Smart Cooling in the Tropics

Low Income Energy Efficiency Program (LIEEP)

Final report to the Department of Industry, Innovation and Science

The Environment Centre NT

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Innovative Housing Solutions

Smart Cooling in the Tropics

Final Report to the Department of Industry, Innovation and Science

Low Income Energy Efficiency Program (LIEEP)

The Environment Centre NT

April 2016

The Project Partners

Smart Cooling in the Tropics

Environment Centre NT

The Environment Centre NT is the leading community environment organisation in the Northern Territory, Australia. The Environment Centre NT and predecessor organisations have been working to protect the environment since 1983.

Since 2002 the Environment Centre has supported COOLmob: a sustainable living program delivering practical information, environmental education, workplace training and home energy assessments as well as retrofits, behaviour change, and capacity building projects.

Carers NT

Carers NT is the key organisation representing the Northern Territory's estimated 30,000 family carers who provide unpaid care and support to family members and friends who have a disability, mental illness, chronic condition, terminal illness or who are frail. Carers NT aims to improve the health, wellbeing, resilience, and financial security of carers and promote the recognition of caring as a shared responsibility of family, community, business, and government. It works with carers, health professionals, service providers, government, and the wider community by offering services to persons with care and support needs to improve their quality of life.

Charles Darwin University

Charles Darwin University is a public university in the Northern Territory. Its Research Institute for the Environment and Livelihoods (RIEL) consolidates CDU's environmental and natural resource management research.

It is currently working with partners in northern and central Australia and the region to expand knowledge to, among other things, underpin innovation in developing new more sustainable technologies, policies, and approaches. RIEL's Centre for Renewable Energy was established through a partnership between CDU and the Northern Territory Government.

It is working to promote the Territory's renewable energy sector and to provide leadership on the deployment of renewable energy and low emissions and energy-efficient technologies.

Council on the Ageing (NT)

Council on the Ageing (COTA) is a peak body for advocacy for the rights and interests of older Australians. COTA (NT) services senior citizens in Darwin, Palmerston and Litchfield in the Top End. It is dedicated to promoting the well-being of Territorians aged 50 years and over and Indigenous Territorians aged 45 years and over. COTA (NT) is strongly connected to the policy development and decision making processes in the Territory through its network of employees and volunteers. It has also been active in developing projects involving delivery of information and assistance programs.

Melaleuca Refugee Centre

Melaleuca Refugee Centre is Darwin's main organisation supporting refugees and survivors of torture and trauma. Melaleuca has over 40 staff and many volunteers as well as a community facilitator training program for migrants of various language backgrounds. This program fosters and/or supports leaders from a number of cultural communities. Melaleuca has four cultural transition courses per year that are led by a community facilitator. The courses run for ten weeks and have up to 20 participants.

Yilli Rreung Housing Aboriginal Corporation

Yilli Rreung Housing Aboriginal Corporation is a peak housing organisation that aims to deliver accessible, affordable, and sustainable housing in the Northern Territory. Yilli Housing is an independent, Indigenous based organisation that provides housing management, maintenance, and construction services. It manages the tenancies and municipal services of Indigenous communities and provides affordable housing to individuals and families who are disadvantaged in the mainstream housing market.

Abbreviations

Organisations

ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
ABS	Australian Bureau of Statistics
BCA	Building Code of Australia
BOM	Bureau of Meteorology
Carers	Carers NT
CDU	Charles Darwin University
COOLmob	Environment Centre NT's COOLmob program
COTA	Council on the Ageing
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DEWHA	Department of Environment, Water, Heritage and the Arts
ECNT	Environment Centre Northern Territory
Jacana	Jacana Energy
LIEEP	Low Income Energy Efficiency Program
Melaleuca	Melaleuca Refugee Centre
NREL	National Renewable Energy Laboratory
PWC	Power Water Corporation
RIEL	Research Institute for the Environment and Livelihoods
The Department	Department of Industry, Innovation and Science
Yilli	Yilli Rreung Housing Aboriginal Corporation

Project and partners

Consortium	CDU, COTA, Carers, ECNT, Yilli, Melaleuca
Delivery partner	COTA, Carers, Yilli, Melaleuca
Research partner	CDU
Smart Cooling	Smart Cooling in the Tropics

General terms

AC	Air conditioning

AUD	Australian dollars
Centrelink	Centrelink delivers a range of payments and services for people at times of major change.
CFL	Compact fluorescent lamp
EEIS	Australian Capital Territory Energy Efficiency Improvement Scheme
ESS	New South Wales Energy Savings Scheme
GHG	Greenhouse gas
GST	Goods and services tax
IT	Information technology
LCD	Liquid crystal display
NEPP	National Energy Productivity Plan
NRAS	National Rental Affordability Scheme
NT	Northern Territory
OCHRE card	It is mandatory for people who have contact or potential contact with children in certain specified areas of employment to hold a 'Working with Children Clearance Notice'.
OH&S	Occupational health and safety
REES	South Australian Retailer Energy Efficiency Scheme
RH	Relative humidity
SLE Lupus	Systemic lupus erythematosus, a systemic autoimmune disease where the body's immune system mistakenly attacks healthy tissue.
VEET	Victorian Energy Efficiency Target scheme

Analysis terminology

AA	After assessment
AVG	Average
BA	Before assessment
CBA	Cost-benefit analysis
CEA	Cost-effectiveness analysis

CI	Confidence interval
COP	Coefficient of performance
MDC	Mean daily consumption
MW U test	Mann-Whitney U test
PAS	Post assessment survey
SHV	Second home visit
WSR test	Wilcoxon signed-rank test

Surveys

Survey 1	Demographic survey conducted prior to or at the time of the home energy assessment to obtain information regarding characteristics of the participant householder/s.
Survey 2	Home assessment survey conducted at the time of the home energy assessment to obtain baseline information regarding the participant household.
Survey 3	Post assessment survey conducted after the delivery of the services to obtain information regarding changes to participant householder/s comfort, behaviours, attitudes, and beliefs.
Survey 4	Second home visit conducted after the delivery of the services to obtain information regarding benefits experienced by participant householder/s as a result of the services.

Glossary

Energy

Energy	Energy and electricity are used interchangeably and refer to the amount of electricity a household consumes unless stated otherwise.
Energy conservation	Energy conservation is achieving the same outcome with less energy.
Energy efficiency	The practices, behaviours or tools used to conserve energy.
Energy productivity	Energy productivity achieves a greater outcome with a decrease, the same amount or a less than proportional increase, in energy. In this report energy productivity refers to improving thermal comfort using the same or possibly less energy. Importantly, the proportion of energy use, relative to the level of outcome, should decrease.

Deemed savings	Deemed Savings are pre-determined, validated estimates of energy and peak demand savings attributable to energy efficiency measures in a particular type of application.

Delivery language

Assessment	Home energy audit to assess how much energy a home consumes and to evaluate what measures could be taken to conserve energy at home.
Services	The defined treatment that participants received on the recommendation of the Smart Cooling Project Officer.

Participant descriptions

Carer	Participant who provides care for someone with a disability, mental illness, long-term illness and/or frail age.
Care recipient	Participant who receives care for a disability, mental illness, long-term illness and/or frail age.
Melaleuca participant	Participant from a refugee background recruited through Melaleuca Refugee Centre.
Non-affiliated participant	Participant who was not recruited through the delivery partners.
Urban Indigenous participants	Participant from an Indigenous background recruited through Yilli Rreung Housing Aboriginal Corporation and living in the Greater Darwin region.

Other

Air Conditioning	Air conditioning in this report refers only to refrigerative space cooling unless stated otherwise.
Heat stress	Heat stress occurs when the body is unable to cool itself enough to maintain a healthy temperature.
Thermal comfort	A person's subjective satisfaction with the thermal environment.
Thermal comfort zone	The combination of personal and environmental parameters in which a person maintains an acceptable level of thermal comfort.
Thermal performance	Refers to the heat transfer between a building and its surrounds.

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Acknowledgements

We would like to acknowledge the Australian Government, Department of Industry, Innovation and Science for their funding of our project and for the strong support we have received from relevant government officers in our delivery of a complex project.

We would also like to acknowledge our delivery partners Carers NT, Council on the Ageing NT, Melaleuca Refugee Centre and Yilli Rreung Housing Aboriginal Corporation. And we acknowledge the support of Environment Centre NT Management Committee and staff.

A special thanks to all the local Darwin contractors who supplied products and delivered services to project participants.

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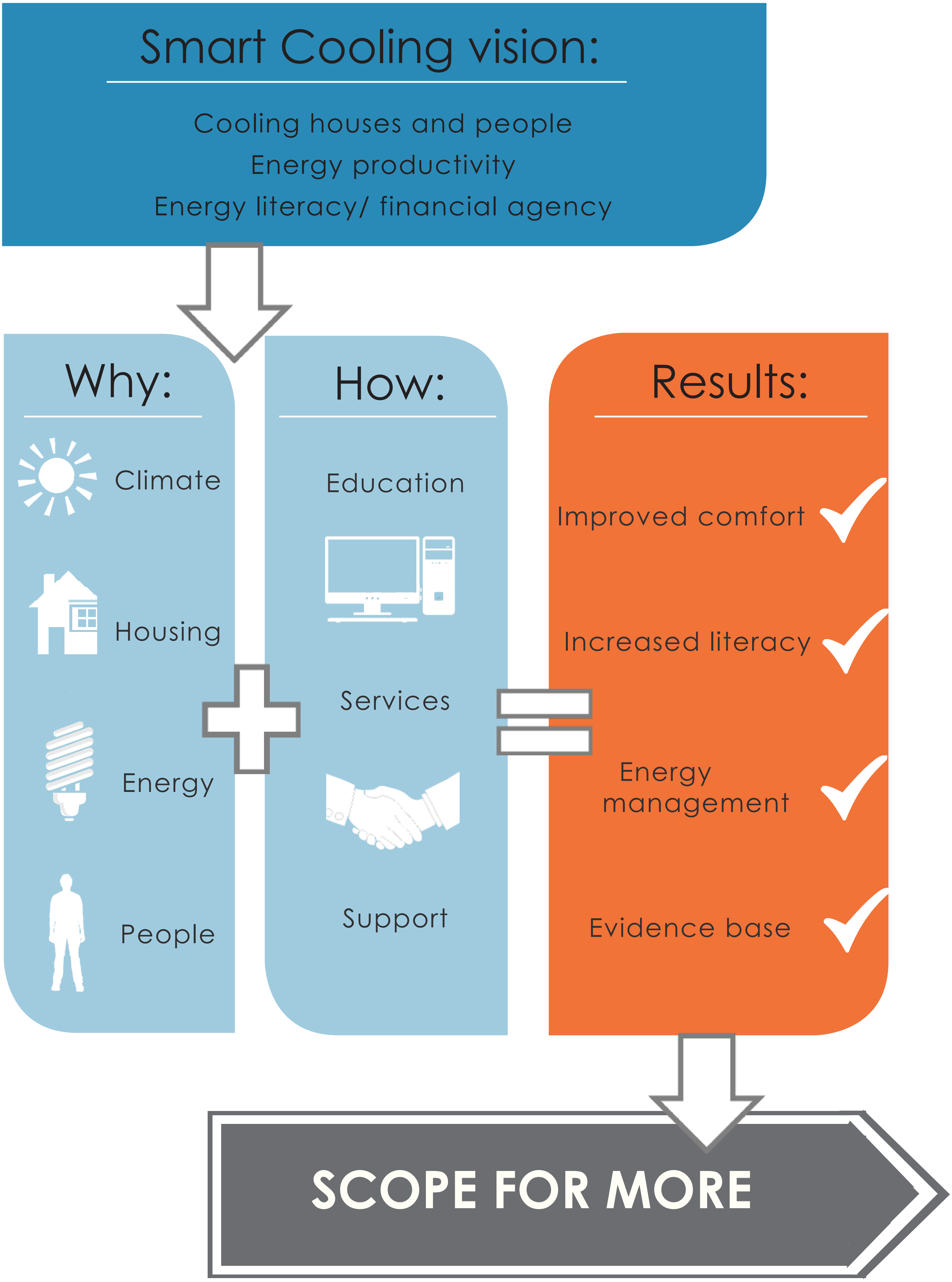
We would like to sincerely thank the participants in the project for their time, patience, openness, and insights.

'Participants learnt that **small things add up** and make a big difference'

Smart Cooling in the Tropics


Smart Cooling vision:
Cooling houses and people
Energy productivity
Energy literacy/ financial agency
Why:
Climate
Housing
Energy
People
How:
Education
Services
Support
Results:
Improved comfort
Increased literacy
Energy management
Evidence base
SCOPE FOR MORE

1.0 Executive Summary

Between 2012 and 2016 the Australian Government's Low Income Energy Efficiency Program (LIEEP) supported 20 national research based pilot projects. The purpose was to trial approaches to improve the energy efficiency of low income households and enable them to better manage their energy use. Smart Cooling in the Tropics was one of these projects.

$2.7 million in funding was provided to the Environment Centre Northern Territory for the trial. It was delivered in collaboration with Charles Darwin University and supported by four local social welfare agencies. The trial was one of Northern Australia's first large-scale projects to identify and measure the effectiveness of a range of approaches to enhance residential cooling, comfort, and energy efficiency in tropical Australia.

The main objective of Smart Cooling was to improve the thermal comfort of vulnerable householders in the hot humid tropics without a disproportionate increase in the amount of energy used and associated costs; this objective was achieved.

The major outcomes of the trial were in alignment with the LIEEP objectives and include:

1. Proven approaches to engage and support low income households, particularly urban Indigenous, refugees, the elderly, and those living with chronic health conditions or disabilities.
2. Increased knowledge among participants of the costs and strategies to reduce pressure on the household budget though energy management.
3. Identified measures to improve thermal comfort without an overall increase in energy consumption at the household level.
4. High customer satisfaction for the advice, service, and support provided by the Environment Centre NT's project team.
5. Unique evidence base for ongoing research, policy, and program development for tropical Australia.

The approaches applied by the trial addressed three barriers; cost, knowledge, and motivation. They involved the provision of home energy assessments, personalised energy reports containing behaviour change recommendations, and complimentary structural modifications (e.g. shade sails, structural modifications (e.g. shade sails, reflective roof paint) or appliance upgrades (e.g. provision of pedestal fans) to improve the energy efficiency and thermal comfort of participating householders.

Smart Cooling identified that certain upgrades to houses influence thermal comfort. More time is needed to fully analyse the data collected to demonstrate the full extent of this influence, including cost benefits.

82% of participants reported an improvement in thermal comfort without an increase in their electricity consumption and in many instances a moderate reduction. It was seen that, in general, participants had more need for improving comfort than saving money on electricity because energy use among participants was already low and their discomfort was high. Additional benefits, such as improvements in health, reduced heat stress, and a greater sense of environmental responsibility were all rated highly by participants.

Education was a cornerstone for improving participants' energy productivity and energy literacy. Knowledge was passed on to participants about how small changes in behaviour can lead to energy savings without sacrificing comfort and can even improve comfort. Deep engagement with skilled project staff was the 'x factor' in making meaningful change for these vulnerable communities. The complimentary services were essential in addressing the participants' financial constraints and the tailored advice and case management approach was aimed at addressing the education and motivation barriers.

Smart Cooling in the Tropics was a unique LIEEP pilot project in that its energy efficiency measures were solely focused on understanding and improving environmental cooling and comfort in an urban tropical Australian climate. Its outcomes stand to be used to inform national and local energy policy, and to influence the development and modification of building codes and other rating systems to make them appropriate for Australia's northern tropical environment.

The project's results are significant in the context of predicted rising temperatures as the climate changes and is expected to adversely affect levels of human comfort. Practical strategies and a robust evidence base for appropriate policies will be critical assets to facilitate mitigation and adaption planning for an increasingly hot climate.

The results also provide insights to inform future program approaches to dealing with the existing housing stock in the tropics. LIEEP has allowed the Environment Centre NT to work with a diverse group of Top End residents and partners. This report provides the tangible 'snapshot' results of the hours of collaboration and implementation.

The legacy of the project will continue beyond the writing of this report. The new local knowledge about comfort and housing performance with regards to the climate will provide the baseline for ongoing research into the health and built environment requirements for a changing Top End climate.

And, at the national level, the results from Smart Cooling in the Tropics and the 19 other trials will inform energy policy developments and reform measures by the Australian Government to support best practice services for vulnerable consumers under the National Energy Productivity Plan.

The Environment Centre's COOLmob program was successful in delivering the trial. COOLmob was well placed to deliver the trial and will be best placed to deliver new, innovative initiatives or programs in the future. The established relationships, reputation, and credibility are valuable assets for future programs.

"A Smart Cooling journey towards energy productivity"

January 2014 - June 2016

2014

January/ February 2014

1. Funding agreement signed
2. Consortium established
3. Project documentation developed

March/ April 2014

1. Project team in place
2. Office set up
3. Trial activities & operating systems developed

May 2014

1. Staff & consortium training
2. Pilot phase commences
3. First home assessment delivered

1st participant

August 2014

First revision of eligibility criteria

September 2014

Evaluation of pilot

September/ October 2014

1. Review of trial approach
2. Delivery phase commences

100 participants

2015

January 2015

Rethink recruitment approach

February 2015

1. Project team expansion
2. Consortium agreements reviewed

February 2015

Second revision of eligibility criteria

200 participants

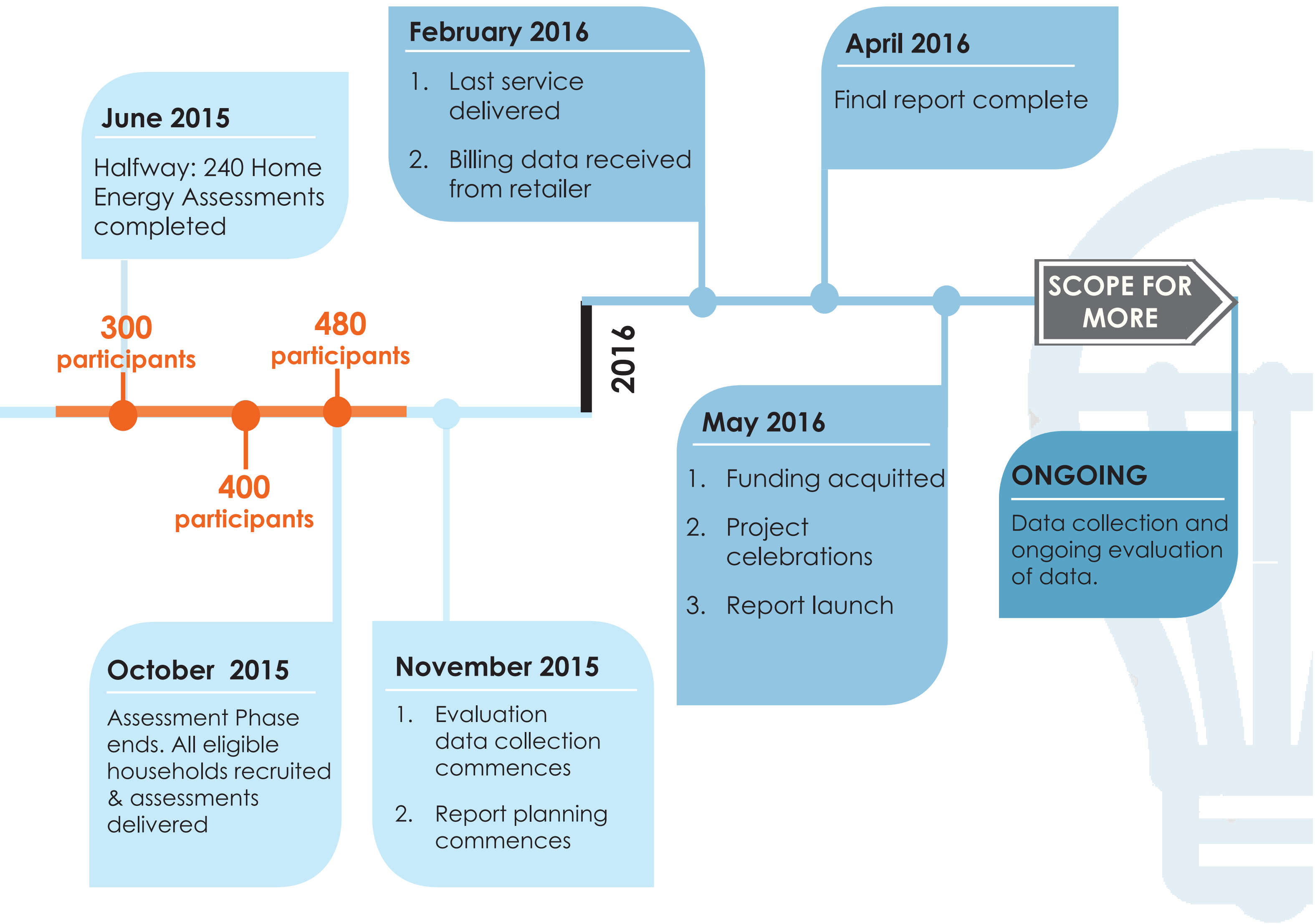
April 2015

New recruitment strategy implemented

Peak delivery

Smart Cooling in the Tropics was funded over a 2.5 year period.

Trial activities occured over a 14 month period. All deliverables were met.



Project phases

1. January/ February 2014:	Project initiation
2. March-May 2014:	Project set up
3. June- September 2014:	Pilot phase & systems design review
4. Oct 2014- December 2015:	Delivery & baseline data collection
5. November - February 2016:	Participant follow up & evaluation of data collection
6. March- May 2016:	Analysis & reporting

2.0 Introduction

The Top End has a hot and humid climate. It is classified as a tropical savannah having a high humidity summer and warm winter.

Smart Cooling in the Tropics

Introduction

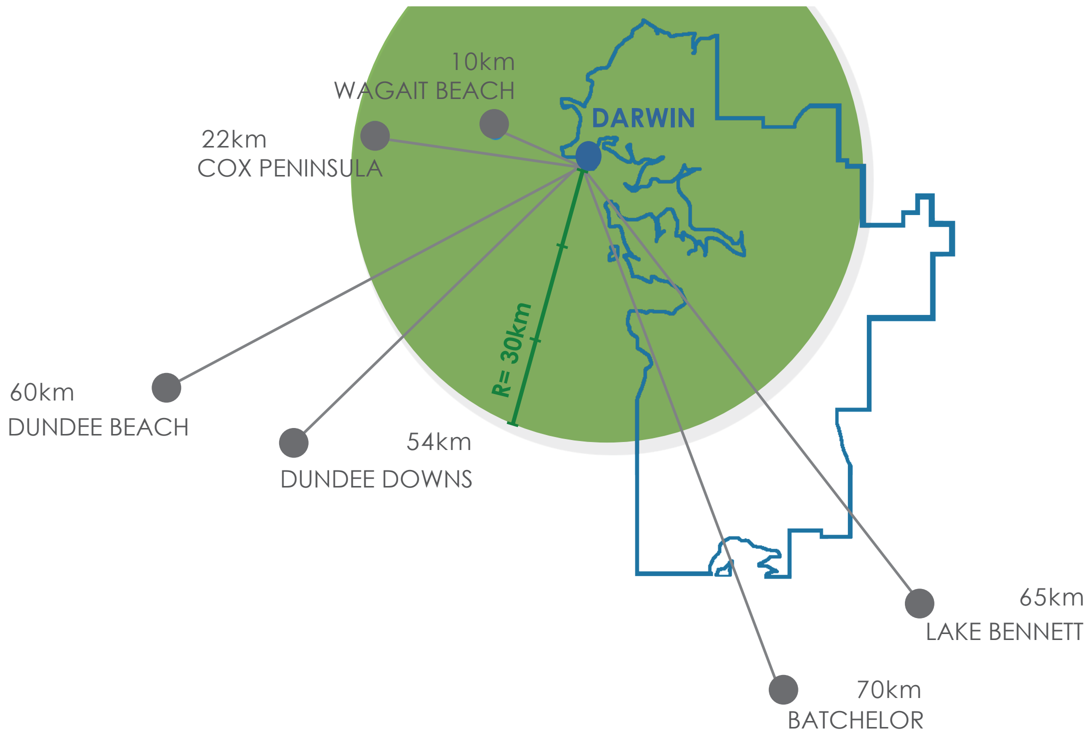
Smart Cooling in the Tropics was delivered by the Environment Centre Northern Territory with funding from the Australian Government. It was one of Northern Australia's first large-scale projects to identify and measure the best approaches to residential cooling, comfort, and energy productivity in tropical Australia. In this report energy productivity refers to improving thermal comfort without increasing energy use.

