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The impact of air conditioning system upgrade on energy use and comfort in low income housing

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Abstract

The ‘Beat The Heat!’ project was a project of the Australian Federal Governments ‘Low Income Energy Efficiency Program’ (LIEEP). This project aimed to enhance the resilience and improve the comfort and wellbeing of Adelaide households during South Australias long, hot summers. The installation of ceiling insulation and new air-conditioners in the main living areas of low-income households were two of the key interventions made through this project. Total electrical energy consumption of each household and the air-conditioner were monitored following these interventions and compared with electricity bills before the installation, during matched summer periods. Indoor temperatures of the main living area were also monitored, following the intervention, to assess the improvement in thermal comfort. Significant differences between the energy use before and after household interventions, along with associated household perceptions, are discussed in this paper. Specifically, the impact on energy consumption of factors such as household income, the source of cooling energy prior to the intervention and differences in climate and thermal comfort are explored. For houses where an old, inefficient and ineffective air-conditioner was replaced by a new, efficient split system (3.23<EER<4.83), a 16% average reduction in mains energy was observed following the intervention. This was partly driven by an overall reduction in electrical energy for cooling, but was also influenced by a change in the households ability to enjoy a more comfortable environment.

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Keywords: cooling energy reduction; energy efficiency, thermal comfort; low income household; air-conditioner upgrade; air-conditioning energy; LIEEP; beat the heat; south australia

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1. Introduction

Through the Australian Federal Government funded LIEEP programme, the ‘Beat The Heat!’ project was undertaken with the aim of enhancing the resilience and improving the comfort and wellbeing of Adelaide households during South Australia’s long, hot summers [1]. The climate of Adelaide is Mediterranean, having mainly mild to cool winters with moderate rainfall and dry summers that are warm to hot. Heatwaves have become significantly more prevalent in the past 15 years, with the vast majority of the warmest years on record being recorded over this period. Specifically, this project targeted the low income tenants of rental properties, in a specific effort to overcome the notorious ‘landlord-tenant split incentive’ barrier, where the economic benefits of energy efficient retrofits afforded to a tenant do not accrue to those who would ordinarily pay for them, namely the landlord. The project attempted to circumvent the split incentive, through collaboration with a real estate agency, by offering free energy efficient capital upgrades for eligible properties in return for a landlord agreeing to implement a legally binding ‘rent freeze’ on the property for a period of at least 12 months.

The project was conducted by Uniting Communities, a South Australian based NGO operating in the community services sector, in consortium with the University of South Australia’s Barbara Hardy Institute (UniSA), Community Data Solutions, the South Australian Department for State Development, Lin Andrews Real Estate, Low Energy Supplies and Services, SA Power Networks and Sustainable Focus. The project offered tenants a number of interventions, aimed at improving energy efficiency and comfort of the households whilst not significantly increasing their energy bills. The main interventions being investigated in this paper are the installation of a high efficiency air-conditioner (3.23< EER<4.83) and, when necessary, R3 ceiling insulation. Where an air-conditioner was installed as part of an intervention, dataloggers were also installed to collect 15-minute interval electricity consumption of both the air-conditioner and the household as a whole and hourly dry-bulb temperature in the area where an air-conditioner was installed. These data were compared to pre-intervention electricity consumption, using utility billing data collected with permission of the households. All participating households were also provided with a home energy assessment, which also served to assess the eligibility of a household to receive an intervention, tailored training aimed to help them reduce energy consumption and an in-home display, aimed at assisting them to better manage household energy consumption. Furthermore, a large proportion of householders participated in pre and post intervention surveys relating to their perceived comfort levels and energy use behaviours, with a smaller proportion also participating in in-depth interviews regarding the overall project.

<table>
<thead>
<tr>
<th>Nomenclature</th>
<th>Description</th>
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<tbody>
<tr>
<td>Pre-Int</td>
<td>Relating to household characteristics (e.g. energy consumption), prior to the project intervention</td>
</tr>
<tr>
<td>Post-Int</td>
<td>Relating to household characteristics, after the project intervention</td>
</tr>
<tr>
<td>No AC</td>
<td>Relating to households that did not have an air-conditioner installed, prior to a project intervention</td>
</tr>
<tr>
<td>Old AC</td>
<td>Relating to households that had an old air-conditioner installed prior to a project intervention</td>
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</tbody>
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2. Household energy consumption and thermal comfort

2.1. Data collection and processing

Over 200 detailed home energy visits were conducted, yielding tailored reports to both tenants and landlords, in this project. Through this process, existing household appliance, construction and detailed socio-demographic data was collected and entered into a database. Out of this group, the majority of whom had an in home display installed through this process, 119 households received a high efficiency reverse-cycle air conditioner and associated electricity and temperature datalogging equipment, with 64 of these also receiving an R3 ceiling insulation upgrade, the remainder having sufficient existing ceiling insulation. Electricity billing data for at least one year prior to the intervention was collected for the majority of households where an air-conditioner was installed. In total, 178 households completed a pre intervention comfort and behaviour survey, 117 households completed a post intervention comfort and behaviour survey and 50 households were interviewed in greater depth about their involvement in the project.
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