Some online interviewees printed their magazines to keep as a reference or pass on to family members, and interviewees from NESBs used the magazines as a visual tool to disseminate the new skills. An interviewee detailed how she used the magazines as follow-up to conversations about possible actions:

> *[When I am] talking to friends about what we're doing they say, "oh, I hadn't thought about that", and this [magazine] is one way of passing it around. MURF1, Melbourne (retiree; face-to-face).*

The resulting uptake of this information, delivered through social networks, is anticipated to be high as the influence and salience is communicated by trusted social connections [2,25].

5.4. Remaining Barriers to Action

Despite these achievements, many interviewees noted a range of barriers still existed for them to introduce energy efficiency behavior. These were financial (namely limited finance to invest in energy-saving infrastructure, such as insulation), infrastructural (including living as tenants in older, inefficient housing stock, and requiring large amounts of electricity to manage medical conditions through heating/cooling or machinery), and social (including limited English language, and the behavior of other members of their household). The main barrier noted by interviewees was social, and is regarding adult children living in the home who do not participate in household financial management or follow their parents' requested behavior:

> *[If] you've got adult kids at home ... they don't pay the bills, [so] you find that there is a bit of neglect ... You try and do the right things but they don't. MPDPo1, Melbourne (information-only group).*

This reflects the need, identified by Steg *et al.* [35], to identify solutions to any legal, financial or infrastructural barriers. Further interventions would benefit from exploring strategies to reduce the barriers identified by participants.

6. Conclusions for the Case Study and for Broader Energy Behavior Change

This evaluation of the case study energy program provides both insights into the specifics of the case study, as well as implications more broadly for the conceptual framework and associated theories.

The case study results suggest that the delivery through discussions within pre-existing groups or groups created within similar demographics increases the uptake of knowledge and stimulates participants to undertake energy-saving actions, in line with the earlier work of Lave *et al.* [24]. This pilot program has provided baseline data of actions currently being undertaken, and the demographic

characteristics of those who were most responsive to the EnergySavers program. Future, larger-scale roll-outs of the program can improve impact in three areas: audience, actions and assessment.

In terms of audience, the program could be targeted to low-income groups who were most responsive to energy behavior change, notably public housing tenants, couples with children, individuals living with family members, and NESB migrants [20]. In addition, further research could identify approaches that are most effective with the remaining demographic groups. Further research would also benefit from exploring whether behaviour change is influenced by participants' existing pro-environmental behavior. Most particularly it would be interesting to explore whether theories, such as the Values, Beliefs and Norms (VBN) Theory, which is useful in explaining judgements of support and acceptability of programs and policies [36], is a determinant of behaviour change amongst low-income individuals. Identifying the importance of economic, social and environmental motivations of low-income participants could inform the path to greater bridge sustainability.

In terms of actions, the future design of EnergySavers could benefit from materials that more clearly prioritise the behaviors that achieve the greatest energy and financial savings. As the table of actions displayed, the lower impact actions in terms of greenhouse gas reductions, such as lighting, were more readily adopted than higher impact actions such as significant changes in use of air conditioners. Further research could identify how to support these higher impact behavior change actions for greater environmental and economic savings.

The main lessons to be learned from this case study for others wanting to develop energy efficiency programs for low-income groups are that participants felt more in control over their energy consumption, and disseminated their new knowledge through their social networks, thus increasing the reach and impact of the program. To strengthen the assessment of EnergySavers' impacts, it would be important to also assess actual changes in energy consumption by accessing households' electricity meter data. A large dataset from a single retailer source with data provided in a uniform structure should facilitate such data analysis. Ideally, such a dataset should include data prior to the program, immediately after completion, and 12 months post program to identify the longevity of the behavior change. The findings of this assessment will inform a larger-scale roll-out of the program in Australia.

This case study has also illustrated and tested three theoretical aspects within energy behaviour change literature and the social-psychological model, namely curtailment behavior, communication effectiveness, and norming. Curtailment (repetitive) behaviours were promoted in the case study program, as earlier literature highlighted that financial constraints and other motivations made this a more appropriate type of behavior change for the low-income audience. These curtailment actions were able to be demonstrated in the communication materials of magazines and video clips, and quantitatively evaluated, with participants reporting increased frequencies in some of these curtailment actions post-program. Further research could introduce and test the uptake of efficiency (one-off) behavior changes, and well as the longevity of the curtailment behavior changes. Delivering the program in a social, face-to-face setting, and within similar demographic groups, appeared to improve receptiveness of the energy information. Finally, the dissemination of the energy information by participants to others in their social networks suggests that these behaviours were considered to be supporting existing or new social norms. Further research could identify which behaviours are most likely to become normative behaviours, and whether these are maintained long-term due to this social support.

This case study has provided a way to address the key concept of "bridge sustainability", by ensuring that social impacts from energy use, cost and consumption are considered concurrently and equally with economic and environmental energy issues [13]. Although energy behavior is only one contributor to household energy consumption, it is a significant contributor in both Australian and other OECD households, and these findings provide new information to penetrate the relatively "invisible" energy behavior of low-income households in Australia. In turn, this contributes to the literature on energy behavior change as well as the specific energy information needs of low-income participants.

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Conflicts of Interest

The authors declare they hold no conflicts of interest over the content and reporting of this research.

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