The Environment Centre Northern Territory was the lead organisation. The consortium comprised Charles Darwin University (CDU), Carers NT, Council on the Ageing NT (COTA), Melaleuca Refugee Centre (Melaleuca) and Yilli Rreung Housing Aboriginal Corporation (Yilli).

$2.7 million in funding was received from the Australian Government as part of the Low Income Energy Efficiency Program with an additional $387,784 worth of in-kind contributions from the consortium. The project operated over a compressed timeframe between 2014 and 2016 for residents across Greater Darwin. This reduction in timeframe reduced the evaluation phase and undermined the availability of complete data sets.

The trial took place in Darwin, the capital of the Northern Territory of Australia. In 2013 Greater Darwin had a population of 136,200 making it the smallest Australian capital city. Greater Darwin includes residents living in the city of Darwin and Palmerston as well as those living in the outer suburbs and townships as shown in the map over the page.

Map of greater Darwin:



The Low Income Energy Efficiency Program (LIEEP) was part of a suite of measures announced in July 2011 as part of the Commonwealth Government's climate change strategy. It was a competitive, merit-based grant program administered through the Department of Innovation, Industry and Science.

Across two funding rounds, 20 recipients were successful in securing grants worth a total of $55.3 million. The Smart Cooling project was funded under the second round.

Smart Cooling contributed to the LIEEP objectives to, trial and evaluate approaches that assist lower income households to be more energy productive, establishing a unique evidence base of data and information for future energy efficiency policy and program approaches.

Smart Cooling contributed to the intended benefits of LIEEP by:

- Increasing energy literacy among participating low income households and building their capacity to manage the impacts of energy price rises.
- Building the knowledge and capacity of social welfare agencies to build long-term energy efficiency among their customers or clients.

The energy efficiency approaches applied by Smart Cooling addressed three barriers; cost, knowledge, and motivation. The approaches used were: energy literacy, deep engagement and complimentary services. They entailed and were defined by the provision of face-to-face home energy assessments, personalised energy reports containing behaviour change recommendations, and complimentary structural modifications (e.g. shade sails, reflective roof paint) or appliance upgrades (e.g. provision of pedestal fans) to improve the energy efficiency and thermal comfort of participating households.

Darwin's tropical climate defined the scope and objectives of Smart Cooling in the Tropics. For the majority of the year, Darwin's climate sits outside the ASHRAE standards for

Barriers and approaches

Smart Cooling targeted three well-known barriers:

1. Financial constraints: financial capacity, such as access to capital and/or limited cash flow
2. Information failures: knowledge or facts have not been accessible or existed
3. Limited motivation: limited motivation to engage in energy efficiency practices

The trial responded to these barriers using the following approaches:

1. Energy literacy
2. Deep engagement
3. Complimentary services

comfort. During the wet season, high humidity persists for the majority of the day and leads to high thermal discomfort. The annual mean maximum temperature is 32 degrees Celsius and the mean minimum is 23 degrees Celsius (BOM, 2016). The constant heat leads to high energy use for space cooling, particularly when combined with the high humidity during the build-up and wet seasons.

To improve energy productivity and achieve greater levels of comfort, the Smart Cooling trial focused exclusively on cooling as this is the number one area of home energy use in the hot, humid tropics. In the Northern Territory, approximately 45% of residential electricity consumption is used on air conditioning (Manicaros, 2016). Education and the complimentary, personalised services concentrated on the cooling appliances (fans and air conditioning units) and the structure of the home.

The project's target group was low income households. Energy is considered a significant issue for low income households where financial constraints become blatantly apparent. Low income households are particularly affected by increases in electricity prices and have limited financial capital to improve the thermal performance of the house or reduce energy use by replacing inefficient appliances.

Nationally, low income households spend proportionally more on their electricity bill than high income households, almost 10% of their gross weekly income (ABS, 2012) which is around three times that of high income households. Residents in Darwin spend more on electricity than consumers in any other Australia capital city (NT COSS, 2013:1). The impact of energy price rises are disproportionate for low income households. Utility bills constitute a greater proportion of the overall expenditure, and they have less room to move in their weekly budgets.

At the time the project was initiated in January 2014, electricity prices had been increased by 20% and cost of living was highest in comparison to all Australian capital cities (NT COSS, 2013:2). A project targeting low income households with the provision of complimentary, practical solutions to energy

> "At the begining there was a sense among participants that being energy efficient would reduce their comfort levels. In the end participants were less likely to believe that **being comfortable** was at odds with energy efficiency."
>
> Smart Cooling Project Officer

management was perfect timing and Smart Cooling in the Tropics assumed it could reduce participants' energy use by 10-30%.

The pilot project quickly verified that the target group were already low energy users and were experiencing high thermal discomfort. Therefore the project quickly re-focused its aim to improve thermal comfort without significantly increasing energy use. The project design trialled methods to establish the thermal comfort of vulnerable low income householders. We assumed that by focusing on cooling we would improve participants' comfort and achieve greater energy productivity.

Many of the services on offer and engagement approaches used were innovative and sought to fundamentally improve the agency of the household to manage their comfort and cooling.

Some household barriers were indirectly related to cooling, for example security, cooking, and cleaning regimes. Broken locks or damaged screens not only pose a security risk but also prevent, or at minimum, diminish the use of passive cooling to maintain comfort in the home. Smart Cooling in the Tropics addressed this problem by upgrading screens and locks. Cooking can generate additional heat within the house, contributing to the overall heat gain. The project addressed this either with the installation of a shade sail or by setting up an outdoor kitchen.

The Smart Cooling in the Tropics project achieved significant outcomes for participants, the local community, and the broader community. The project increased energy productivity, thermal comfort, and energy literacy amongst participant households.

It also achieved increased capacity, knowledge, skills, and awareness amongst local energy efficiency businesses, consortium partners, and the general public.

More broadly, the project resulted in:

- reduced social costs (improved health and wellbeing, opportunities for social connectedness and increased social capital);
- reduced environmental costs (less energy consumption, GHG emissions); and
- reduced economic costs (less electricity demand, less financial burden on lower income households).

The project also generated reliable data for future research and analysis to inform government strategy, policy and program development. In particular, the research will contribute to the evidence base to better enable policy-makers to develop effective adaptation strategies to increase the resilience of vulnerable communities to the health impacts of climate change.

Smart Cooling in the Tropics assumed that information failures and limited motivation affected the target group. Education consequently underpinned the trial model in conjunction with a deep engagement strategy in order to improve energy literacy and encourage behaviour change. Smart Cooling in the Tropics delivered its objectives through face-to-face home energy assessments, easy to understand and engaging energy information, personalised home energy reports and an ongoing support program.

Energy efficiency recommendations were made (reduce lighting, efficient appliances, efficient pool pumps and so on) at home visits and in feedback to the participants. This created a tangible fabric of interwoven energy and lifestyle information and messages.

Overall, project services and education focused on getting maximum efficiency from existing cooling devices and making participants' homes easier places to keep cool. For many participants the project and the services on offer were practical, targeting their financial constraints and existing information failures and boosting their motivation. Concurrently, evaluation data was collected to ascertain current use of energy as well as the project's impact on energy consumption and comfort levels.

Various frameworks have been developed to conceptualise vulnerability. Some models suggest that vulnerability, whether to policy or weather events, is a combination of exposure, sensitivity, impact of the exposure, and to what extent risks can be mitigated by adaptive capacity (Allen Consulting, 2005).

Adaptive capacity in the context of working with the project's sub-groups can be defined as knowledge and capacity to reduce your energy bills or maintain a comfortable and healthy home. Using this approach, the impacts of policy changes, price rises, and trending increases in heat severity are likely to have direct and indirect impacts on low income and disadvantaged groups.

Direct impacts include exposure to high temperatures, extreme weather events, and lack of water. Indirect impacts include price rises for food and energy, social impacts, and changes in availability and distribution of employment. Increasing heat will have impacts on health and fuel poverty. Living in poorly designed, poorly shaded housing stock increases discomfort.

Low income households have an enhanced risk to the direct and indirect impacts of climate change.

Low income households are more likely to live in poorly designed housing stock, with less financial capacity, tenure agency or confidence to enhance thermal performance. As the majority of time is spent indoors, the built environment plays a fundamental role in provision thermal comfort. It is well established that thermal comfort, in turn, plays a crucial role in influencing energy efficiency behaviours.

Dwellings which are suitably designed and constructed to maximise passive cooling create cooler spaces (or thermal comfortable zones) and reduce or in some instances avoid altogether the use of space cooling, which, in theory, could reduce the weekly costs of living. Suitable dwellings would also limit exposure to the climate and limit health conditions such as heat stress due to network disruptions. This is why Smart Cooling aimed to gather information on participants' dwellings in order to connect this data with the surveys' results. The research framework considered a range of factors including which services produced energy cost savings, which households achieved improvements in household comfort levels, and which participants gained better awareness of energy consumption issues and opportunities.

The project also sought to benefit the consortium members. The aim was to build their knowledge of and capacity for energy efficiency so they would be able to pass that knowledge to their customers or clients. Personal interaction, varied media on energy efficiency and workshops were the implemented methods of choice.

Limitations

Eligibility restrictions and reduced time frames affected the scope of the project.

Exclusion of Territory housing changed the scope of the project. Many eligible low income earners live in Territory housing, particularly members and clients affiliated with the consortium. This limited the consortium's ability to facilitate recruitment and led to a delay in recruitment.

Reduction in funding timeframes intensified every phase of the project and ultimately reduced the evaluation phase, critically undermining the availability of complete data sets for effective analysis on energy and non-energy benefits over the Top End seasons.

The social welfare agencies were funded to appoint staff that facilitated the project internally. Smart Cooling trialled the effectiveness of working through these established community networks to recruit and engage low income householders. The exclusion of Territory Housing, whose clients make up a great number of the consortium's clients and members, proved to be a great limitation in achieving the required participant numbers. As a consequence, a targeted community advertising campaign was implemented alongside this approach to reach the project's intended participants.

This report outlines the specific contribution from the Environment Centre's Smart Cooling project to the national Low Income Energy Efficiency Program. It introduces and discusses the trial's approach, partners, participants, results, and recommendations. Interwoven through these chapters are stories of benefit and change experienced by the project's participants and a presentation of the houses and the climate reality in which our Top End communities reside.

3.0
Trial methodology

> "The personalised advice we received was very helpful and has given us a **better understanding** of saving power and money."
>
> Project participant, 2015

A combination of energy assessments, education and retrofits was used to deliver the LIEEP objectives to targeted low income households in Darwin.

480 low income households living in greater Darwin were targeted for this project.

Community engagement was embedded into every aspect of the trial to ensure that the full range of data collection methods were used and delivered effectively. This safeguarded the data integrity and facilitated a positive consumer experience.

Over the duration of the project, staff and delivery partners closely monitored the effectiveness of each activity and approach. If required, approaches were altered or ceased. Project materials were altered when necessary (e.g. translated, corrected, conveyed verbally rather than in written form), in alignment with the project's Funding Agreement requirements.

Project staff followed an 'action research' approach to the delivery of the project, to regularly reflect and discuss, analyse what is working and what is not, and tailor approaches if necessary, then re-assess those changes. A deep engagement with participants was used during the trial. This consisted of a face-to-face discussion between the assessor and the participant during the home energy assessment which took, on average, 1.3 hours. Shortly after, a personalised home energy report was generated by the assessor and posted to the participant. Each report contained personalised and specific information for the participant about their home and their energy use. A sample report is available in Appendix A.

3.1 Assumptions

The Top End of the Northern Territory has a hot and humid climate. It is classified as a tropical savannah, having a high humidity summer and warm winter (Sturman, 2008). There are two seasons in Darwin, which are based on the amount of precipitation: the dry season and the wet season. The wet season runs from approximately October to April, while the dry season spans May to September. The transitional months from the dry to the wet, generally from early September to mid- to late-December, are locally referred to as the "build-up", due to increased humidity but lack of the cooling effect from monsoonal rains. During the dry season, climate conditions generally fall within ASHRAE standards for comfort (ASHRAE).It is during the wet season where thermal discomfort is high and lasts for the majority of the day.

Thermal discomfort is highest when humidity is at its peak. Under these conditions, the use of space cooling is high. The local electricity retailer estimates that Darwin residents use about 45% of their electricity on space cooling (Manicaros, 2016). This reflects the COOLmob programs' findings over its 14 year history and is evidenced in the Smart Cooling project survey data.

With the need for an energy-demanding mechanism to remain comfortable but financial restraints in place, certain issues inevitably ensue. Since participants were all low income, their ability to meet their comfort and health needs through space cooling may come at a high percentage of their income. In this situation, the concerns are that either participants cannot afford to cool their homes and are living in discomfort or that they are cooling their homes to ensure comfort but at a large cost to their discretionary income. Residents in Darwin spend more on electricity than consumers in any other Australia capital city (NT COSS, 2013:1). In 2013 expenditure on electricity had increased by $10.80 per week.

3.1.1 Barriers

Cost, knowledge and motivation were the key barriers identified and targeted through the trial methodology.

The cost of structural retrofits or appliance upgrades can cost large amounts of money, and low income participants would be less able to cover these costs. For renters, the additional barrier of split-incentives would be a factor. All aspects of the trial were fully funded, overcoming this barrier.

Other barriers anticipated were in regards to knowledge. Participants may not be aware of the most efficient ways to make themselves comfortable in their homes. They may also not know of behaviour changes they could implement to save energy in other areas not related to comfort.

Motivation was the third identified barrier and links in closely with knowledge. Consortium members identified that health concerns would affect motivation. Two of the original consortium partners work with the elderly and people who need medical care. In these instances, it could be expected that savings might be limited by the higher thermal comfort needs of the participants. Motivation was addressed through positive and consistent engagement with the target group and tailored recommendations aimed at addressing the specific mobility or health requirements.

3.1.2 Services

Services are the defined treatments that participants received on the recommendation of the Smart Cooling Project Officer. When designing possible services for Smart Cooling to provide to participants, certain assumptions had to be made to determine what services would be appropriate to offer.

3.1.3 Home occupation times

It was assumed that most of the homes of participants would be unoccupied during the day; adults would be at work and children at school. This was one reason ceiling insulation was ruled out. Insulation works to slow the rate of heat transfer between two spaces. In an insulated building the peak indoor temperature inside is reduced because less heat enters the building during the daylight hours. On the other hand, the heat that does enter the building during the day takes longer to escape at night (Reardon, 2013). Since the aim was to make participants more comfortable in their homes, and it was assumed most homes would be vacant during the hotter parts of the day, homes could better be passively cooled during occupation times. As passive cooling does not consume electricity, it was thought passive cooling was a better option than using insulation to make mechanical cooling more efficient.

3.1.4 AC usage times

The times of AC usage were not known for Darwin but Singapore has a similar climate and a study has shown that residents mostly use their AC only at night for sleeping (Chua, 2010). As our only reference point, the services offered were designed around this concept.

3.1.5 Need for cooling

The Smart Cooling project focused on helping people feel more comfortable in their homes in the most energy efficient ways possible. The very core of the project assumed that cooling was an extremely important need and that low income participants may struggle with meeting this need.

3.1.6 Proposed outcomes

- That improving the thermal performance of a home would improve thermal comfort of the residents
- That increasing knowledge about the use of the AC system would lead to changed behaviour in the use of this appliance
- That highlighting alternatives to avoid and/or reduce use of the AC would not have a negative impact on thermal comfort and would lead to changed energy use patterns
- That a reduction of 10-30% electricity consumption would be realised

3.2 Recruitment

3.2.1 Initial cohorts

Initially, this project was designed to include only participants who were referred by the contracted social welfare agencies (delivery partners). Additionally, participants also had to meet the low income and geographical selection criteria.

In Darwin, the **climate dominates everything**. Peak energy use typically coincides with the build-up and wet seasons.

Participants were grouped into five cohorts of low income household: refugees (multicultural clients of Melaleuca Refugee Centre); seniors (clients of COTA NT); Indigenous or Torres Strait Islanders (clients of Yilli Housing); carers of people (clients of Carers NT); care recipients (people with disabilities, the frail aged, mentally ill or long term ill; cared for by clients of Carers NT). Initial recruitment targets for each cohort were:

- Refugees n=120
- Indigenous n=120
- Seniors n=120
- Carers and care recipients n=120 (roughly n=60 of each)
- Total n=480

A sixth cohort was added as the project expanded and the eligibility criteria changed (see 3.2.2). These eligible participants registered independent of any agency and were categorised as unaffiliated for the purpose of this report.

The first phase of recruitment was delivered through closed referral pathways provided by the social welfare agencies. This included promotion of the initiative through their programs, services, advertising channels, and membership base.

3.2.2 Eligibility criteria

The original recruitment strategy did not deliver a sufficient number of participants. A new recruitment approach was developed to allow a broader base of households to meet enrolment criteria. Under the new approach, participants no longer needed to be a member of the consortium partner organisations but still had to meet the low income and geographical requirements. This second phase of recruitment utilised the local media extensively through two purposeful and dynamic advertising campaigns. These rapidly increased the project's profile across the community and validated the project for eligible households. Under the new strategy, many participants outside the original trial scope were able to join the project.

i. Income: At the beginning of the project, a single participant needed an annual income of no more than $16,000 per annum before tax. This excluded many legitimate low income households unnecessarily. The threshold was raised in line with the National Rental Affordability Scheme (NRAS) to be more reflective of local living expenses (NTCOSS, 2013:2).

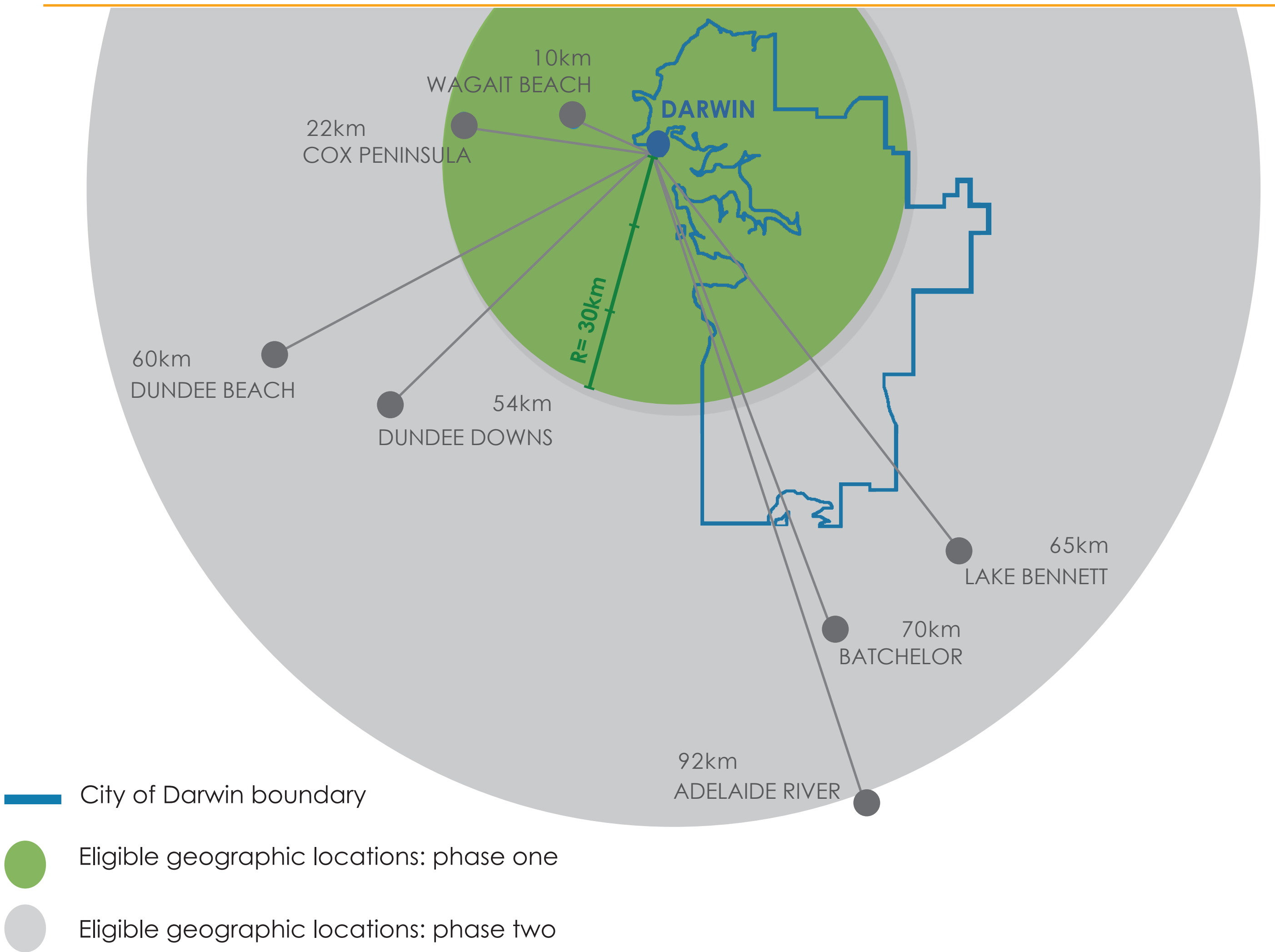
ii. Approved payments as indicators: Other factors that allowed participants to identify for enrolment included:

- They held a low income healthcare card
- They received certain Centrelink payments
    - Age pension
    - Carers allowance
    - Carers payment
    - Carers supplement
    - Disability support pension
    - New start allowance

iii. Housing: participants were eligible only if they lived in privately owned or rented property. The limitation that participants could not live in public housing posed a large challenge. It is possible that social welfare agencies would have been able to meet recruitment goals if this restriction had not been present.

iv. Geography: Initially, participants came from within a 30 km radius of Darwin city centre, in order for the project to engage both urban and suburban households. Later, this boundary was enlarged to improve recruitment numbers. Participants in outer townships, as far away as Adelaide River (~100 km away), were accepted. Logistically, larger distances than that were not feasible.

Figure 2 Map of the eligible geographic locations for Smart Cooling in the Tropics



3.2.3 Communication and promotional strategies and activities

A community engagement approach was used to deliver the project. Working with local trusted agencies with client networks greatly assisted the project in brokering trust with the targeted low income households. Furthermore, these agencies provided expertise to customise language and messaging to appeal to the specific sub-cohorts e.g. multicultural, generational.

The set-up phase of the project involved engagement with staff in the delivery partner agencies to understand the barriers and motivations and start tailoring engaging messages for the target householders. For example, in liaising with COTA NT, staff explained the need to present information clearly and non-patronisingly, with practical demonstrations of how to use energy-consuming appliances efficiently.

As the project commenced, COOLmob continued to engage regularly with the social welfare agencies to ensure other project activities were developed most effectively, e.g. promotional materials, home energy assessment templates, and recruitment activities for home energy assessment households.

Promotional materials were developed in the first eight weeks of the project. This pilot phase provided an opportunity to test and refine the materials and systems early on.

Materials included:

- Background pack for delivery partners
- Recruitment brochure and poster
- Energy saving fact sheets
- Data collection surveys - including the home energy assessment template
- Behavioural reminders e.g. stickers.

Social media campaign 2015

Brochure evolution

Posters and brochures

Posters and brochures provided information about the project and eligibility criteria. These were distributed in key community service locations such as libraries, medical centres, and shopping centres. Project specific displays were set up at contracted social welfare agencies and at Centrelink.

Print media

Print media was utilised heavily in the second phase of recruitment. Advertising in local newspapers (NT News and Darwin Sun) promoting the project was effective for recruitment.

Sponsorship of the special Green edition of NT News included tips on managing electricity costs as well as a specific editorial to increase recruitment numbers.

Workshops

The project delivered free workshops and information sessions for community members to learn about energy efficient home cooling. These workshops took place at accessible locations including the library and the premises of each of the delivery partners. Project staff delivered workshops with advice and assistance from delivery partner community facilitators. Involvement of the delivery partners facilitated the delivery of appropriate messages.

COOLmob evaluated both the impact of these workshops and the capacity building of delivery partners' knowledge on saving energy at the end of the project.

Marketing/ media campaigns

The project initiated a widespread newspaper advertising campaign in the second phase of recruitment. Three successive print advertising campaigns, each running over consecutive weeks, were conducted in regional (NT News) and local (Darwin Sun) newspapers.
The campaign began with a one-off advertisement in February 2015 and three intensive campaigns between May and September 2015 where advertisements were run over consecutive weeks.

The print media campaign also included three media releases in local and regional newspapers between February and September 2015.

In addition, the project was promoted through the COOLmob webpage on the ECNT website where people could request an assessment by completing an online form. The website included testimonials and case studies from participants. General promotions were via monthly newsletters emailed to subscribers of COOLmob and ECNT's regular newsletter as well as via the Smart Cooling project's participant email distribution list.

Figure 3 newspaper advertisement

Social media activities included a Facebook campaign during the final weeks of the recruitment phase (July-September 2015). Each week a different participant with a quote from them was posted. These were sponsored posts to increase the reach. In total, eleven posts were included on the Facebook page.

Advertisements were also screened at the Deckchair Cinema in Darwin every night over three successive months. Project staff were interviewed about the project on local radio (Territory FM) and a 30 second radio advertisement was run daily over a period of two to three months.

Public presentations (both educational and promotional) were delivered by project staff at various events, including:

- 'Probus' event (national body/club for elderly)
- Multicultural Council (NT)
- Charles Darwin University for the Adult Migrant Education Program

Information was also disseminated via stalls at events organised for World Refugee Day, Tropical Garden Spectacular, Sustainable House Day, Italian Festival (with COTA) and Carers (NT), Bagot Community reconciliation week, Berrimah Estate during NAIDOC week, and Seniors Week (COTA) at the Museum and Arts Gallery of the NT.

Both the presentations and the stalls were brokered and supported by the consortium members.

3.3 Home energy assessment

A major feature of the project was the provision of a free home energy assessment for low income households. A trained COOLmob Project Officer delivered each assessment. The aim of the assessment was to establish the energy use of each home, catalogue the dwelling characteristics, establish the thermal comfort zone, and document the household behaviours and attitudes. Later on, analysis of energy use patterns was undertaken using the household's energy consumption history. Strategies to improve the home's energy efficiency were recommended and provided in the home energy report (see 3.3.4). The primary focus was on measures to make the home cooler and/or to cool it more efficiently and raise energy literacy. The home energy assessment formed part of the deep engagement approach.

The project team regularly monitored and improved the format and delivery of the home energy assessment, ensuring alignment with the Data Collection and Reporting Plan.

3.3.1 Purpose of the assessment

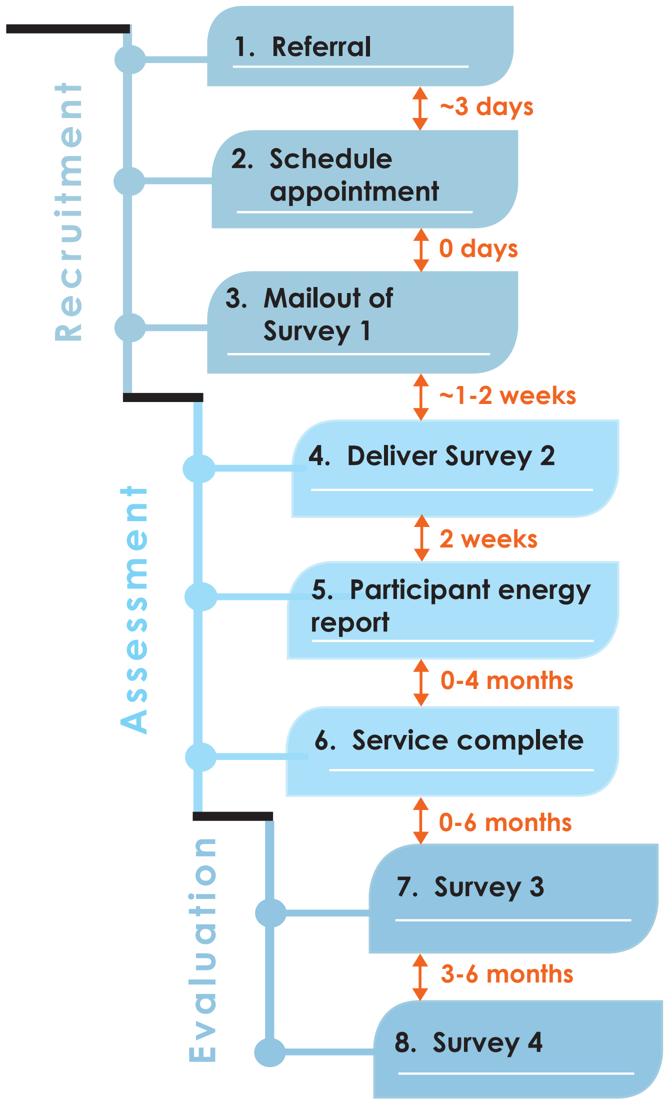
- To deliver energy efficiency information and behaviour change recommendations to each household. This was presented in a format tailored to each household using clear concise English, interpreters and translators, and a demonstration of recommended actions.

- To establish which energy saving service was appropriate for each household. Services were tailored to suit individual circumstances. (See Section 3.4)

- To collect data on householders' energy consumption patterns and attitudes. This was executed in alignment with LIEPP data portal requirements and forwarded to Charles Darwin University for analysis.

- To establish a platform for project staff to provide ongoing support to householders, including a post-assessment home visit. The face-to-face rapport developed at the home energy assessment was an important precursor for successful engagement at the post-assessment home visit.

Figure 4:
Participant process timeline



3.3.2 Assessment timeframe

- An assessment visit took approximately one hour to complete in the home.
- Household recruitment, reminder phone calls, post-assessment presentation of recommendations, follow up visits etc. meant each assessment took several hours or even several days.
- Behavioural advice and simple energy saving products were given at the time of the home energy assessment.
- Follow-up liaison regarding appliance upgrades and investigating larger-scale structural modification and hardware installation took place as soon after the home energy assessment as possible.
- Installation of larger-scale products by tradespeople took place over three to six months.
- Behavioural changes and billing data were to be evaluated at three, six and twelve month intervals to determine differences in behaviour in different seasons, i.e. the wet and the dry when householders' energy consumption patterns would most probably vary. Ultimately, due to the reduced timeframes and difficulty in recruitment at the beginning, evaluation took place at various intervals.

3.3.3 Participant starter pack

A participant starter pack included energy and comfort measuring devices along with educational material developed from COOLmob's existing intellectual property. The starter pack was given to participants at the time of the home energy assessment.
The pack contained:

- Fact sheets for effective cooling and household appliances running costs
- Stickers with prompt messages (e.g. recommended temperature settings for an AC)
- An invitation to attend workshops explaining electricity bills and ways to save electricity
- A temperature and humidity gauge to inform participants of their surroundings. Both measurements are displayed on a jumbo-sized LCD screen. A minimum and maximum function allows tracking the highest and lowest temperature and relative humidity readings for reference.

- A portable, single appliance energy monitor (Watts Clever) to use as an educational tool to show how much energy different appliances in the house use.

3.3.4 Home energy report

Shortly after the home energy assessment a personalised home energy report was generated and posted to each participant. An example is included at Appendix A.

Each report contained personalised and specific information for the participant about their home and their energy use. Importantly the report outlined the complimentary services the project would provide and outlined who would be contacting them and the approximate timeframe. The tone of the report was positive and empowering throughout, building on the face-to-face rapport developed at the home energy assessment.

It was important to positively motivate and encourage the participants to act on the recommendations in their action plan but even if the participants decided not to invest in the change or action, the home energy report provided a pathway to increasing their knowledge and energy literacy.

> "Smart Cooling brought about a major change for some participants. It was the begining of them reclaiming their house maintenance, it was the first step."
>
> Smart Cooling Project Officer

The homeowner's electricity use was compared with local and national averages (historical consumption data was obtained from the local electricity retailer). A personal action plan outlined energy-saving recommendations based on the assessment results and a suggested target kWh use.

Using the deemed savings methodology recommendations were outlined in the report listing potential savings or improvements associated with the action.

Dot points, infographics, and an easy to read layout maximised readability for the participants. This was particularly important for people with poor eyesight, low literacy levels or English as a second language.

3.4 Services

After the home energy assessment, the Project Officer recommended one of the available services that best suited each participant. Each service was fully funded by the project and no participant contribution was needed. Split-incentives were avoided by requiring the owner of the home to give permission for any service that required modifying the building itself.

Services delivered

Structural modification

Structural modifications altered the building fabric to improve the built environment.
This included measures such as introducing shading devices and improving the passive cooling through modification of windows or doors. Each participant was eligible for one complimentary service based on the results of home energy assessment. Additional recommendations were made that could increase or support the same objective.

	Service	Description	Number delivered:
1.	**Reflective roof paint**	Paint roofs with a heat reflective roof paint.	32
2.	**Shade sail**	Install external shade sail/ shade cloth	32
3.	**Window shading**	Install external window shading/ blinds	29
4.	**Attic ventilation**	Install roof / gable ventilation/ whirly birds	8
5.	**Flyscreens / security screen package**	Upgrade of security screens/ flyscreens to allow windows to be opened	54

Behaviour change

Behaviour change involved education on effective ways of improving energy efficiency and thermal comfort using existing cooling systems. It included cooling management practices such as closing of windows and doors and setting temperatures to efficient settings.

	Service	Description	Number delivered:
1.	**Timer pack**	A timer switch to monitor/ turn off appliances & a single appliance energy monitor.	18
2.	**Home cleaning package**	A professional cleaning contractor will clean flyscreens and fans at the home to improve air flow.	16
3.	**No service**	Assessment only	14

Table 1 Services offered to participants based on the results of their energy assessment

Appliance upgrade

Appliance upgrade involved replacing or upgrading existing and/or old inefficient cooling devices with more efficient ones.

	Service	Description	Number delivered:
1.	**Fan package**	A selection of free standing fans to be used in conjunction with a higher setting on the air conditioner	94
2.	**Standby saver package**	A stand by saver switch designed to easily turn off appliances & a single appliance energy monitor	23
3.	**AC cleaning service**	Air conditioner cleaning service	92
4.	**Thermostat control service**	Programmable thermostatic controllers, for box air conditioners or plug-in fans	8
5.	**Ceiling fan**	Upgrade ceiling fans	41
6.	**AC reinstallation**	Refit poorly installed air conditioning units	6
7.	**Wall fan**	Install two wall mounted fans	9

3.5 Evaluation methodology

The project was evaluated using three criteria:

1. Savings in energy consumption,
2. Improvement in thermal comfort and
3. Increase in knowledge. By achieving one or all of the goals, the main objective of the LIEEP program to assist lower income households in managing energy use would be realised.

The project did not establish a control group. As this element was not included in the initial project and budget design, and in consideration of the reduced delivery timeframes, establishing a robust and effective control group was not feasible. The target recruitment number of 480 was considered to be statistically meaningful, therefore meeting this target was a priority.

A baseline measurement was incorporated into the data collection framework to allow for before and after analyses of the identified project barriers as well as the impact of the services.

The project utilised multiple qualitative and quantitative data sources; participant energy use data, surveys and interval meter data. To establish measurable parameters for thermal comfort, temperature loggers, thermal cameras, anemometers were installed in a number of homes.

Smart Cooling evaluated the impact of services on a group by comparing the state of the group before and after delivery of the service. It was assumed that the state or the condition of the group would be steady without service. Any significant changes of conditions observed during the service were taken into account.

3.5.1 Energy data

As a key component of any energy management project, energy consumption formed an integral part of the project evaluation. Energy data was obtained from the sole electricity retailer in Darwin. Originally, it was proposed to use this participant data for before and after the project comparisons. However, as outlined in section 4.2.2 of this report, measurements for changes in consumption were only possible for a small portion of participants due to slow initial recruitment and time constraints of the delivery. Billing data was only available in three-month increments. It was originally planned that Project Officers would occasionally visit households to read the electricity meters. However, this was not feasible given the compressed timeframes for delivery of assessments and services.

Consumption results of different cohorts was also investigated.

Energy control group

No control group was established. Comparisons relied on before and after data only.

Interval meter

Two of the services provided were of special interest and so extra evaluation means were employed. It has been demonstrated many times that reflective roof paint can reduce the heat gain of a building and therefore reduce space cooling costs as well (Akbari, 1998; Synnefa, 2007; Cheng, 2005), but it was not known what the performance would be in Darwin's climate. Temperature loggers were placed in both the attic and the living space of treated houses to measure temperature changes due to the roof paint. One participant who was identified to run AC during the day, also had an energy interval logger installed on the AC circuits of the house.

The other service of particular interest was professional AC cleans. Since ACs are responsible for a large portion of residential electricity consumption in Darwin, any treatment that can make them run more efficiently is worth investigating. Though many professional AC cleaning services claim to improve AC efficiency, little evidence has been found to back up these claims. The sole source found (Ergon Energy, 2011) showed an increase in efficiency of 10-30%. It was decided that more information was needed on the effectiveness of this service, but indications were that it would be beneficial.

3.5.2 Thermal comfort improvement [and other benefits]

A second objective of the project was to investigate thermal comfort. Data collection methodologies and activities aimed to understand and improve comfort levels, and at the very least, to maintain current comfort levels in a more energy conservative manner.

> If energy-saving measures are introduced to a household, but peoples' thermal comfort decreases, these changes are not likely to be long-lasting.

To gauge improvements in thermal comfort, we compared responses of participants' multiple thermal comfort surveys given over the course of the project.

Physical measurements that affect thermal comfort were taken at the time of the home energy assessment. Temperature, relative humidity, wind speed, and radiant temperature were recorded at each home. Time did not permit evaluation of these measurements but they were helpful engagement tools and valuable in ascertaining which service was a good option for a participant.

3.5.3 Deemed Savings

Deemed savings methodology uses pre-determined, validated estimates of energy and peak demand savings attributable to energy efficiency measures for a particular type of application. It was used to undertake the cost benefit analysis for Smart Cooling in the Tropics in lieu of energy use data for all project participants.

The methodology was initially developed to provide approximate energy saving information to participants relating to the services and as insurance in the instance that energy consumption data was not available for project participants. All assumptions and calculations are in Appendix 3.

3.6 Surveys

3.6.1 Participant surveys

The majority of the data collected came from four surveys delivered to participants by Project Officers. To minimise the risk of influencing participants to provide 'false' or overly 'positive' self-reported responses on surveys and interviews, officers were trained in professional social research methods.

3.6.1.1 Survey 1: Demographic survey

After registration, the participant was provided with an initial survey (usually sent through post or email) designed to collect demographic information. Questions related to age, gender, number of people in the household, participant income level, education, etc. formed part of this survey. Additional questions were included regarding electricity usage behaviours and general attitude toward energy conservation. Some of the attitude and behaviour questions were asked again in Survey 4 at the completion of the project to assess changes.

Sending out Survey 1 before the assessment was designed to be a timesaving measure. However, in some cases it was completed during the home energy assessment along-side Survey 2.

This was especially true for participants who did not speak English as the form was only in English and for Yilli Rreung participants who did not receive any mail. In all these cases, Survey 1 was collected at the time of the home energy assessment.

3.6.1.2 Survey 2 - Home assessment survey

Survey 2 was carried out at the same time as the home energy assessment. It was used to collect a large amount of information about the participants' dwelling characteristics and psychological attitudes. The following type of information was recorded:

- Structural characteristics such as dwelling type, wall construction, and roof material
- Major appliances such as air conditioners (ACs), refrigerators, and water heaters
- Personal questions about participant thermal comfort especially in regard to their home.

The information collected during Survey 2 helped inform the Officer which service was appropriate for the participants. This survey also contained most of the information that was uploaded to the CSIRO database.

3.6.1.3 Survey 3 - Post-assessment survey

Survey 3 was delivered three to twelve months after Survey 2, depending on when the participant registered. It was an important opportunity for participants to provide feedback on the services. Incentives in the form of prizes (e.g. supermarket vouchers) were offered to encourage participants to complete the survey. The survey was delivered face-to-face, over the telephone, online or by post. The inclusion of certain questions in the survey was partly driven by answers to the previous two surveys. Data was collected regarding occupation time of the home and AC usage behaviours to guide future energy-saving recommendations as well as future studies.

Survey 3 was designed to collect changes in the household that may have been a result of joining the Smart Cooling project. Thermal comfort questions were repeated for before and after comparisons.

The survey also asked participants if they had made any behaviour changes with a focus on the personal recommendations from their energy report. Responses to these question were used to estimate the deemed savings for evaluation.

3.6.1.4 Survey 4 -Second home visit survey

Survey 4 was the last opportunity to get feedback from participants. The questions concerning attitudes and behaviours toward energy efficiency from Survey 1 were asked again in Survey 4 to evaluate any variations from the beginning of the project to the end. The participants were also asked to suggest any benefits they received from the Smart Cooling project. Benefits other than energy savings were mostly sought after so they could be understood and evaluated. A few of these questions were used for cost-effectiveness calculations.

Participants were also given the opportunity to evaluate project staff, contractors and their overall satisfaction with the Smart Cooling project.

Because of time constraints, only a small portion of the participants was selected to receive Survey 4. The participants were not chosen at random but in accordance with certain selection criteria:

- An attempt was made to survey participants across all services delivered so these could be fully evaluated.
- Households where participants had interval loggers for collection of data were of particular interest.
- Some participants were simply easier to contact.
- Another criterion for selection was the date the participant joined the project and received their complimentary service. A longer period of time over which to measure any benefits was preferred.

3.6.2 Other surveys

Staff survey

Staff surveys were conducted to collect anecdotal information regarding the benefits and barriers for participants in implementing energy efficiency measures in their home. This information formed part of the anecdotal evidence regarding the impact the project had on participants.

Staff were asked a series of questions about design, approach, and implementation of the project. They provided recommendations regarding future projects and policies using their operational experiences.

Contractor survey

The main contractors involved in the delivery of the services to participants' homes (both structural and appliance upgrade) were interviewed at the conclusion of the project.

Delivery partner survey

The delivery partners were interviewed at the conclusion of the project.

3.6.3 Case studies

Several case studies were selected to reflect the types of benefits participants gained through their involvement in the project. The case studies were also chosen to reflect the various cohorts represented and the range of services delivered by the project as well as the location of the participants (Darwin/ Palmerston/ rural) and the housing type.

Another criterion for selecting the case studies was the date the participant joined the project and received their complimentary service. As with Survey 4 a longer period of time over which to measure any benefits was preferred.

3.7 Determining benefits

The benefits of the trial (as a whole) and individual trial components and/or services can be grouped into three different categories:

1. Monetised benefit- These benefits are determined by the electricity cost savings from a particular service.

2. Non-monetised quantified benefits- These are benefits that can be quantified in units other than monetary units, e.g. kWh saved, improved thermal comfort, reduced heat stress, and improved quality of sleep.

3. Qualitative benefits- These are benefits that are not quantified but are reported through surveys.

For quantifiable benefits, a cost per unit of benefit can be calculated. There are many levels of costs associated with a large project such as Smart Cooling. The costs were grouped into four different levels and are outlined below:

For cost details of the different levels see Appendix B.

The cost per energy savings is the ratio of these costs to the deemed savings of each service. With the electricity tariffs, the energy savings can be converted to dollar savings, and the cost-benefit is found for each service. The timeframe for savings was determined by the warranty period of the product or service if available, otherwise the Federal Register of Legislation provided by the Australian Taxation Office (Taxation Ruling TR 2015/2).

As an attempt to quantify some of the benefits, questions in Survey 4 had scaled responses with respect to changes in thermal comfort levels, heat stress, noise, and sleep quality. Each response is compared to the cost of the service that brought about the change. There is no means of comparison between the scales nor a way to quantify the monetary equivalent of the changes in this work. Results are found in Section 4.9.3.

Table 2 Different cost levels associated with the project. The cost-benefit analysis at each level can be found in the Results section of this report.

Cost level	Cost data required
Direct trial approach (Level 1)	The delivery of an outcome for: **a. the cost of delivering the trial approach to a participant**. For example: The calculated cost of delivering: - the retrofit hardware and install cost per participant - the home energy assessment and coaching cost per participant - the education program per person
Trial component (Level 2)	The delivery of an outcome for the: a. the cost of delivering the trial approach to a participant, **and** **b. costs associated with:** **i. recruiting a participant, and** **ii. maintaining a participant.** (For example media and advertising, staff time, conducting interviews, screening applicants, maintaining resources to support ongoing participation etc.).
Total business (Level 3)	The delivery of an outcome for: a. the cost of delivering the trial approach to a participant, and b. costs associated with: i. recruiting a participant, and ii. maintaining a participant. **c. cost of running an organisation to do the above** (For example renting office space, IT infrastructure, energy costs (gas and electricity), running costs, over-heads etc.).
Total trial (Level 4)	The delivery of an outcome for: a. the cost of delivering the trial approach to a participant, and b. direct costs associated with: i. recruiting a participant, and ii. maintaining a participant. c. cost of running an organisation to do the above **d. cost of participating in a government funded trial** (Total cost of the trial, including funding, co-contributions (in-kind and cash) and administrative and compliance costs associated with participating in a government funded trial – for example costs associated with preparing milestone and financial reports and time spent working with the department to meet Funding Agreement requirements).

4.0 Results

"This project has definitely **given me** the necessary **information to understand** the energy use in my home."

Project participant, 2016

Smart Cooling in the Tropics

4.1 Introduction

Smart Cooling in the Tropics achieved its intended objective to improve the thermal comfort of vulnerable households in the hot humid tropics without a disproportionate increase in the amount of energy used and associated costs.

This chapter of the report provides the results of the qualitative and quantitative data collected during the project evaluation phase. The primary data sources used are participant energy use data provided by the local electricity retailer in January 2016 and data collected through the delivery of surveys to project participants. Please refer to 3.6 for details of these four surveys.

Limitations

The energy data available for this report was limited. Therefore results relating to energy change must be reviewed carefully. The cost benefit and cost effectiveness analyses were calculated using deemed savings due to insufficient energy data.

4.2 Summary of results

The following is a summary of the key results detailed in this chapter.

Energy use baseline:

- On average project participants use 15% less energy than the rest of the Darwin population.
- Participants from a refugee background are the lowest energy users overall.
- The age group who use the most electricity per day is the 40-49.

Attitudes before and after the trial:

- Participants feel they have more control over energy use and finances after the trial.

- Participant's perceptions of energy efficiency improved as a result of the trial
- Participants feel more comfortable in their homes after the trial.

Barriers and benefits:

- Although the project addressed or removed many of the identified barriers, cost remains a significant barrier for low income households to improving energy use.
- The greatest benefit for project participants as a result of the trial is comfort. This is closely followed by a better understanding of electricity use.

- ***Upgrades to ceiling fans had the largest impact on reducing heat stress compared to all other services, indicating that air flow plays an important role in thermal comfort.***

- The free standing fan package, security screen upgrade and ceiling fan upgrade all rate well for improving quality of sleep. Although this is not statistically significant it is encouraging as it demonstrate that passive and low cost services can have a significant health and wellbeing benefit.

Recruitment and communication:

- Word of mouth and advertising were the most effective recruitment pathways.

4.3 Demographic background

Demographic breakdown of Smart Cooling participants:

- There was an over-representation of women at a 2:1 ratio of women to men (318:158).
- The proportion of participants who classified themselves as Indigenous was 10.5%, which is in line with Darwin at 9.2% (ABS, 2011)
- Almost 66% of participants were born in Australia, similar to the Darwin population of 67.5% (ABS, 2011). The most common regions from which immigrants came to Australia were from Europe (14%), Southeast Asia (6.7%) and Sub-Saharan Africa (4.6%).
- Over 86% of participants spoke English as their primary language at home. A few of the participants who were refugees needed translators present for interaction with officers.

participants with almost 60% above 60 years of age. Darwin is Australia's youngest-aged capital with a median age of 33 (ABS, 2011) so a younger demographic could have been expected. The median age of participants was 64.

- Most participants (65%) had completed at least a secondary education. The education level of participants was similar to the general Darwin population where 66% are at this level (Census, 2011).

- The largest employment category was retired at 46%, with 23% employed at least part-time. The remaining participants said they were looking for work or could not work because they were unable or studying.

- The average number of people per house was 2.75, which is similar to the Darwin average of 2.7 (ABS, 2011).

- There was a high level of home ownership, 55% of participants owned their home outright and a further 19% had a mortgage.

- 75% of dwellings were free standing houses. The remaining homes were mostly town-houses and apartments.

- Dwelling ages tended to be quite old, with 69% of properties being over 20 years old.

4.4 Energy consumption

Electricity data was received from the sole residential retailer in Darwin. The retailer checks electricity meters nominally every 92 days. The mean daily consumption (MDC) per participant household in a billing period is found by

$$\text{MDC} = \frac{\text{total consumption in billing period}}{\text{number of days in billing period}}$$

As a very crude approximation, each day within the period was assigned the same value as the MDC. This was necessary to compare participants over the same date ranges because meters were checked on a rolling basis and the dates of individual participants often did not align. It was not expected that participants actually consumed the same on a day to day basis, but the resolution of the data limited the accuracy of the analysis. Since the billing period was long enough to incorporate changes in seasons, there would likely have been a general trend of increased consumption heading into the wet season and a decrease heading into the dry season that was not accounted for on an individual basis. When the MDCs of the participants were averaged together, the inaccuracy in seasonal variation consumption was reduced but not eliminated. An example of the calculations can be seen in Table 3. The group mean on a particular day is the average of all the participant's MDC on that day.

Table 3 Example of mean daily average calculations from available billing data

Participant	Date 1	Date 2	Total consumption	Mean daily consumption	Group mean on 01/03/2015
1	01/01/2015	01/04/2015	1000	11.1	20.1
2	05/02/2015	07/05/2015	1500	16.5	
3	27/12/2014	29/03/2015	3000	32.6	

If the retailer was unable to access a meter to obtain the current reading, an estimated reading was used by the retailer based on historic consumption patterns. However, residents had the option to read the meter themselves and report it to the retailer for the bill instead of the estimated read. Retailer readings and customer readings were classified as actual readings.

Nearly **80% of participants** said they changed some of their habits based on recommendations in the report.

These changes were estimated to save 80kWh per year.

One of the goals of the project was to improve thermal comfort and so usage patterns of participants could be expected to change. Since the change would have occurred during the project, historic usage patterns may not have been accurate. For this reason the retailer estimated readings were not used and only actual readings were. If there was a billing period where an actual reading was not available, the estimated reading was ignored and the MDC was calculated over two billing periods instead of one. If two or more consecutive estimated readings arose in a participant's billing information, data for this time period was discarded for accuracy reasons.

Data was sought from the electricity retailer from 1 January 2013 until 1 January 2016, as that was the date range specified on the participant consent form. In all,

energy consumption data was available for 394 participants. However, very few participants had continuous data for the project's duration.

Not all reasons are known for missing data, but some of the known reasons were participants moving into and out of dwellings, numerous estimated readings as explained above, and the participant not always being the same person whose name was on the account.

Baseline energy consumption was calculated for the participants for the 1 July 2013 to 30 June 2014 financial year. All participant data used in the calculations was before enrolment; there were two participants who joined Smart Cooling before the end of the financial year but their data was not included in the calculation.

Only participant households whose data was available for the entirety of the year were used in the calculation. Figures provided by the electricity retailer at the time (Power and Water Corporation) placed the mean daily consumption per household per day in the Greater Darwin region at 26.0 kWh. With the available data, the MDC for participants was 22 kWh (N = 305, sd = 13 kWh), that was 15% less electricity than the Greater Darwin

population. Before joining Smart Cooling the participants were already using substantially less energy than the general public of Greater Darwin.

4.4.1 Electricity consumption for different participant categories

Different cohorts within the sample population had different needs and consumption patterns. The Smart Cooling project was designed to identify these differences in order to determine which services were helpful to everyone and which ones should be targeted toward specific groups. Table 4 below identifies the mean daily consumption for each participating cohort. MDC is broken down by cohort and displayed in Figure 5 and Table 4.

Key result: Yilli Rreung households are the highest energy consumers.

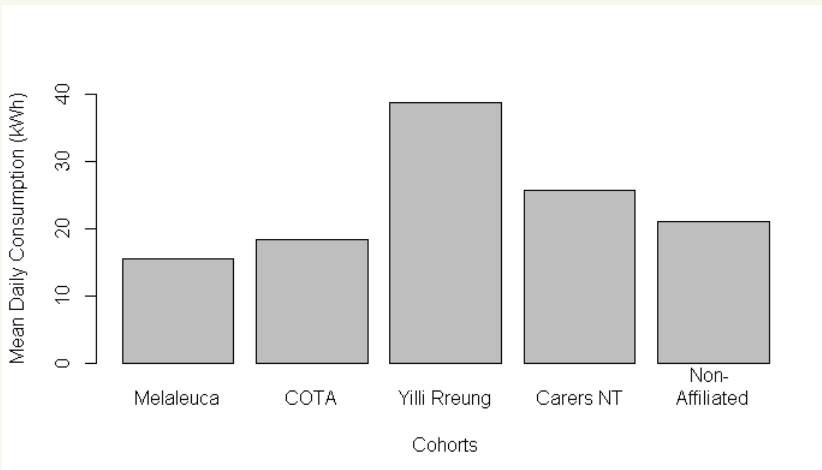
However However they use the least amount of energy on a per person basis.

Participants from a refugee background are the lowest energy users overall.

Table 4 Mean daily consumption by cohort.

Partner	Mean (kWh/day (household)	Standard deviation	N
Melaleuca	16	7	7
COTA	18	13	46
Yilli Rreung	39	14	10
Carers	26	14	46
Non-affiliated	21	12	196

Figure 5 Mean daily consumption by cohort.



The group with the lowest consumption was from Melaleuca. The amount of available billing history for members of this group was very small, likely due to often having to move to different rental properties.

Next to Melaleuca clients, COTA members were the next lowest energy users. With 85% of members (N=61, total COTA sample) being retired or unable to work, it could have been more likely for their energy use to be higher due to them being at home more often than other participants who work during the day.

Yilli households used the most energy. This was most likely due to their households having more people in them as well as method of payment as discussed later.

Households with carers were the second highest users which was not unforeseen. These were households where there were many medical issues and a healthy environment had to be maintained. Many people in these homes had reduced mobility as well. Even though their needs necessitated continuous climate control in their homes, they still did not use more than the Darwin average.

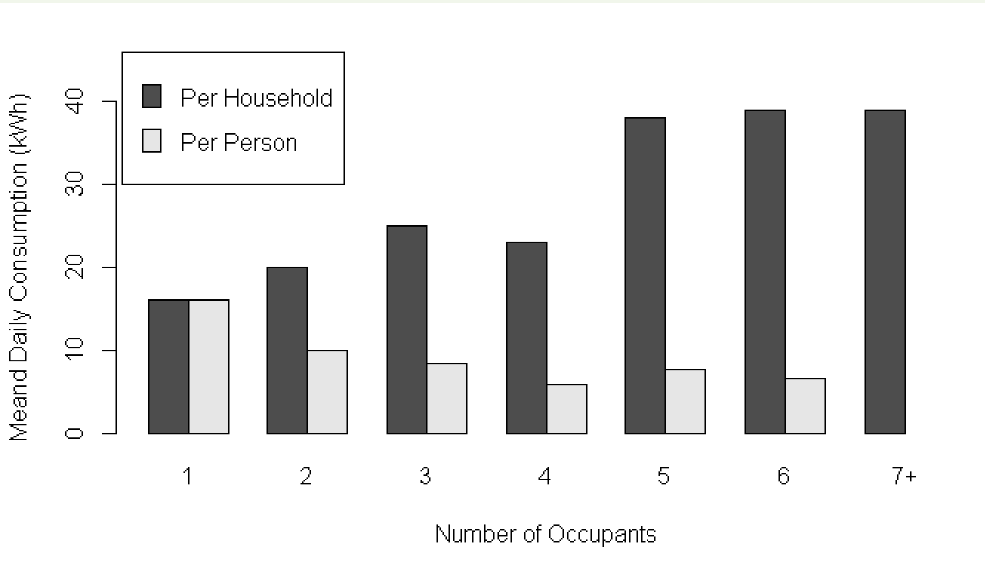
The number of people in a home affected the MDC of a household. The breakdown in MDC by number of people in the house is shown in Table 5 and Figure 6. Not surprisingly, the MDC of the households went up with the number of occupants with single occupancy dwellings having the lowest MDC. On the other hand, electricity consumption per person was lower for multiple occupancy homes but did not monotonically decrease with the number of people. This indicates that other factors were also responsible for consumption in multiple-occupancy dwellings.

Key result: Table 5 shows the number of people per household is one factor in home energy consumption.

Table 5 Mean daily consumption by number of occupants.

People per household	Mean (kWh/day) (per person)	Standard deviation	N
1	16 (16.0)	12	81
2	20 (10.0)	10	123
3	25 (8.3)	12	39
4	23 (5.8)	10	30
5	38 (7.6)	19	17
6	39 (6.5)	16	11
7+	39	13	4

Figure 6 Mean daily consumption by number of occupants in a household.



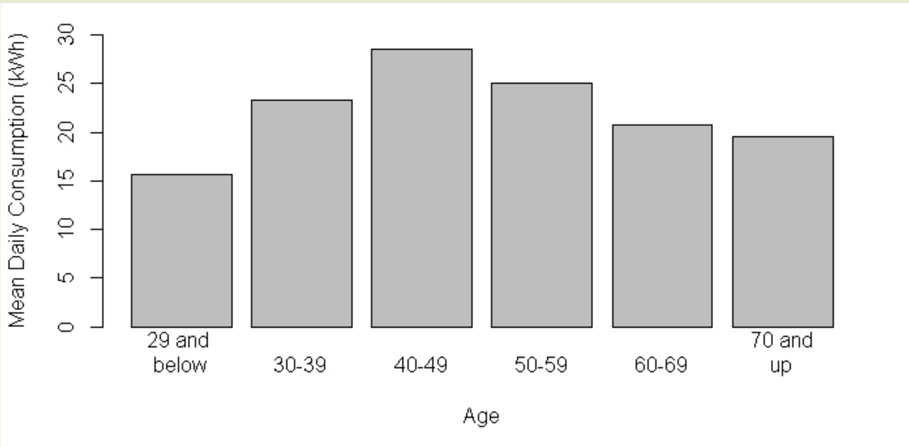
Age of the participant also seemed to be a factor on household MDC as seen in Figure 7 and Table 6. The age range of highest consumption was 40-49. The 30-39 age bracket had the same average number of people per household as the 40-49 bracket at four people per household. The 50-59 bracket had an average of three people per household and their MDC did not drop below that of the 30-39 bracket. Older participants were among the lower users, and these results reflect those found previously when looking at COTA participants. The different MDCs found for the different age groups are interesting and further investigation is needed to determine why this is the case.

Key result: The age group whose household uses the most electricity per day is the 40-49 and the group who uses the least is 29 and below.

Table 6 Mean daily consumption by age.

Participant age	Mean (kWh/day)	Standard deviation	N
29 and below	16	3	3
30-39	23	14	26
40-49	29	14	41
50-59	25	15	22
60-69	21	12	108
70 and above	20	13	105

Figure 7 Mean daily consumption by age.



Three types of electricity tariff were identified across the participant group (Table 7).

1. Standard domestic
1. Concession
2. Standard prepaid.

Table 7 Average domestic electricity tariff for the NT: 1 January 2014 - 31 December 2015.

Tariff	Price per kWh ($)	Daily charge ($)
Standard	0.26	0.51
Concession	0.20	-0.84
Prepaid	0.29	0

On 1 January 2013 electricity rates increased by 20% in the NT, followed by two more 5% increases over the next year at six month intervals. Over the course of the project, the tariff rates increased twice and decreased three times but stayed within a two cent range per kilowatt-hour. Average rates from 1 January 2014 to 31 December 2015 are given in Table 7. Concessions on standard domestic tariffs offered a discount on usage as well as a set daily compensation; prepaid customers on concession received around $1100 in power cards for the year. Records were not available for all concession rates over the period of the project, but they generally give customers a 40-50% discount on their bills. Seniors, pensioners and carers were eligible for concessions.

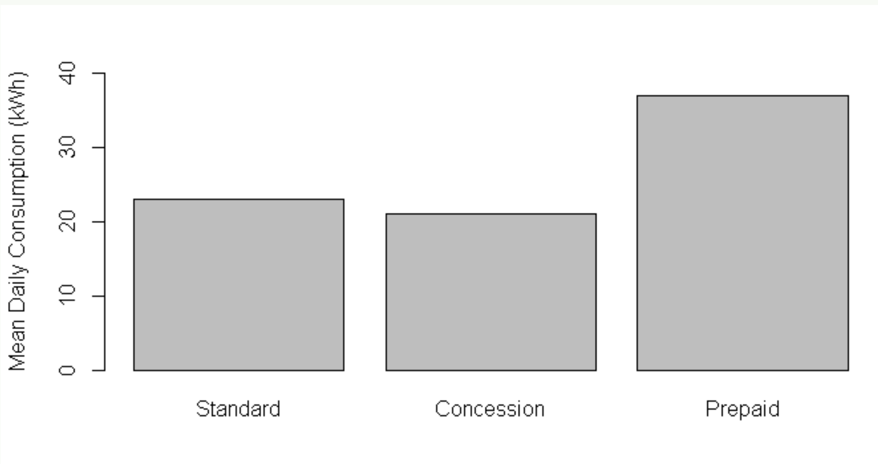
Mean daily consumption according to the three tariff rates are shown in Table 8 and Figure 8. Interestingly, households on the concession rate did not use more energy than those on the standard rate.

Key result: Households with prepaid meters use the most electricity per day. Prepaid meters are largely associated with Yilli residents.

Table 8 Mean daily consumption by tariff.

Tariff	Mean (kWh/day)	Standard deviation	N
Standard	23	13	91
Concession	21	12	204
Prepaid	37	15	10

Figure 8 Mean daily consumption by tariff.



Energy data for Indigenous participants is shown in Table 9 and Figure 9. Indigenous households tended to use more electricity than non-Indigenous ones. However, Indigenous households tended to have more occupants in a dwelling with an average of 4.6 people compared to the group average of 2.8. When calculated on a per person basis, Indigenous households used the least amount of energy.

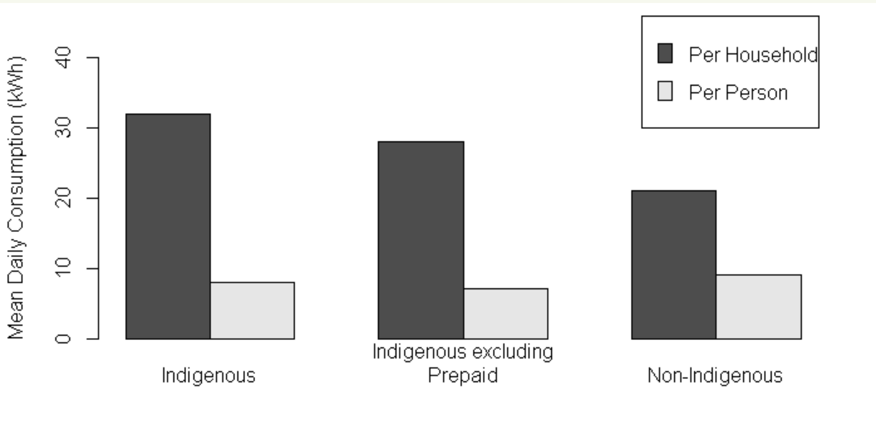
Indigenous households that were on a standard domestic tariff tended to use slightly less electricity than Indigenous households that were on a prepaid tariff. This could have been due to the different way of paying for electricity. However, with sample sizes this small it may just be a sampling error.

Key result: Table 9 indicates that the urban Indigenous households use more electricity per day than other households.

Table 9 Mean daily consumption for Indigenous and non-Indigenous households.

	Mean (kWh/day)	Standard deviation	N
Indigenous	32	15	22
Indigenous excluding prepaid users	28	13	13
Non-Indigenous	21	13	271

Figure 9 Mean daily consumption for Indigenous and non-Indigenous households.



4.4.2 Energy changes from Smart Cooling

Year-to-year energy consumption changes

The compressed timeframe of this project was less time than needed to gather and analyse the necessary billing information for all participants to identify energy consumption changes.

In order to identify energy benefits three approaches to energy consumption savings were applied using the available billing data:

1. 12 month before and after service comparison of billing data (30 participants);

2. 6 months billing comparison for the same six months in the year before project and year following the service (62 participants);

3. Step wedge method (Brown, 2006), complete on a continuous rolling basis and using available billing data for 394 participants.

Each method identifies savings for participants based on the services delivered by the trial. However, definitive conclusions are not available. Primarily this is because more billing data, spanning at least 12 months before and 18 months after the services were complete is needed to draw conclusions on the effectiveness of the services in reducing energy consumption.
Additionally there are conditions affecting energy changes that are not measureable or within the scope of the project's evaluation methodology.

Approach 1
Table 10 presents data for the first approach. (N=30). The mean daily consumption of 30 participants one year before and one year after assessment was compared. Note that the MDC for each service is given for both years as well as energy savings; negative savings mean there was an increase in consumption.

Many participants were **concerned about the costs associated with keeping cool**, even though their usage was low in comparison to the average Darwin household.

Smart Cooling in the Tropics

Key result: Although the numbers are not statistically significant, it is interesting to observe the energy changes for each of the services. According to these numbers portable fans and AC cleans had a beneficial impact on energy use.

Table 10 Approach 1: Mean daily consumption by service

Service	Number of participants	MDC Before (kWh)	MDC After (kWh)	Year to year savings (%)
Plug-in timer	1	21.3	22.2	-4.2
Home cleaning	2	15.4	12.7	17.5
Portable fans	5	10.4	9.7	6.7
Electric cable switch	1	24.3	28.0	-15.2
AC clean	10	27.3	29.7	-8.8
Plug-in thermostat	1	28.6	27.6	3.5
Roof paint	1	15.4	22.0	-42.9
Shade sails	1	26.9	23.0	14.5
Window shades	2	15.6	15.5	0.6
Attic ventilation	1	10.2	11.9	-16.7
AC reinstallation	2	36.2	46.4	-28.2
Flyscreens	2	16.1	20.4	-26.7
Assessment only	1	16.1	16.2	-0.6
Total	**30**	**21.2**	**22.9**	**-8.0**

Energy consumption data, from before and after services were delivered, was compared to determine energy savings from the project. Billing data for the year before service to the year after service was used to account for seasonal variations.

The analysis in Table 10 is for 30 participants as their billing information was continuous, starting one year before their assessments to one year after. The comparison was done using the mean daily average before and after the service was delivered.

Home energy assessments occurred between 17 July and 26 November 2014, with services being carried out between 01 March 2014 and 14 December 2015. Even though some of the services had not been completed by the second period, these participants were included because they were given a lot of information around behaviour changes that they could have implemented. The services breakdown for these participants is given in Table 10.

The services listed reveal a variation in mean daily consumption. Overall there was actually an increase of energy consumption for the group of 30 participants. This is thought to be an anomaly as later results tend to show a decrease in consumption. For instance, two of the participants had increases greater than 10 kWh/day in consumption, which is most likely due to changes unrelated to the project.

For the AC clean participants, there was almost a 9% increase in consumption. This may have been caused by the so-called rebound effect (Berkhout, 2000): Participants thought their AC units were costing less to run and usage patterns increased.

Approach 2

Table 11 outlines the second approach taken to identify energy savings. (N=62). This approach compares energy savings of mean daily consumption for 62 participants for the six month period from 31 March to 30 September for the years 2014 and 2015. All assessments were conducted between 5 November and 22 December 2014, while services were carried out between 3 March and 22 May 2015.

Key result: Numbers are too low to be statistically significant, however using this group of participants security screen upgrade seems to have had a beneficial impact on energy use.

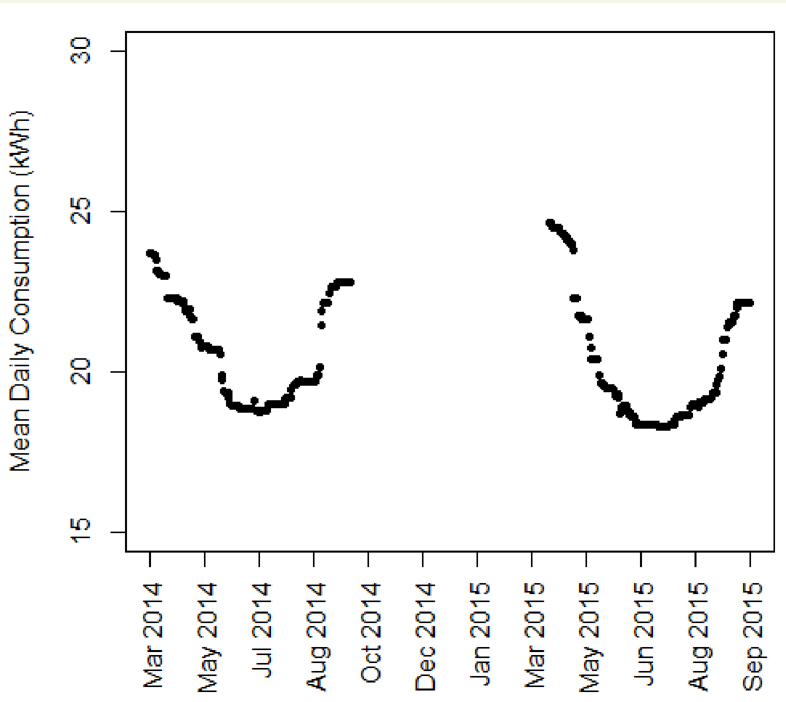
Table 11 Approach 2: Mean daily consumption by service

Service	Number of participants	MDC 2014 (kWh)	MDC 2015 (kWh)	Year to year savings (%)
Plug-in timer	1	66.7	47.0	29.5
Home cleaning	2	15.1	11.6	23.2
Portable fans	7	19.9	18.2	8.5
Electric cable switch	4	24.7	24.6	0.4
AC clean	17	18.6	18.0	3.3
Plug-in thermostat	1	12.3	10.7	13.0
Roof paint	5	18.4	18.9	-2.7
Shade sails	4	25.9	23.5	9.3
Window shades	6	13.5	17.7	-31.1
Attic ventilation	4	21.8	19.4	10.0
Security screens	1	24.1	19.4	19.5
Ceiling fan	3	27.9	26.5	5.0
AC reinstallation	3	30.2	35.3	-16.9
Flyscreens	3	13.4	16.6	-2.4
Assessment only	1	14.7	14.1	4.0
Total	**62**	**20.7**	**20.2**	**2.4**

As seen in Table 11, energy consumption did appear to come down by 2.4% for this small sub-group of participants. The Darwin daily average for the 2014-2015 financial year was 25.3 kWh, down 2.7% from the year before. So the decrease in consumption from the treated group cannot be conclusively shown to be due to the Smart Cooling project. Additionally, the time periods being compared occurred in the lower consumption times of the year when space cooling is needed the least; the period where savings were expected to be highest could not be assessed. Savings could be expected to have been higher but more time would be needed to collect the necessary data.

Figure 10 shows the mean daily consumption for all participants during the period from 31 March to 30 September in the years 2014 and 2015 (N=62).

Figure 10 Approach 2: Mean daily consumption



Most of the specific services above in Table 11 were given to very few participants, with the exception of AC cleans, which is in contrast to the results in Table 10. Because of the low numbers it was not possible to see if any changes occurred due to the project because the findings were statistically insignificant. AC cleans did show a slight decrease in consumption which is in contrast to above. But these readings were also taken during the lowest time of AC use and were in line with the Darwin average change.

Approach 3

The third approach used to measure energy use changes is a version of the Stepped wedge design. This methods uses billing data from 394 participants.

Participants were put into one of two categories 1. Before Assessment (BA) group or 2. After Assessment (AA) group. Initially, all participants were placed in the BA group since this project had not started yet. In a stepped wedge approach the BA group is designed to act as a control group to the other participants. On the day of the energy assessment participants started getting a lot of information and suggestions about using less energy to accomplish the same goals, i.e. thermal comfort. Much of this information required behaviour changes that participants could start implementing immediately. Therefore, the date a participant was removed from the BA group and placed in the AA group was on the assessment date. On average the service date occurred 91 days after assessment.

The stepped wedge analysis was used to try to get some general idea of changes in energy usage among participants from this project. This approach did take seasonal effects into account, though many issues limited the applicability and usefulness of this approach in analysing this dataset.

Issues regarding stepped wedge analysis

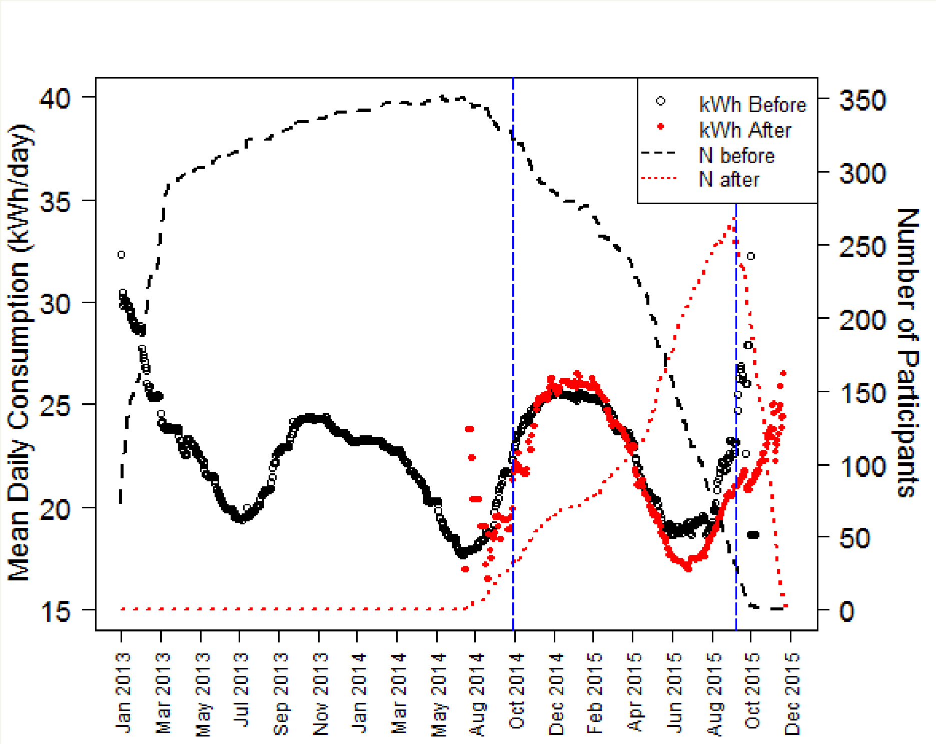
1. The BA group was used as a control group even though there was no mechanism in place to ensure they actually were a control compared to the AA group. With so many factors it is difficult to say if the change in MDC for a group was because of an actual change in participant consumption or if changes were simply due to a user with significantly different consumption changing groups.

- Participants joined and were assessed on a rolling basis and so there was not a possibility to characterise and separate households into different categories for comparison.
- There were large variations in dwelling characteristics that affect consumption such as size, number of rooms, orientation, shading, etc.
- Household makeup that affects consumption including number of people, ages, times when homes are occupied, etc. varied.
- The different appliances and their ages in homes also varied widely, leading to different energy profiles.

2. The date a participant left the BA group and entered the AA group was determined by the assessment date but the billing data meant their registered change in energy usage may not have happened until three months later. Therefore, if therewas a reduction in consumption, it would not show up at the proper time and falsely raise the MDC of the AA group.

Key result: This graph demonstrates seasonal variation.

Figure 11 Mean daily consumption of the BA and AA groups



A plot of the daily average energy consumption of the BA and AA groups is seen in Figure 11. The energy consumption on a certain day in the graph is not very accurate as described above and the shape of the plots should be used more as a guide for a general trend than accurate measurements. The peaks in the energy plots would be larger and more sharply peaked if actual daily data was available. Averaging over large periods of time improves the accuracy of the calculations.

The very first point of the AA group shows a decrease in consumption compared to the BA group. This is due to a single low user being placed into the AA group. When the second participant is added to the AA group, a dramatic increase is seen due to a very above average user. The large majority of the early members of the AA group were signed up through consortium partners.

The results in Table 4 show the large differences in electricity consumption between the consortium participants and the non-affiliated participants. The mean daily consumption for consortium participants for the 2014-15 financial year was 24 kWh compared to 21 kWh of the non-affiliated participants. This difference in baseline usage was one reason the BA group could not be used as a true control group. However, a comparison between the AA and BA groups could still be informative.

Electricity savings from the project were calculated for a yearlong period by comparing the difference in consumption between the BA group and the AA group. By selecting a duration of a year, seasonal effects were accounted for. The date range from 4 October 2014 to 3 October 2015, indicated by the vertical lines in Figure 12, was used for the calculation. The specific dates were chosen to ensure that enough participants were in each group over the time period. The BA group began with 322 households and finished with 31, while the AA group started with 33 households and ended with 251. Over the year, the AA group used 2.8% less electricity than the BA group. Considering the AA group contained most of the consortium partner participants early on, which had a 14% higher baseline MDC than the non-affiliated participants, this is indicative of real savings from the project.

Allowing for the issues with the analysis of the available data outlined above, and taking the decrease in energy use of the general Darwin population into account, energy savings from Smart Cooling were likely in the 1-10% range.

4.5 Personal conditions affecting energy efficiency

Smart Cooling measured changes in participant's behaviours and attitudes to help determine energy efficient actions in a home. The results compliment the energy analysis by identifying changes in household consumption and inquiring into changes in behaviours and attitudes.

To identify the personal factors that influence energy consumption in households, participants were asked a series of questions relating to their attitudes, perceived constraints and actions in regards to energy efficiency and related issues.

These questions were first asked in Survey 1 and completed by all participants. The responses established the baseline measure to understand participants before any assessments or services had been completed. The same questions were asked again at the final stage of the project to determine how this project impacted their attitudes and behaviours regarding energy efficiency. There were ten questions in total and all were based on a five-point Likert-like scale.

The Smart Cooling project was focused on thermal comfort in a hot and humid environment, so energy efficiency in this sense was defined as: 1. using the same amount of energy but feeling more comfortable, 2. using slightly more energy to feel more comfortable, 3. using less energy and feeling more comfortable or 4. using less energy to feel the same amount of comfort. The idea of saving energy was coupled with thermal comfort and so the results must be looked at concurrently.

Due to time constraints, only a small subset of the original sample population was asked the questions the second time in Survey 4. These participants were selected by certain criteria and were not random. Some questions on Survey 4 were used to assess the cost-effectiveness of each service and so participants were chosen to try to get a spread of cases to cover the services. Other reasons some of the households were chosen were because they had interval monitors and temperature loggers installed, they were going to be used for case studies, and sometimes they were simply easier to arrange a second meeting.

The entire sample populate was separated into two groups: 1. Group 1 is the portion of the sample that only answered the questions the first time on Survey 1 and 2. Group 2 is the subset of the sample that answered the questions the first time and second time on Survey 4. The sum of the population of Group 1 and Group 2 is equal to the entire sample population. Unless stated otherwise, the sample size for Group 1 is 413, for Group 2 is 63 and the sample population is 476.

As the participants who answered Survey 4 were not chosen at random, the first statistical test run was used to see if these participants could reasonably have been expected to be chosen at random. The second test compared the responses of Group 2 to Group 1 from Survey 1 to see if Group 2 was a good representation of Group 1 for Survey 4. The last test run compared the answers of Group 2 from Survey 4 to Group 2 from Survey 1 to determine if any changes occurred during the rollout of the project. The analysis of the first question is run through in detail as an example below and all subsequent analyses follow the same form. All statistical tests were carried out using the R programming
language unless stated otherwise.

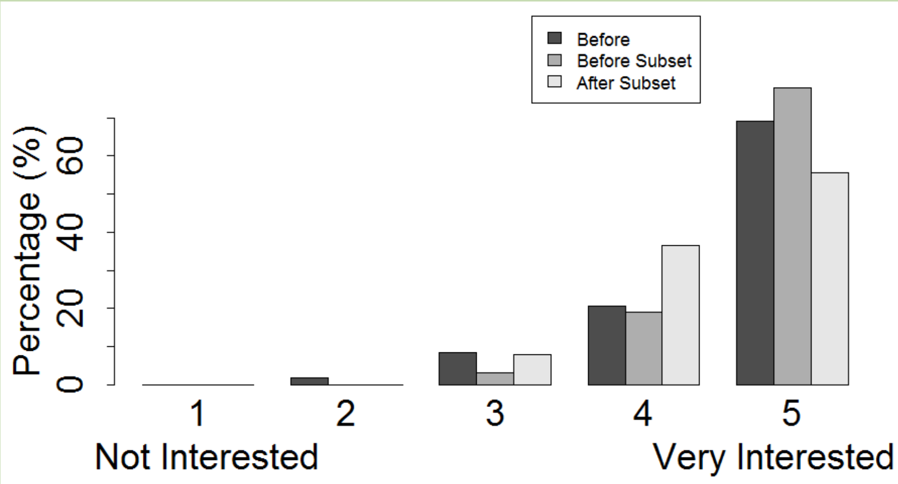
4.5.1 Interest, constraints and behaviours that influence energy efficiency

Interest in energy efficiency

IIn order to determine the likelihood of behaviour changes suggested by the Project Officers, it was important to determine how interested participants were in conserving energy. The responses to the question "How interested are you in conserving energy in your home?" are displayed in Figure 13. The entire sample population was asked this question at the start of the project (N = 476) and a subset was asked the same question at the end of the project (N = 63).
The total sample population as well as the subset (Group 2) are shown; Group 1 is not shown. As can be seen, the responses were largely "very interested" in energy efficiency at the start of the project. This is not surprising since this project was a self-selecting home energy efficiency project.

Key result: Participants' interest in energy efficiency reduced after the trial measures were delivered.

Figure 12 Interest in energy efficiency



Looking at Figure 12, there does appear to be a drop off in interest at the conclusion of the project compared to the start.

To determine if the subset represented a random sample taken from the entire sample population, the bootstrap method was performed on the mean of the subset. The null hypothesis is that the subset was a random resample of the sample population. One million random resamples of size 63 were taken from the entire sample population without replacement. The average value of the resamples was used to calculate the 95% confidence interval (CI). The CI was found to be (4.40, 4.73) and random resample of the sample population. One million random resamples of size 63 were taken from the entire sample population without replacement. The average value of the resamples was used to calculate the 95% confidence interval (CI). The CI was found to be (4.40, 4.73) and the mean value of the subset was 4.75. The mean of the subset was just outside the CI and so the null hypothesis is rejected and Group 2 cannot be considered as being a random resample.

To determine if the Group 2 was representative of the rest of the Group 1, a Mann-Whitney (MW) U test was carried out comparing Group 1 to that of Group 2. The null hypothesis is that the Group 1 population and the subset were not significantly different. The p-value was found to be 0.07, so the null hypothesis is accepted and these subset responses were not significantly different from the rest of the sample responses. So the subset is accepted to be a fair representation of the sample.

Because the bootstrap test and MW U-test were verging on being significantly different, it is believed that Group 2 was not a great representation of Group 1 and the sample population. Similar changes in Group 2 may be expected to be seen in Group 1 or the sample population.

There does appear to be a drop off in interest at the conclusion of the project compared to the start by looking at Figure 13. To verify if there was significance in change, a Wilcoxon signed-rank (WSR) test was used on Group 2. The null hypothesis in this case is that there was no significant difference in the subset before and after joining this project. The calculated p-value was 0.003, so the null hypothesis is rejected.

Table 12 shows the results of the three statistics tests run to determine if changes seen in the subset (Group 2) could have been expected to have been seen in the entire sample population. The null hypothesis for all three tests is that the samples are from the same population. The methodology for the remaining questions is the same and so only results from the tests will be displayed in similar tables.

Table 12 Statistical test results for Interest in energy efficiency

Bootstrap test			**Mann-Whitney U-test**		**Wilcoxon signed-rank test**	
Group 2 mean	Confidence interval	Null hypothesis	p-value	Null hypothesis	p-value	Null hypothesis
4.75	(4.40, 4.73)	Rejected	0.07	Accepted	0.003	Rejected

The subset regarding interest in energy efficiency changed. However, because the results of the bootstrap test and the MW U test suggest the subset was on the border of being a good representation of the entire sample population, a similar trend in interest level for the entire sample could not be said confidently. At least it has been shown that the subset changed and there is a possibility the entire sample did as well.

Going back to Figure 13, it is seen that at the start of the project the majority of participants gauged their interest in energy efficiency as the highest possible. At the end of the project, the subset still indicated that most of them were at the highest interest level even though there was a decrease. The largest increase was in selecting an interest level of 4, which was still high and not down to a level of concern. Interest level was probably still high within the entire sample.

Control of finances

Figure 13 shows responses to how in control of their finances participants feel. The entire sample population was asked this question at the start of the project (N = 475) and a subset was asked the same question at the end of the project (N = 62).

"Do you feel you are in charge of how your money is used?"

Key result: This graph shows a general trend towards participants feeling more in control of how money is used after the trial.

Figure 13 Control of finances

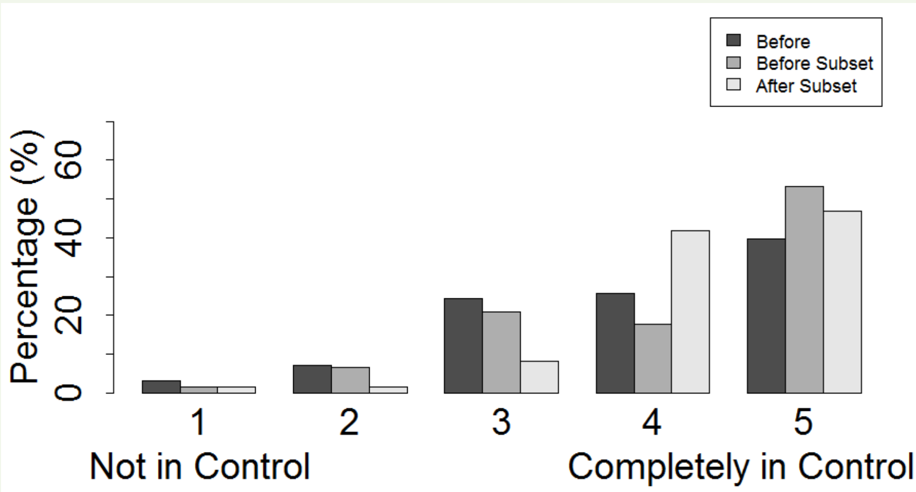


Table 13 Statistical test results for Control of finances

Bootstrap test			Mann-Whitney U-test		Wilcoxon signed-rank test	
Group 2 mean	Confidence interval	Null hypothesis	p-value	Null hypothesis	p-value	Null hypothesis
4.15	(3.66, 4.16)	Accepted	0.06	Accepted	0.01	Rejected

Cost was recognised as a barrier to being more energy efficient when referring to buying more efficient appliances or paying for structural upgrades. The electricity bill itself was difficult for some participants to understand. Consequently participants did not know what they were paying for.

The results in Table 13 show that there was a change in the feeling of control among Group 2 participants over the course of the project. There was a slight decrease in the number who selected 5 as their rating of control, but a large increase in those who selected a 4. Before assessment 70.9% chose either a 4 or 5 and after assessment 88.7% did the same. The Group 2 feeling of control increased but from the results of the statistics tests it is not known if the remainder of the sample population experienced a change. Overall, the levels that participants felt in control were very high.

Control of energy consumption (Empowerment)

Figure 14 shows responses to how in control of how energy was used in their homes participants feel. The entire sample population was asked this question at the start of the project (N = 475) and a subset was asked the same question at the end of the project (N = 63).

"Can you control/ determine your energy consumption?"

Key result: This graph demonstrates that participants feel they have more control over energy consumption after the trial.

Figure 14 Control of energy consumption

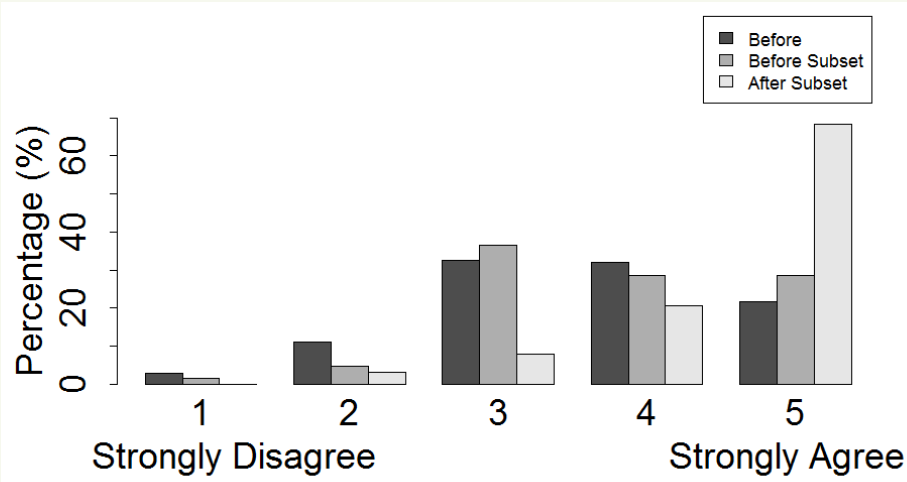


Table 14 Statistical test results for Control of energy consumption

Bootstrap test			Mann-Whitney U-test		Wilcoxon signed-rank test	
Group 2 mean	Confidence interval	Null hypothesis	p-value	Null hypothesis	p-value	Null hypothesis
3.78	(3.35, 3.83)	Accepted	0.15	Accepted	0.002	Rejected

At the beginning of Smart Cooling participants were less likely to agree with the above statement as seen in Figure 15 than the previous two statements.

The results of the WSR-test in Table 14 show that Group 2 had a large change in their attitude toward how in control of consumption they felt. Results from the Bootstrap and MW U-test indicate that we should expect similar changes from the entire sample population. These changes were likely due to the educational portion of the project.

Comfort level

Figure 15 shows responses to how comfortable participants are in their homes. The entire sample population was asked this question at the start of the project (N = 476) and a subset was asked the same question at the end of the project (N = 63).

"How comfortable are you in this house?"

Key result: participants feel more comfortable in their homes after the trial.

Figure 15 Comfort level in this home

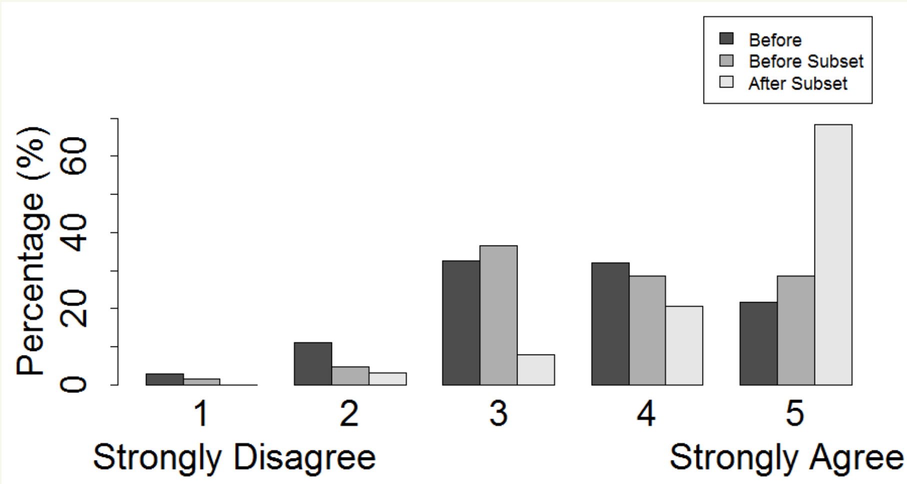


Table 15 Statistical test results for Comfort level in this home

Bootstrap test			Mann-Whitney U-test		Wilcoxon signed-rank test	
Group 2 mean	Confidence interval	Null hypothesis	p-value	Null hypothesis	p-value	Null hypothesis
3.83	(3.51, 3.98)	Accepted	0.57	Accepted	0.01	Rejected

Interest in comfort changes had two concerns: 1. Assessing one goal of the project to make people more comfortable in their homes and 2. If certain services or recommendations by the Project Officers led to a reduction in comfort. Figure 16 shows that comfort levels at the beginning of the project were not as high as they could have been, but there was an improvement at the end of the project.

participants with almost 60% above 60 years of age. Darwin is Australia's youngest-aged capital with a median age of 33 (ABS, 2011) so a younger demographic could have been expected. The median age of participants was 64.

- Most participants (65%) had completed at least a secondary education. The education level of participants was similar to the general Darwin population where 66% are at this level (Census, 2011).

- The largest employment category was retired at 46%, with 23% employed at least part-time. The remaining participants said they were looking for work or could not work because they were unable or studying.

- The average number of people per house was 2.75, which is similar to the Darwin average of 2.7 (ABS, 2011).

- There was a high level of home ownership, 55% of participants owned their home outright and a further 19% had a mortgage.

- 75% of dwellings were free standing houses. The remaining homes were mostly townhouses and apartments.

- Dwelling ages tended to be quite old, with 69% of properties being over 20 years old.

4.4 Energy consumption

Electricity data was received from the sole residential retailer in Darwin. The retailer checks electricity meters nominally every 92 days. The mean daily consumption (MDC) per participant household in a billing period is found by

$$\text{MDC} = \frac{\text{total consumption in billing period}}{\text{number of days in billing period}}$$

As a very crude approximation, each day within the period was assigned the same value as the MDC. This was necessary to compare participants over the same date ranges because meters were checked on a rolling basis and the dates of individual participants often did not align. It was not expected that participants actually consumed the same on a day to day basis, but the resolution of the data limited the accuracy of the analysis. Since the billing period was long enough to incorporate changes in seasons, there would likely have

"Is energy efficiency too much hassle?"

Key result: This graph demonstrates that participant's perceptions of energy efficiency improved as a result of the trial, although it was not a significant change.

Figure 16 Energy efficiency is too much hassle

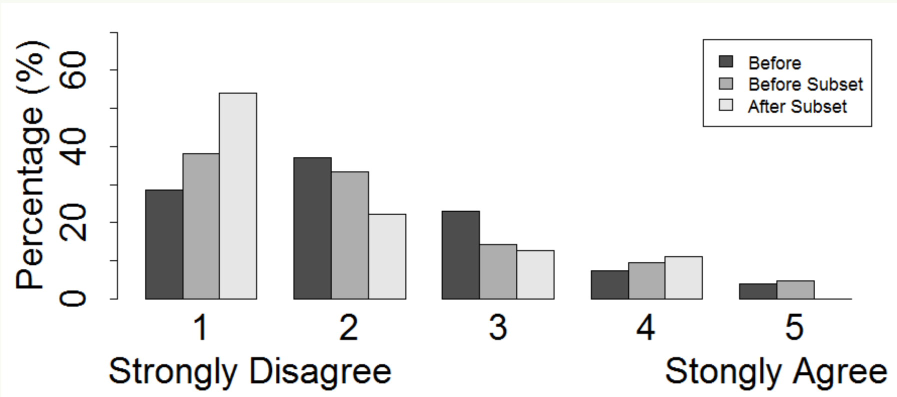


Table 16 Statistical test results for Energy efficiency is too much hassle

Bootstrap test			Mann-Whitney U-test		Wilcoxon signed-rank test	
Group 2 mean	Confidence interval	Null hypothesis	p-value	Null hypothesis	p-value	Null hypothesis
2.10	(1.97, 2.46)	Accepted	0.18	Accepted	0.09	Accepted

From the beginning participants mostly disagreed with the prospect that being energy efficient was a hassle as seen in Figure 17. As most of the recommended behaviour changes involved taking an action that required additional effort, there was the possibility that these actions could be viewed as a hassle.

From the test results in Table 17 it is clear that Group 2 was a good representation of the sample population. Figure 17 does show an increase in disagreement with the statement, but Group 2 did not show a significant change in their attitude toward the hassle of being energy efficient. Therefore it is unlikely the remaining participants experienced a significant change either.

It is an important result that participants did not find energy efficiency to be more of a hassle after joining the project. There were a large number of behaviour changes recommended to participants and many participants took on some changes that required extra activity. So even with the added actions, participants did not find them dissatisfying enough to indicate energy efficiency was now more of a hassle.

Energy consumption and comfort

Figure 17 shows responses to participants' belief that energy consumption and comfort are linked. The entire sample population was asked this question at the start of the project (N = 475) and a subset was asked the same question at the end of the project (N = 63).

"I feel like saving energy means I have to be less comfortable in my home."

Key result: As a result of the trial more participants feel that comfort can be maintained while being energy efficient.

Figure 17 Link between energy consumption and comfort

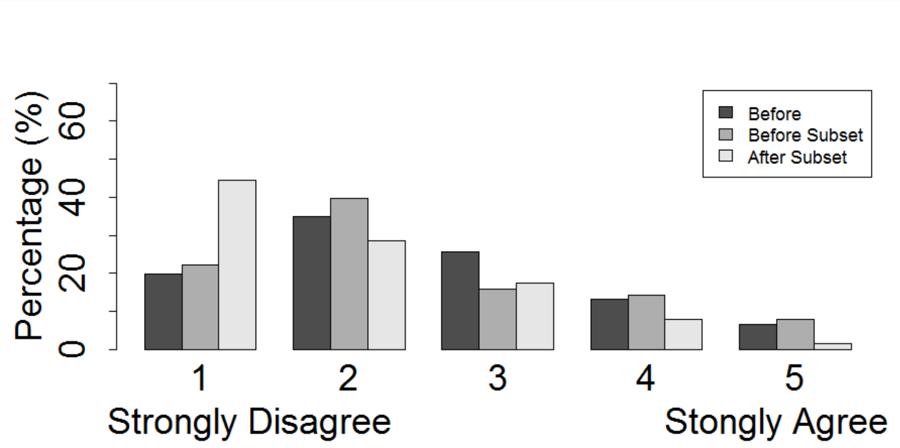


Table 17 Statistical test results for link between energy consumption and comfort

Bootstrap test			Mann-Whitney U-test		Wilcoxon signed-rank test	
Group 2 mean	Confidence interval	Null hypothesis	p-value	Null hypothesis	p-value	Null hypothesis
2.46	(2.25, 2.78)	Accepted	0.49	Accepted	0.003	Rejected

At the outset, there was some sense by participants that being energy efficient would reduce their comfort levels as seen in Figure 18. This question was of central importance to Smart Cooling because it dealt directly with the interplay between energy and comfort.

Group 2 attitudes closely resembled those of Group 1 as seen in Table 17 and the WSR-test showed that Group 2 had a significant change. Figure 18 shows the change was that participants were more likely to disagree that saving energy would decrease comfort.

In the end participants were less likely to believe being comfortable was at odds with energy efficiency.

Energy consumption and quality of life

Figure 18 shows responses to participants' belief that a decrease in energy consumption affects their quality of life. The entire sample population was asked this question at the start of the project (N = 476) and a subset was asked the same question at the end of the project (N = 63).

"I feel like my quality of life will not be as good if I reduce the amount of energy I use."

Key result: As a result of the trial more participants feel that quality of life can be maintained while also reducing energy, although it was not a significant change.

Figure 18 Reduced energy use equals reduced quality of life

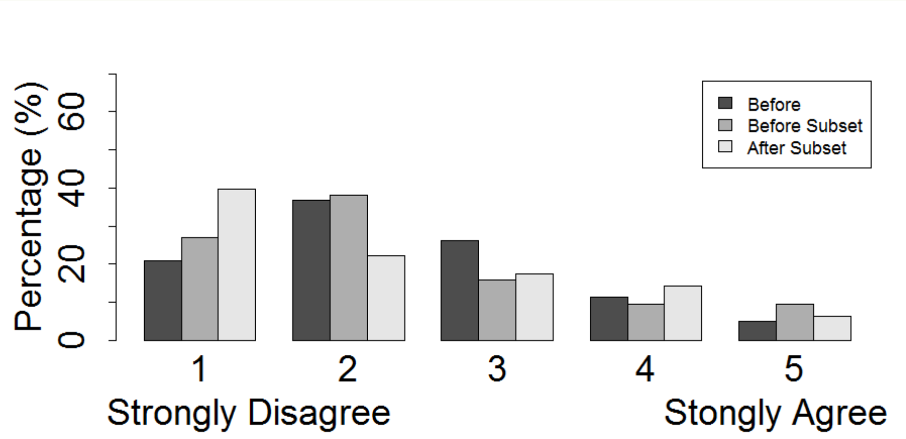


Table 18 Statistical test results for Reduced energy use equals reduced quality of life

Bootstrap test			Mann-Whitney U-test		Wilcoxon signed-rank test	
Group 2 mean	Confidence interval	Null hypothesis	p-value	Null hypothesis	p-value	Null hypothesis
2.37	(2.17, 2.68)	Accepted	0.32	Accepted	0.40	Accepted

Feelings toward quality of life and toward comfort are probably not independent, so it is not unforeseen that answers to both questions had similar responses as seen in Figure 18 and Figure 19. On the other hand, feelings toward comfort showed a change for the sample population while the results in Table 18 reveal there was not a clear change in their feelings to the effect on their quality of life.

Energy consumption and freedom

Figure 19 shows responses to participants' belief that a decrease in energy consumption and restriction of freedom are linked. The entire sample population was asked this question at the start of the project (N = 476) and a subset was asked the same question at the end of the project (N = 63).

"I feel like using less energy will restrict my freedom."

Key results: More participants feel that energy efficiency will not restrict their freedom as a result of the project.

Figure 19 Energy efficiency will restrict my freedom

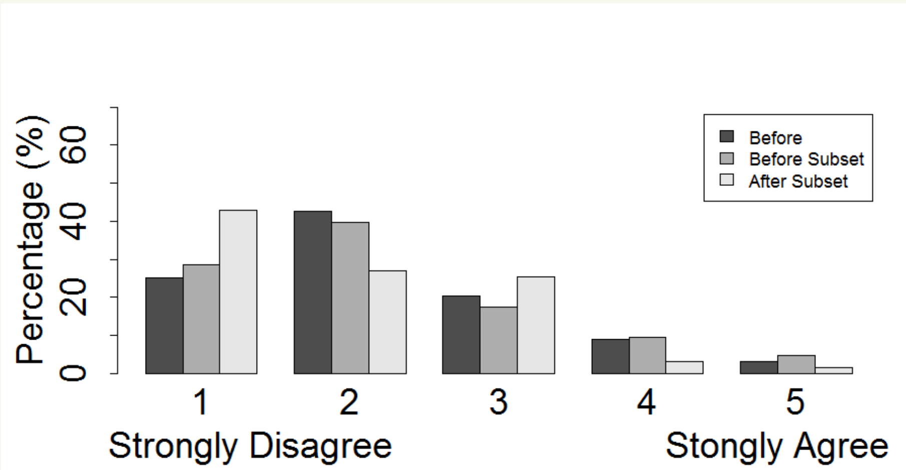


Table 19 Statistical test results for Energy efficiency will restrict my freedom

Bootstrap test			**Mann-Whitney U-test**		**Wilcoxon signed-rank test**	
Group 2 mean	Confidence interval	Null hypothesis	p-value	Null hypothesis	p-value	Null hypothesis
2.22	(2.00, 2.46)	Accepted	0.76	Accepted	0.06	Accepted

In all three cases regarding energy efficiency in Figure 20, participants who answered 1 or 2 made up close to 70% of the responses. The results in Table 19 show that Group 2 was very likely to represent Group 1 but the changes to Group 2 are approaching significance so similar changes may have occurred in the sample population. Participants in Group 2 were less likely to select 1 or 2 after service.

Energy consumption and enjoyment

Figure 20 shows responses to participants' belief that a decrease in energy consumption has a negative impact on enjoyment. The entire sample population was asked this question at the start of theproject (N = 476) and a subset was asked the same question at the end of the project (N = 63).

"I feel like saving energy will not be enjoyable."

Key result: More participants feel that saving energy could be enjoyable as a result of the project.

Figure 20 Saving energy will not be enjoyable

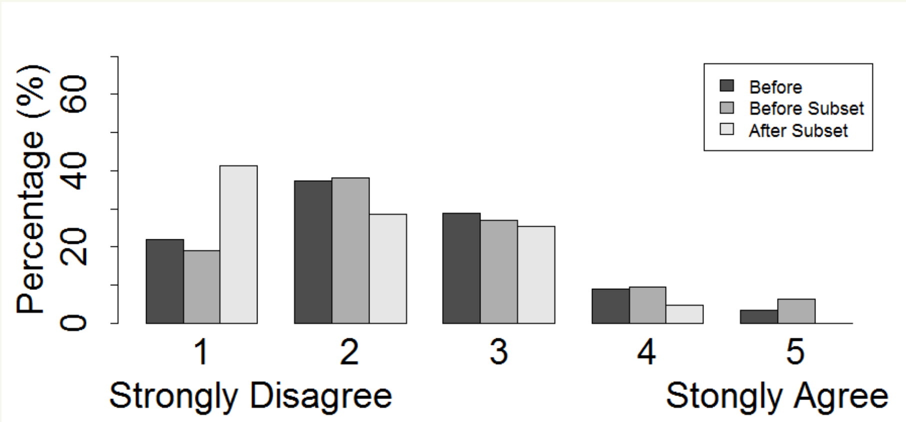


Table 20 Statistical test results for Saving energy will not be enjoyable

Bootstrap test			Mann-Whitney U-test		Wilcoxon signed-rank test	
Group 2 mean	Confidence interval	Null hypothesis	p-value	Null hypothesis	p-value	Null hypothesis
2.46	(2.11, 2.59)	Accepted	0.47	Accepted	0.002	Rejected

Figure 21 shows that participants were less likely to believe that saving energy would decrease enjoyment after the project. The percentage of participants that answered with a 1 after service was the largest and all percentages of other numbers were lower than before. From Table 20 it is seen that Group 2 was a good representation of the remainder of the group and similar changes would have been likely with them.

Recent efforts of reducing consumption

Figure 21 shows responses to participants' attempts to reduce consumption within the last two years. The entire sample population was asked this question at the start of the project (N = 474) and a subset was asked the same question at the end of the project (N = 63).

"Have you tried to use less energy over the last 2 years?"

In Surveys 3 and 4, during the evaluation phase, this question was changed to "Have you tried to use less energy since participating in the Smart Cooling program?" to see what changes were a result of actually participating in this project. Key result: This graph indicates that the trial had a beneficial influence on the levels of motivation for the participants to use less energy.

At the beginning of this project participants were already making an effort to reduce consumption as seen in Figure 22. They continued this effort after all information was given and services completed. The results in Table 21 reveal that all participants had not changed the amount of effort dedicated to being more energy efficient; on the other hand they continued to maintain a high level of effort.

Figure 21 Attempts to reduce electricity consumption

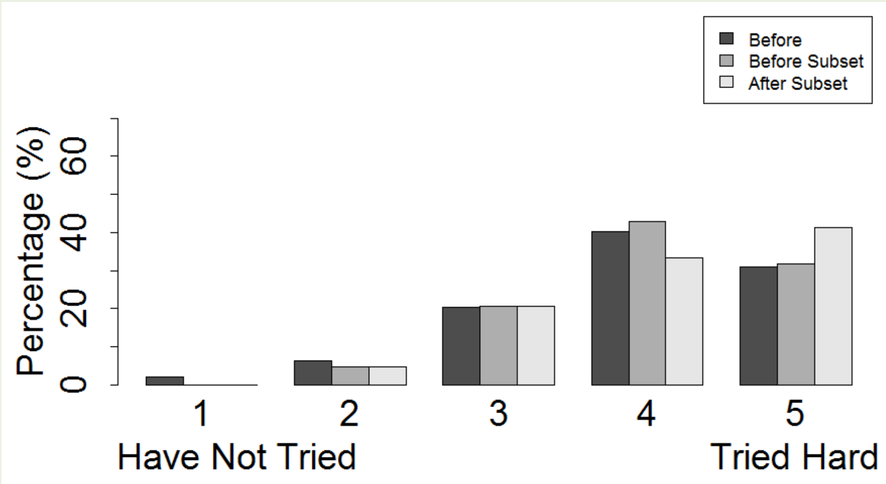


Table 21 Statistical test results for Saving energy will not be enjoyable

Bootstrap test			**Mann-Whitney U-test**		**Wilcoxon signed-rank test**	
Group 2 mean	Confidence interval	Null hypothesis	p-value	Null hypothesis	p-value	Null hypothesis
4.02	(3.68, 4.13)	Accepted	0.57	Accepted	0.66	Accepted

4.6 Barriers

4.6.1 Barriers identified by participants

After participants had received the starter kit, home energy assessment, report, and their service, they were asked if there were still barriers preventing them from reducing their electricity consumption even further. A large portion answered that they were already using the least amount possible as seen in Table 22 (N = 96).

Key result: This table demonstrates that although the project addressed or removed many of the identified barriers, cost remains the largest barrier for low income households to improving energy use.

Table 22 Major barriers still present

Barrier	Percentage acknowledged as barrier
None—already using the lowest amount possible	44.8
Mobility/ health	9.4
Security	9.4
Cost—appliances	11.5
Cost—structural retrofit	25.0
Comfort	16.7
Other people	12.5

4.6.2 Barriers identified by staff

All project staff were interviewed at the conclusion of the project and were asked to identify the key benefits and barriers for participants.

The barriers most commonly identified by staff were:

1. Motivation. For some, energy efficiency was not a priority given the difficulties of their personal circumstances
2. Financial. Cost of upgrading appliances/home
3. Information/knowledge
4. Climate e.g. need AC and pool pump to maintain comfort levels
5. Health i.e. age, illness, disability
6. House and garden design.

4.7 Benefits

Near the conclusion of Smart Cooling, participants were queried about how beneficial they found the project to be. Of the 88 surveyed, 87 indicated that they had benefitted in some way. Participants were also asked to delineate in which specific areas they thought they had benefitted.

There were several prepared options of potential benefit to select from as well as the option for open responses. Of the responses that were made, participants were also asked to rank their top three most important benefits. Each of the participants' ranks was given equal weight. The most selected and most ranked areas are shown below.

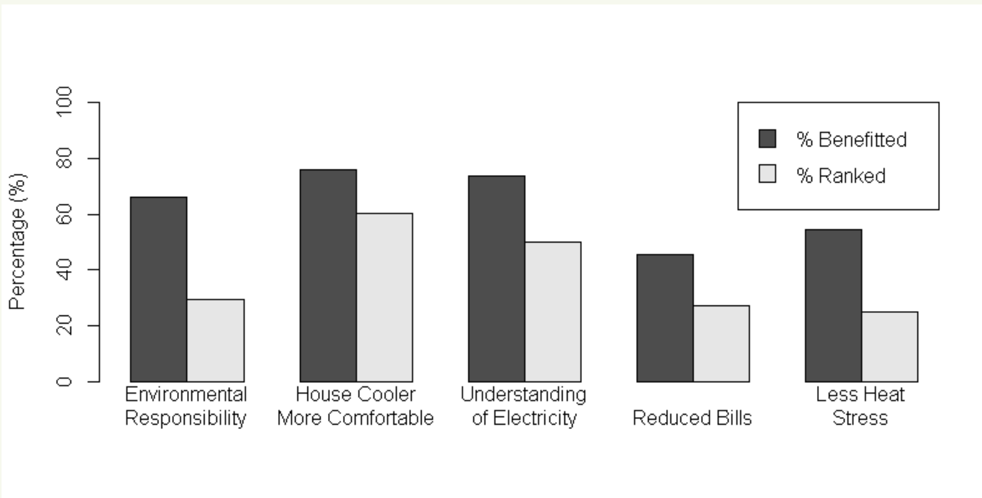
Table 23 shows benefits identified by participants and their relative value of importance at the completion of the project. Values indicate the number of participants who identified the benefit and ranked it. (N= 88)

Key result: The greatest benefit for project participants as a result of the trial is comfort. This is closely followed by a better understanding of electricity use.

Table 23 Benefits and their relative importance

Benefit	Number who valued this benefit	Number who ranked this benefit in their top 3
Greater sense of environmental responsibility	58	26
House is cooler/more comfortable	67	53
Better understanding of electricity use/efficiency	65	44
Reduced electricity bills	40	24
Less heat stress	48	22

Figure 22 Benefits and their relative importance



Participants valued their comfort more than any other benefit produced by Smart Cooling. They also indicated this was the area of greatest improvement. Increased comfort was also reported in Survey 2, where 56% of participants claimed an increase in comfort while less than 4% found themselves to be more uncomfortable (N = 144). The difference in the answers between the surveys is largely due to the variation in individual participants. Participants who responded to Survey 4 made up 42% of those who responded to Survey 2; those who completed both surveys largely answered in a similar way.

Figure 23 shows Benefits identified by participants and their relative value of importance at the completion of Smart Cooling. Values indicate the percentage who said each benefit was important and if they ranked it within their top three most important benefits. (N=88)

One of the more interesting findings was that having a better understanding of electricity was the second highest chosen benefit and second highest in rankings. Education itself was seen as a highly valued outcome. With a better understanding of consumption, energy productivity advice may be more readily acted upon. More than 80% (N=98) of participants also said that they felt more in control of their electricity use since joining this project. This suggests information packets and energy assessments were fruitful and may give evidence that an information campaign in the future would be favourable.

Reduction in electricity bills was rated highly, even though less than half of the surveyed participants saw this as a major benefit. The reason may have been that the economic benefits were not seen as substantial enough by the participants' standards. Energy data showed a 1-10% savings, a monetary savings of about $15-$150 for the year per participant. Responses from Survey 2 showed that only about 40% of participants said their electricity bills were lower. Still, over half of those who did value this benefit did rate it highly so the savings may have been significant to those who valued it.

It is clear that participants valued more than economic benefits alone. For instance, this project was not focused on promoting environmental responsibility directly, so it is seen as a positive tangential consequence.

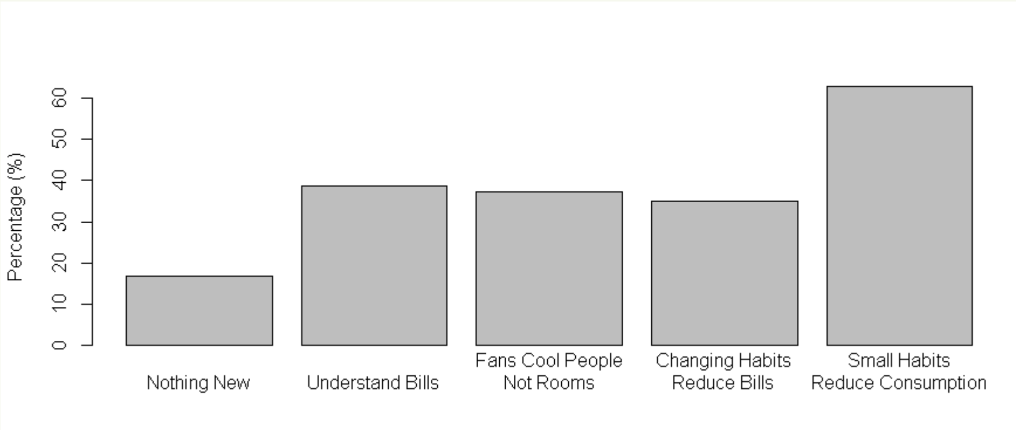
When participants (N= 86) were asked if the economic benefits or the non-economic benefits were more valuable or if they held the same value, 9% did not know the relative value of the benefits with the remainder of the responses spread equally across the three options. When the same participants were asked how valuable all of the benefits from this project were, over 94% responded that they found the project valuable with over half of them replying that it was "very valuable."
Only a single participant did not find any value in the benefits from participating, and the remaining participants did not know how valuable this project was to them. It is apparent that participants have benefitted from this project and highly value the benefits they have received.

4.7.1 Learnings from an education approach

Energy assessments were a two-way communication process with participants able to address energy related questions to the officers. Based on the Project Officers' experience in the field during the assessments, some of the questions that came up often were put into Survey 2 to quantify the number of participants who gained this knowledge.
Results from the survey are shown in Figure 24. (N = 83).

Key result: Figure 23 indicates that participants knowledge increased against multiple measures.

Figure 23 Information learnt from the Smart Cooling project



The survey results indicate that energy literacy is an important first step in improving energy productivity among the residential sector of low income households. Even with a group with energy thrift behaviours, information and education increased their known range of responses to energy management.

4.7.2 Energy savings based on behaviour changes

Providing participants with information was a key emphasis in this project. General information was given in an information pack at the time of the assessment. Afterwards, a personalised energy report with tailored advice for each participant was delivered. The extent to which this information was consumed was high, with more than 87% claiming to have read at least some of the information provided (N= 64). However, education itself does not lead to energy productivity. Individual action is needed.

The personal Energy Reports were effective at changing participants' habits in regards to electricity use. Near 80% of participants said they had changed some of their habits based on recommendations contained in their personalised report (N=136). The most common habits changed are shown in Table 24 (N=136).

Key result: Of the habit changed as a result of the trial's education program, 40% of participants now turn appliances off at the wall and 39% turn off the lights when not in the room.

Table 24 Habit changes based on recommendations in energy report

Energy efficiency action	Percentage that changed habit (%)
Turn off lights when not in the room	39.7
Turn off appliances at the wall	40.4
Open the house up and turn on fans for ventilation	25.7
Raise AC thermostat by at least 1°C	22.8
Use a fan when using the AC	25.7
Create a "cool zone" in the house	14.7

4.7.3 Benefits identified by staff

All project staff were interviewed at the conclusion of the project and were asked to identify the key benefits and barriers for participants.

The benefits most frequently identified by staff were:

1. Energy literacy and knowledge gain
2. Comfort and health improvement (particularly for those with a disability
3. Overcoming cost and physical barriers e.g. installing shade sail, cleaning fans for people who cannot reach them
4. People felt connected, particularly those who are socially isolated, by being part of a project and part of something bigger.

4.8 Cost-benefit analysis

The limitations of available energy data prevented a determination of savings using the supplied CBA methodology. There was some indication of savings though not a complete picture. The savings that were seen did not appear to be large, and so conservative estimates were used for the cost benefit analysis. Many of the treatments were also used more to improve thermal comfort than to reduce energy costs, so low estimates were also appropriate. The longevity of the treatments was determined by the warranty period, if available, otherwise the lifetimes were provided by the Australian Taxation Office (Taxation Ruling TR 2015/2).

Assumptions for the deemed savings used in the CBA calculations of each service are described below. The CBA results can be found in Appendix B The cost-benefit value was calculated as the quotient of cost to benefit by

$$\text{"cost-benefit"} = \frac{\text{(Total cost of services for all participants who received the specific service)}}{\text{(Total savings of all participants who received the specific service)}}$$

so the value is the average for each service.Table 25 shows the costs per services using the four levels defined by the prescribed cost-benefit methodology. All prices exclude GST.

Table 25 Cost-benefit analysis for each treatment

Service	Service cost/ benefit	Level 1	Level 2	Level 3	Level 4	Number of services	AVG cost per service ($)	Longevity (years)
Assessment only	65.3	65.3	175.8	266.0	332.2	14	1096.17	-
Timer	1.5	22.1	57.1	85.6	106.6	18	77.89	1
Home clean	3.9	24.52	59.5	88.0	109.0	16	204.97	1
Standby saver	1.8	54.2	142.8	215.2	214.1	23	37.52	1
AC clean	8.6	30.0	66.3	95.8	117.6	92	440.13	1
Thermostat	1.7	34.0	88.6	133.1	165.8	8	58.94	1
Roof paint	6.5	8.6	12.3	15.2	17.4	32	3319.28	10
Shade sail	15.5	19.8	27.1	33.0	37.4	32	3947.22	10
Window shade	10.4	17.6	29.7	39.6	46.9	29	1593.94	6
Attic vent.	2.5	5.7	11.2	15.6	18.9	8	850.89	10
Security screens	5.5	9.6	16.6	22.3	26.5	17	1448.32	5
Flyscreens	4.3	8.4	15.4	21.4	25.3	37	769.58	5
Reinstall AC	1.7	4.3	8.6	12.1	14.7	6	732.86	5

Key result: Table 25 above demostrates that education measures have a strong effect on energy savings.

4.8.1 Assessment savings

Behaviours with the largest uptake (stated in Survey 3) following the energy assessment were used for the CBA calculations. These behaviours were:

1. Turn off lights when leaving the room
2. Turn off appliances at the wall
3. Turn off second fridge when not in use
4. Create a ‘cool zone’.

The savings for each behaviour were multiplied by the fraction who reported making the change and applied to all participants equally. The assessment savings

were included for everyone as all participants received an assessment. It is unknown how long a behaviour will last therefore any savings were set to be as long as the expected lifetime of the services. The lifetime of the assessment was set to oneyear. Assumptions and calculations for these four behaviours can be found in Appendix 4.

4.9 Cost effectiveness analysis

Smart Cooling focused on improving thermal comfort and the quality of life of participants as much as saving money. An assessment of the cost effectiveness of the identified measurable benefits, such as reduced energy consumption, personal comfort and the subjective benefits such as reduced heat stress is below. The costs of treatments are the same as those in the CBA section.

4.9.1 Energy savings

Energy savings were calculated by dividing the monetary savings in the CBA section by the weighted average tariff of participants as of 1 January 2016, $0.2073/kWh. Table 26 outlines the cost effectiveness of each service delivered in the trial. It uses all four levels as defined by the prescribed methodology.

Table 26 Cost-effectiveness calculation ($/kWh saved)

Service	Level 1	Level 2	Level 3	Level 4
Assessment only	14	36	55	69
Timer	5	12	18	22
Home clean	5	12	18	23
Standby saver	11	30	45	56
AC clean	6	14	20	24
Thermostat	7	18	28	34
Roof paint	2	3	3	4
Shade sail	4	6	7	8
Window shade	4	6	8	10
Attic vent.	1	2	3	4
Security screens	2	3	5	5
Flyscreens	2	3	3	5
Reinstall AC	1	2	4	3

4.9.2 Greenhouse gas emissions savings

Greenhouse gas emissions savings were found by multiplying the energy savings by the carbon dioxide equivalent factor of 0.77 kg CO_2/kWh for the Darwin fuel cycle (National Greenhouse and Energy Reporting (Measurement) Determination 2008).

Table 27 Cost-effectiveness calculation ($//kg CO_2-equivalent)

Service	Level 1	Level 2	Level 3	Level 4
Assessment only	18	47	71	90
Timer	6	15	23	29
3 hrs clean	7	16	24	29
Standby saver	15	38	58	72
AC clean	8	18	26	32
Thermostat	9	24	36	45
Roof paint	2	3	4	5
Shade sail	5	7	9	10
Window shade	5	8	11	13
Attic vent.	2	3	4	5
Security screens	3	4	6	7
Flyscreens	2	4	6	7
Reinstall AC	1	2	3	4

4.9.3 Subjective benefits

It is difficult to evaluate benefits that are very subjective (Clinch, 2001; Heffner, 2011). For benefits that were mostly subjective, Survey 4 was used to allow participants to scale their responses on identified topics where the Smart Cooling project aimed to make a difference. The questions were posed on a 7-point Likert scale centred on zero to help evaluate improvements in thermal comfort levels, perceived changes in bills, the amount of noise in a dwelling, changes in heat stress, and improvement in sleep quality. Positive values mean the improvement was in the desired direction, negative values mean the participant is worse off and zero means no change. No attempts were made to monetise the non-economic benefits.

Thermal comfort levels

Table 28 indicates cost-effectiveness for thermal comfort ($/ comfort level increase). The scale average column is the average rank. The last column indicates how many participants answered the question for each treatment.

Key result: Home cleaning service and the security screen upgrade were the most cost effective services for improving thermal comfort delivered at the project scale (Level 4).

Table 28 Cost effectiveness for thermal comfort ($/ comfort level increase)

Service	Level 1	Level 2	Level 3	Level 4	Scale average	N
Fan package	832	2025	2999	3713	1.6	9
Home clean	520	1,263	1,869	2,313	2.5	2
AC clean	1,051	2321	3358	4118	1.5	13
Roof paint	2007	2851	3539	4044	2.2	19
Shade sail	2522	3450	4207	4763	2.0	9
Window shade	1614	2728	3637	4304	1.7	9
Attic vent.	-974	-1902	-2659	-3215	-2.0	1
Security screens	954	1650	2218	2635	2.7	3
Flyscreens	1259	2304	3155	3781	1.8	7
Ceiling fan	1030	1914	2635	3164	2.1	10

Perceived bill savings

Table 29 shows cost-effectiveness calculations for perceived bill changes ($/ perceived bill savings). The scale average column is the average rank. The last column indicates how many participants answered the question for each treatment.

Key result: Using level 1 the key result in this instance is that participants who received the home cleaning service reported the highest savings on their energy bills.

Table 29 Cost-effectiveness for perceived bill changes ($/ perceived bill changes)

Service	Level 1	Level 2	Level 3	Level 4	Scale average	N
Fan package	3881	9450	13993	17328	0.3	9
Home clean	520	1263	1869	2313	2.5	2
AC clean	2304	5089	7361	9028	0.7	9
Roof paint	5887	8362	10382	11864	0.8	12
Shade sail	10087	13800	16829	19052	0.5	8
Window shade	4304	7274	9698	11476	0.6	8
Attic vent.	3894	7607	10636	12859	0.5	2
Security screens	7633	13203	1746	21081	0.3	3
Flyscreens	5224	9555	13089	15683	0.4	5
Ceiling fan	2780	5167	7114	8543	0.8	9

Amount of noise coming in

Table 30 shows cost-effectiveness for change in noise entering the dwelling from outside. The scale average column is the average rank. The last column indicates how many participants answered the question for each treatment.

Key result: Although limited data was available for this benefit, this table demonstrates that the ceiling fan upgrade had the best impact on noise reduction for participants (Level 1).

Table 30 Cost-effectiveness for noise entering the dwelling from outside ($/ noise level change)

Service	Level 1	Level 2	Level 3	Level 4	Scale average	N
Fan package	10348	25199	37316	46208	0.13	8
Home clean	-	-	-	-	0.0	2
AC clean	16899	37319	53980	66206	0.1	11
Roof paint	23549	33450	41527	47455	0.2	15
Shade sail	-	-	-	-	0.0	9
Window shade	12105	20459	27275	32276	0.2	9
Attic vent.	-	-	-	-	0.0	2
Security screens	-	-	-	-	0.0	3
Flyscreens	-	-	-	-	0.0	7
Ceiling fan	10812	20094	27667	33224	0.2	10

Change in heat stress

Table 31 shows cost-effectiveness calculations for changes in heat stress. The scale average column is the average rank. The last column indicates how many participants answered the question for each treatment.

Key result: Using Level 1 the ceiling fan upgrade had the largest impact on heat stress. This indicates that air flow plays an important role in thermal comfort. Roof paint also rated very well using this methodology. The roof paint has a longer useful life (10 years) so could be considered a very cost effective service for reducing heat stress.

Table 31 Cost-effectiveness for heat stress ($/ change in heat stress)

Service	Level 1	Level 2	Level 3	Level 4	Scale average	N
Fan package	1301	3158	4672	5784	1.0	9
Home clean	1301	3158	4672	5784	1.0	2
AC clean	9217	20356	29443	36112	0.2	12
Roof paint	2706	3844	4772	5454	1.6	18
Shade sail	4127	5645	6885	7794	1.2	9
Window shade	2018	3410	4546	5379	1.3	9
Attic vent.	-1947	-3803	-5318	-6429	-1.0	2
Security screens	2544	4401	5915	7027	1.0	3
Flyscreens	3358	6143	8415	10082	0.7	7
Ceiling fan	1138	2115	2912	3497	1.9	10

Quality of sleep

Table 32 shows Cost-effectiveness calculations for changes in quality of sleep. The scale average column is the average rank. The last column indicates how many participants answered the question for each treatment.

Key result: Fan package, security screen and ceiling fan upgrade all rate well for improving quality of sleep. This is encouraging as it once again demonstrates that passive and low cost services can have significant health and wellbeing benefits.

Table 32 Cost-effectiveness for sleep quality ($/ sleep quality change)

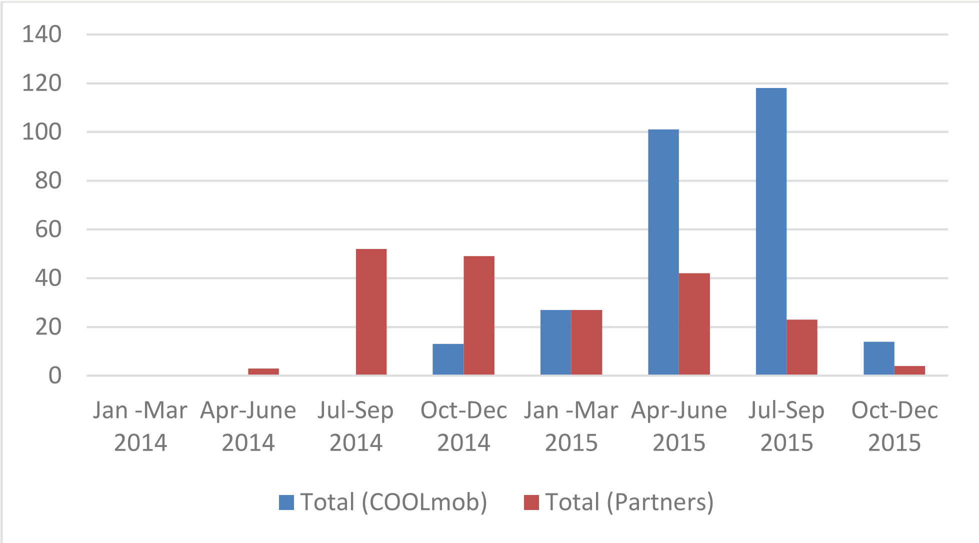
Service	Level 1	Level 2	Level 3	Level 4	Scale average	N
Fan package	1164	2835	4198	5198	1.1	9
Home clean	867	2105	3115	3856	1.5	2
AC clean	6657	14702	21565	56081	0.2	13
Roof paint	6255	8885	11031	12605	0.7	16
Shade sail	7565	10350	12622	14289	0.7	9
Window shade	5380	9093	12122	14345	0.5	8
Attic vent.	-3894	-7607	-10636	-12859	-0.5	2
Security screens	1908	3301	4437	5270	1.3	3
Flyscreens	4478	8190	11219	13442	0.5	6
Ceiling fan	1966	3653	5030	6041	1.1	10

4.10 Communications and recruitment

Figure 24 below demonstrates that recruitment from social welfare agencies (delivery partners) was initially successful. Eligibility parameters were changed in February 2015 to improve further recruitment. The five month recruitment campaign led by the project team from April to August 2015 was successful in producing volume within a short period of time.

Key result: Recruitment required additional pathways to meet the project target.

Figure 24 Participant recruitment numbers over the period of the project.



Key result: Eligibility changes alone would not have facilitated achievement of the recruitment target as seen in figure 25 below.

Figure 25 Cumulative recruitment numbers and the dates where eligibility criteria were updated

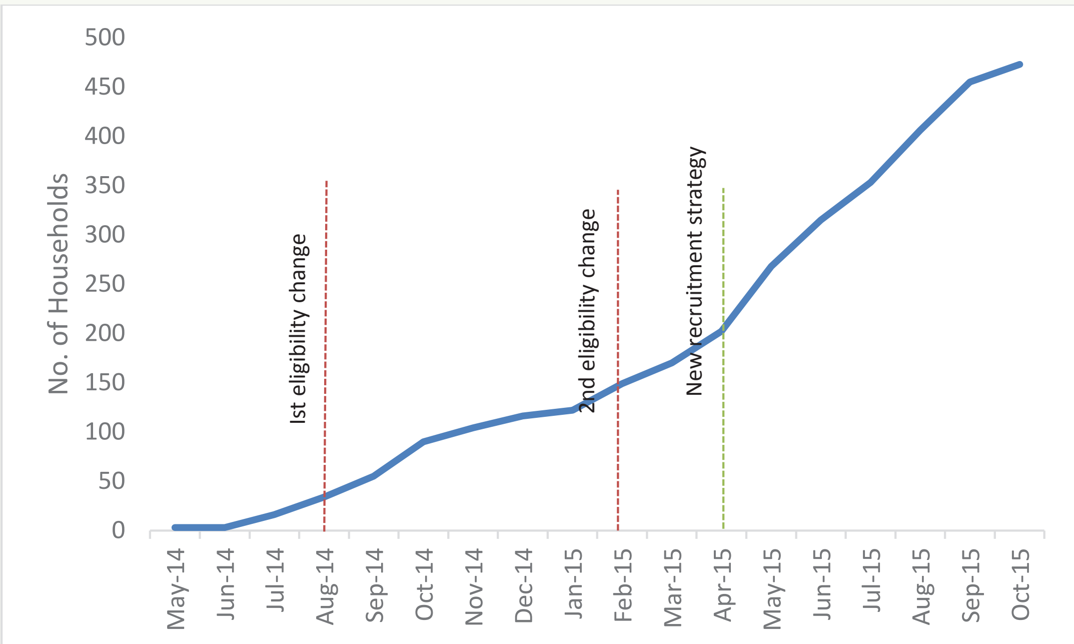


Figure 26 below describes the successful channels used to gain recruitment into the project. It depicts the progress of the two primary stakeholders, the project team and the group of social welfare agencies responsible for recruitment. Importantly, it demonstrates the rapid growth in recruitment numbers coinciding with the period in which the project team reoriented the recruitment strategy.

Recruitment methods included three successive print advertising campaigns in regional (NT News) and local (Darwin Sun) newspapers. The campaign began with a one-off advertisement in February 2015 which proved successful and led to three intensive campaigns from 27 May-10 June (2 advertisements), 14 July-5 August (4 advertisements), and 1-22 September 2015 (3 advertisements). The success of these print advertising campaigns in recruiting participants is reflected in the recruitment pathways graph above which indicates that recruitment numbers spiked significantly during April-June and July-September 2015.

The print media campaign also included three media releases in local and regional newspapers on 27 February, 8 July, and 23 September 2015.

In addition, the project was promoted through the COOLmob webpage on the ECNT website where people could request to book an assessment by completing an online form. A total of 89 people requested assessments through this medium (though not all were eligible).

Social media activities included a Facebook campaign during the final weeks of the recruitment phase (July-September 2015). In all, 11 advertisements were posted resulting in a total of 13,794 views, 24 shares, and 104 likes.

Key result: Word of mouth and advertising were the most effective recruitment pathways.

Figure 26 Cumulative recruitment over the project along with the pathway of recruitment

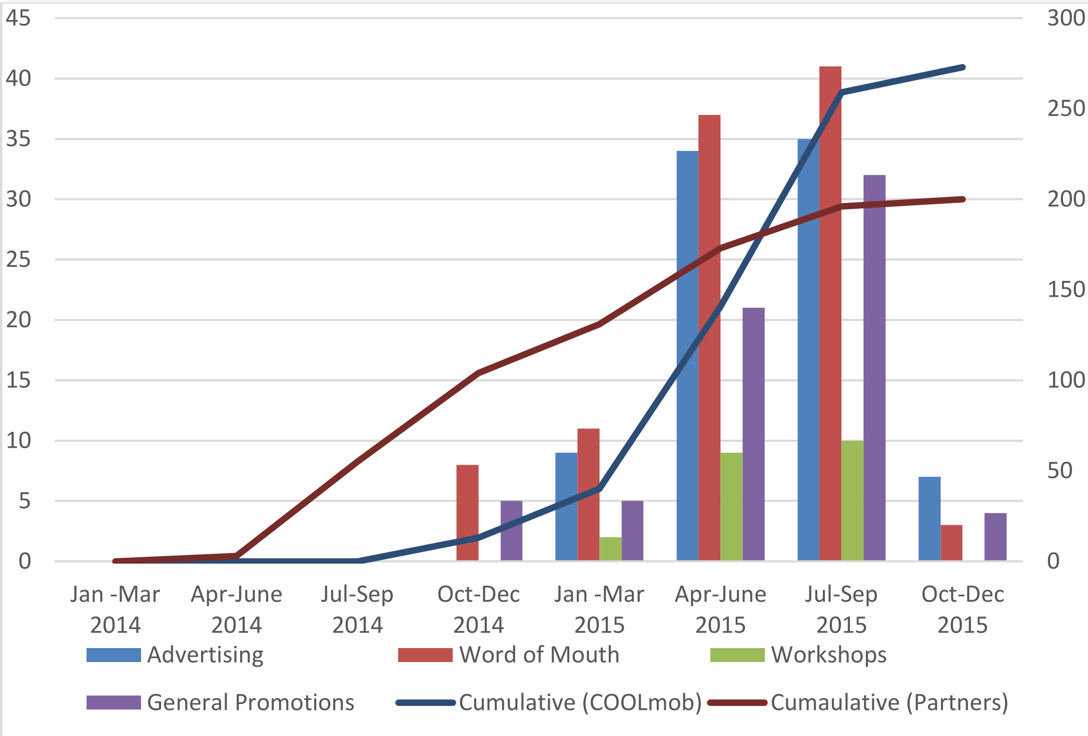


Figure 26 marks the points in time that changes were made to the scope of the project to benefit recruitment. It took twelve months to get half-way to the project's recruitment targets and only five to achieve the remaining half.

Case study A

Passively cooled home

> "I feel energised since the 'blanket' has been lifted from my roof."
>
> 'Passively cooled home' case study

A's home is a traditional elevated house built in the 1960s and is typical of the era. It has a wood frame, metal sheeting walls and roof (light coloured to reflect the sun), and louvre windows (for maximum cross ventilation). It has an appropriate orientation (north-facing) catching breezes from the north-west in the wet season and the south-east in the dry season. Its elevation also allows the house to catch a breeze more easily than a ground level house. Lightweight construction means that the walls cool down much quicker once the sun has set.

The design of A's home allows for passive cooling rather than having to depend on extensive mechanical cooling. Generally, A relies on breezes and ceiling fans for cooling rather than air-conditioning. Her tropical garden provides extensive shade to the home.

Attic ventilation improves thermal performance by removing hot air in the roof cavity. This lowers the temperature in the roof cavity and reduces the amount of heat entering the living space. In total, eight attic ventilation systems were installed in participant homes as a result of the trial.

The project benefits most valuable to A were the thermal comfort benefits rather than energy bill savings. A experienced a significant improvement in her comfort levels as a result of the treatment. She experienced less heat stress and her sleep improved which A says *"improved my physical, mental, emotional wellbeing, and productivity"*.

Case study A

Passively cooled home:

Occupants: 1 Person
House style: Elevated house
House age: 50-59 years
Materials: Metal sheeting on roof and walls

Design features:
The house design allows promotes passive cooling and the tropical garden provides abundant shade. Both factors limit the need for extensive active cooling.

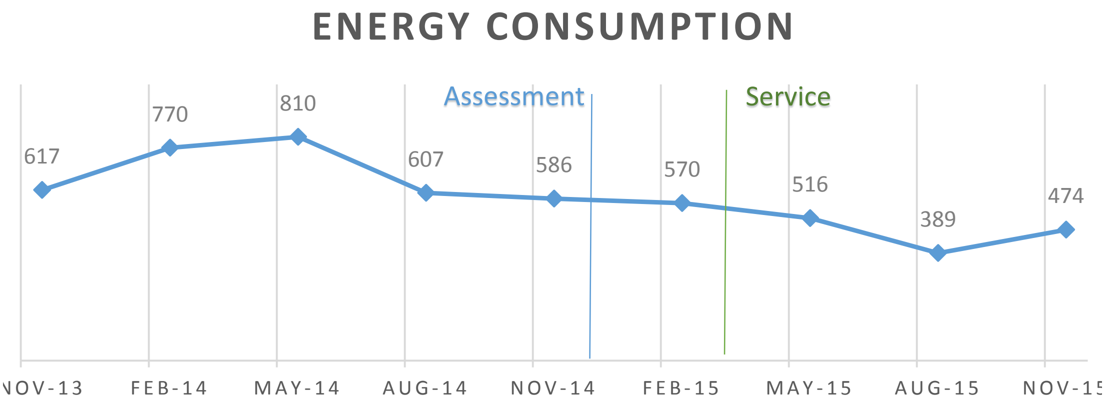
Energy use for A's appliances / day

Appliance	Quantity	Cost
Ceiling fan	x7	=0.18c
Fridge	x1	= .87c
Lights	x15	= .25c

Calculation: see appendix D. Source: jacanaenergy.com.au/save

Existing billing data:

This graph shows participant A's energy use for the 12 months prior to home assessment. A has experienced a 30% reduction since the assessment.

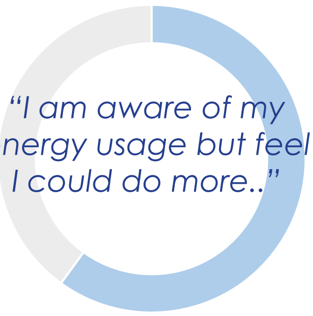
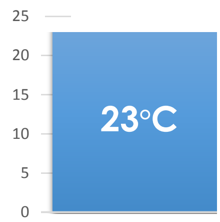
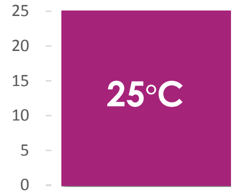


Service:

Installation of two static vents (attic ventilation).

Recommendations:

- Set AC between 26°-28°C
- Use the cold wash in the laundry
- Continue to monitor individual item electricity use with the energy monitor supplied.

	Energy habits:	Control	Comfort:	Air-conditioner
Before:	 *"I am aware of my energy usage but feel I could do more.."*	 *"I have control over tmy energy use"*	 Comfort Level:	Temperature setting:  23°C
After:	 *"I am trialling new methods to reduce my energy usage"*	 *"I feel I have control over the majority of my energy use"*	 Comfort Level:	Temperature setting:  25°C

"I feel energised since the 'blanket' has been lifted from my roof."

Participant response at the second home visit.

Case study B

Actively cooled home

B's home is built of cement slabs with a flat cement roof and fixed windows. It was built after cyclone Tracy to withstand cyclonic winds. Its high thermal mass and lack of cross ventilation limit the passive cooling opportunities and B relies on the six AC units, especially the living room unit, for comfort during the build-up and wet season.

Smart Cooling in the Tropics provided B with a complimentary clean and service of their six air conditioners. Maintaining household cooling appliances, such as air conditioners and ceiling fans, extends their lifetime and ensures appliances are working at their best. Smart Cooling in the Tropics cleaned and serviced air conditioners for 92 participating households and provided 16 cleaning packages for ceiling fans and screens.

The project benefits most valuable to the B's were energy cost savings. The project's deep engagement approach has facilitated a number of activities by B to improve household energy productivity including increasing air conditioner temperatures from 24°C to 29°C.

"We used the money we saved from the complimentary AC clean to invest in a replacement air conditioner for the living room which is more efficient and quieter. It has made the living room glorious. Next we are going to seal off the living room and kitchen from the hallway to make further energy savings. The complimentary energy monitor indicated that our 'cool room' costs about $350 a month - a cost we are happy to cover, but we turn it off while on holidays. We are now using the energy monitor to assess the efficiency of our freezer."

> "We used the money we saved from the six A/C cleans to invest in a more efficient AC."
>
> 'Actively cooled home' case study

Case study B

Actively cooled home:

Occupants: 3 People
House style: semi-detached
House age: 40 years
Materials: Concrete roof and walls
Outstanding comfort issues:
Participant B's home was built after cyclone Tracy and has high thermal mass. B relies on active cooling (AC) to maintain comfort.

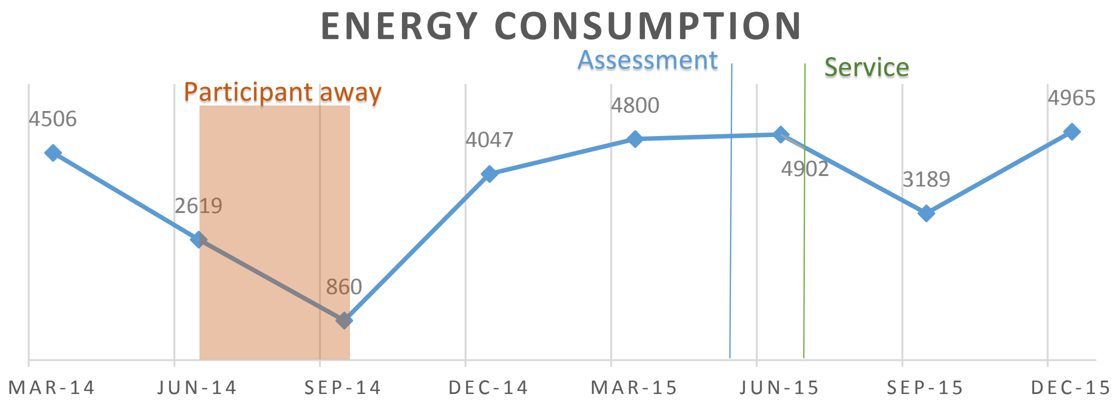
Energy use for B's appliances / day

Appliance	Quantity	Cost
AC	x6	**=$7.26**
Fridge	x3	**=$2.61**
Lights	x27	**= .57c**

Calculation: see appendix D. Source: *jacanaenergy.com.au/save*

Existing billing data: *

This graph shows participant B's energy use for the 12 months prior to home assessment. B has experienced a 27% increase since the assessment.



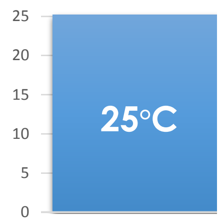
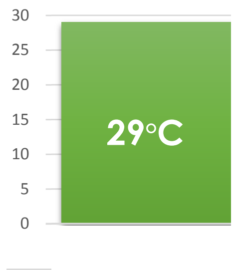
* To account for a 3 month absence in 2014 billing data from 2013 was used to identify changes in B's energy consumption.

Services:

Professional clean and service of AC.

Recommendations:

- Set air conditioners between 26°-28°C
- Use a fan in conjunction with your AC
- Consider turning off the second & third fridges.

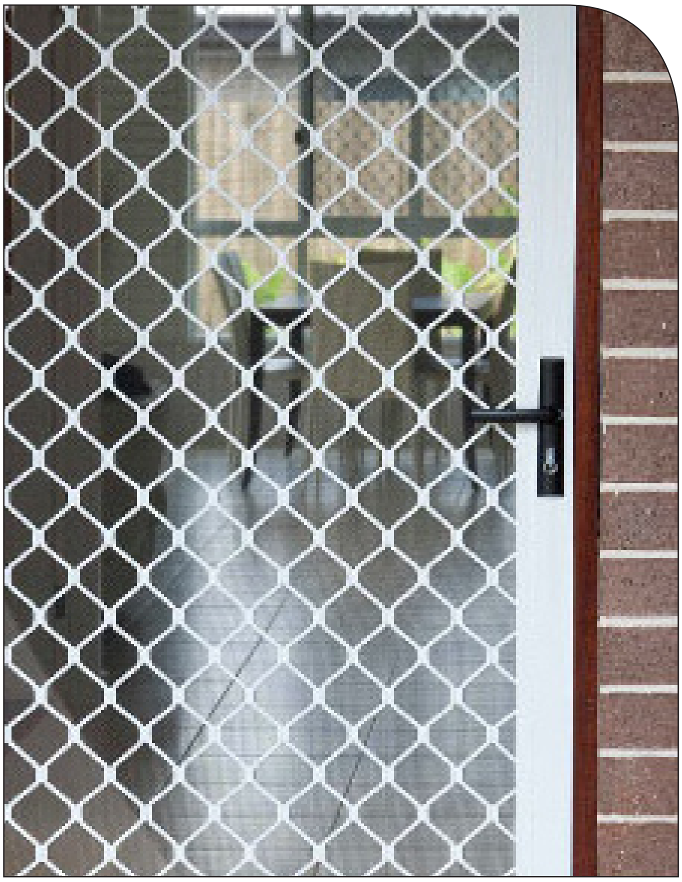
	Energy habits:	Control	Comfort:	Air-conditioner
Before:	*"I am aware of my energy usage."*	*"I feel I can moderately control my energy use"*	Comfort Level:	Temperature setting: 
After:	*"I am trying hard to reduce my energy usage but feel I could do more.."*	*"**Now** I feel I have complete control over my energy use"*	Comfort Level:	Temperature setting: 

"We used the money we saved from the six AC cleans to invest in a more efficient AC."

Participant response at the second home visit.

Case study C

Education and service



C's family home is a large low-set brick veneer home with a dark, tiled roof. The design of the home and its orientation on the block is not conducive to passive cooling. There is little shade surrounding the home and there are extensive exposed paved outdoor areas.

At the time of the home energy assessment, C's household energy consumption was more than double the Darwin average and the family regularly had their electricity disconnected or borrowed money to pay their bills.

The first home visit with Smart Cooling Project Officers identified that C kept doors and windows closed all day and night and the air conditioning on as a result of broken security screens. The Project Officer explained the AC costs, and developed strategies for C and her family focusing on finding passive cooling solutions and behavioural adjustments.

New fly screens and security locks were installed on all the doors and windows where the existing ones needed replacing or repairing. This combined with education maximised benefits for C. Following the assessment and the complimentary service the household energy use dropped from 8.4 kWh per day to 6.7 kWh 12 months later. This represents about a 20% reduction* in the household's energy consumption.

"Thank you COOLmob for the new flyscreens and locks and for helping me reduce my energy costs. I can now open my windows and doors to let in cooling breezes, and I don't need to use the air conditioning as often."

[*Electricity consumption calculated on per person basis due to change in household composition]

> "We knew our bills were expensive, but we didnt know how to change this."
>
> 'Education & services' case study

Case study C

Education and services:

Occupants: 4 People
House style: Single storey
House age: 15-19 years
Materials: Brick veneer with tiled roof

Design features:
The design of C's house and its orientation is not conducive to passive cooling. There is little shade and exposed paved outdoor areas which increase the thermal heat absorbed by the home.

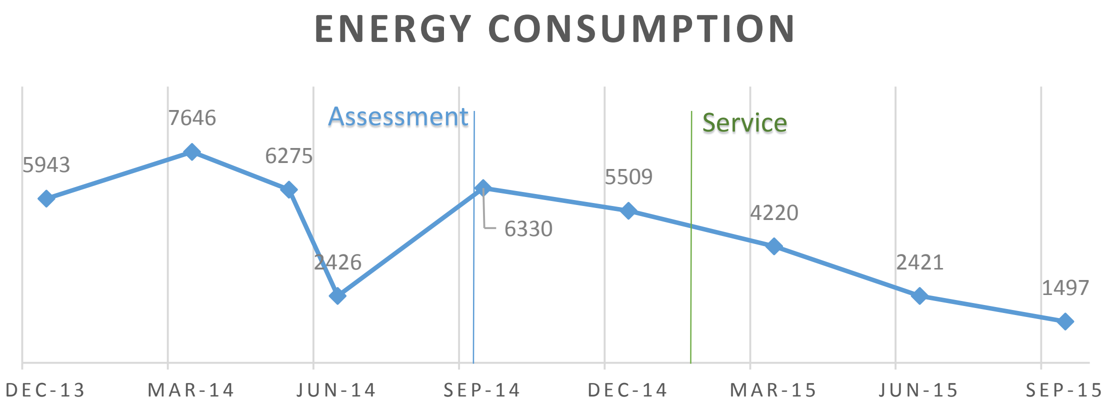
Energy use for C's appliances / day

Appliance	Quantity	Cost
AC	x6	=$7.25
Fridge	x2	= 1.74c
Lights	x32	= .74c

Calculation: see Appendix D. Source: *jacanaenergy.com.au/save*

Existing billing data:

This graph shows participant C's energy use for the 10 months prior to home assessment. C has experienced a 40% reduction since the assessment.

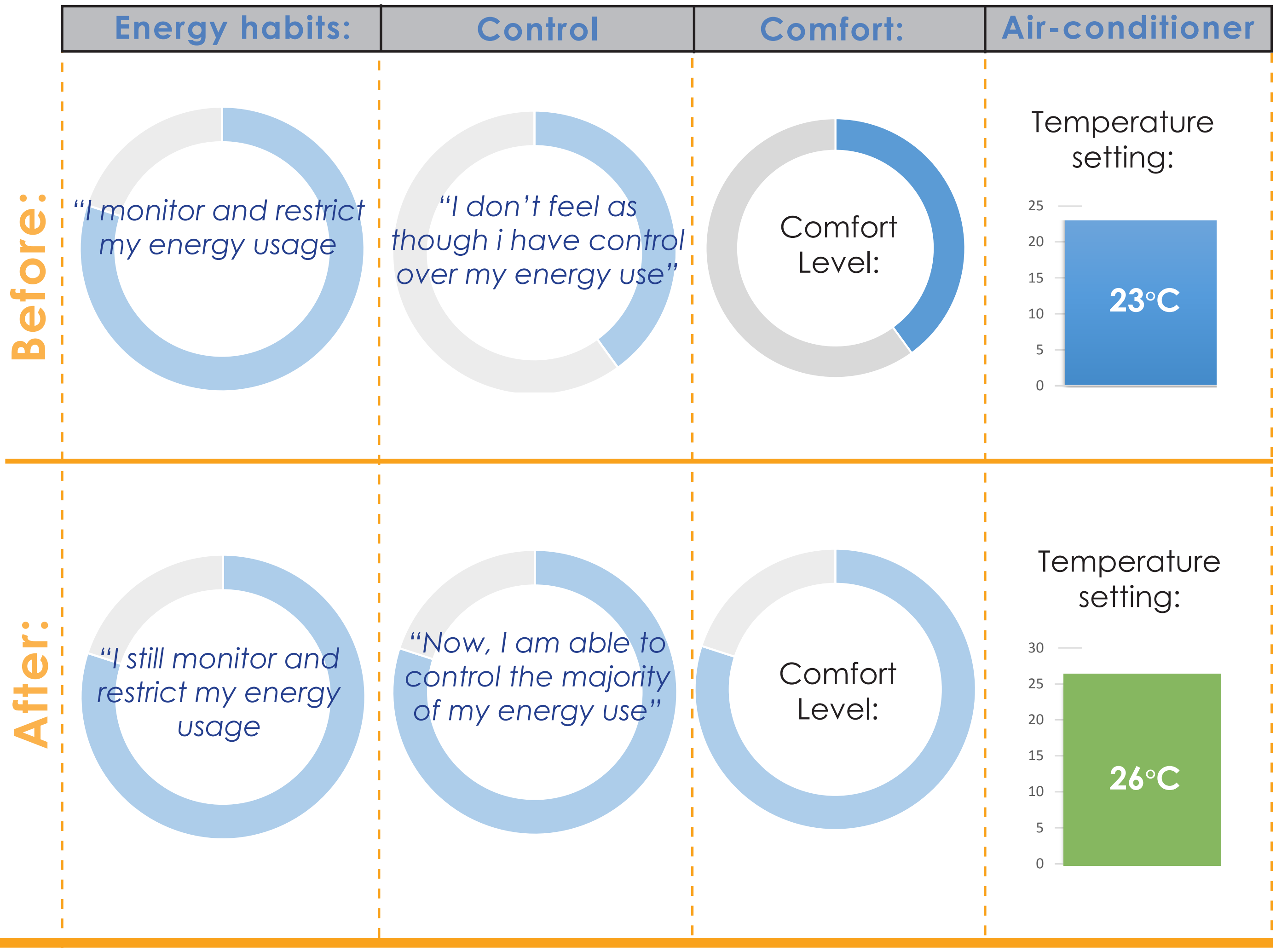


Service:

Flyscreen & security screen package.
A professional replacement of damaged flyscreens on doors and windows.

Recommendations:

- Use the portable fan and open windows before using the air conditioner
- Try cooking on a BBQ outside in the shade
- Set AC between 26°-28°C.



"Now I open my windows & doors to let in cooling breezes, and I don't need to use the air conditioner as often."

Participant response at the second home visit.

Case study D

Health and wellbeing

“My eyes are affected by the use of ceiling fans due to my condition, so portable fans are perfect to prevent dryness in my eyes.”

‘Improved health’ case study

D’s home is in an outer township of Darwin which experiences higher than average temperatures than Darwin. The home was built in 1976 and is low-set with mixed wall construction louvered windows and a light coloured metal sheeting roof.

D lives with an autoimmune disease and her eyes become sore, dry, and irritated from the ceiling fans when lying in bed. Portable (floor and pedestal) fans were provided as an alternative. The fans allow for greater flexibility of air movement and allow D to sleep better at night and reducing her heat stress. Her thermal comfort has increased without affecting her health, in particular her eyes.

Smart Cooling delivered 94 fan packages to participating households. An additional 49 upgrades to ceiling and wall fans were made. Fans are a lower cost cooling appliance and are a fundamental tool for comfortable and affordable living in the tropics.

Some participants with health conditions, like D, experienced health benefits through their involvement in the project. The project’s deep engagement approach identified indirect issues influencing behaviours. In the case of D, a chronic health condition was directly influencing use of cooling appliances, particularly the ceiling fan.

”My eyes are affected by the use of ceiling fans due to my condition so portable fans are perfect to prevent soreness and dryness in my eyes.”

Case study D

Health and wellbeing:

Occupants: 2 People
House style: Single storey house
House age: 30-39 years
Materials: Metal sheeting roof and composite walls

Outstanding comfort issues:
D's home is in an outer township where temperatures tend to be higher. D's health condition is negatively influenced by ceiling fans.

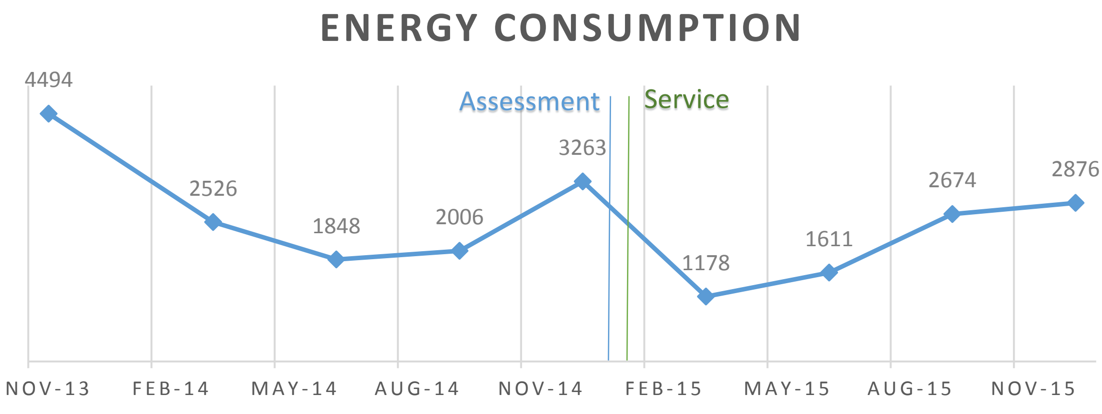
Energy use for D's appliances / day

Appliance	Quantity	Cost
AC	x1	**=$1.21**
Fridge	x2	**=$1.74**
Lights	x9	**= .21c**

Calculation: see appendix D. Source: *jacanaenergy.com.au/save*

Existing billing data:

This graph shows participant D's energy use for the 11 months prior to home assessment. D has experienced a 14% reduction since the assessment.

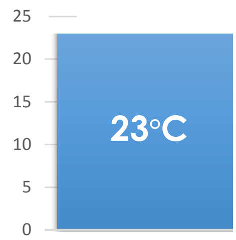
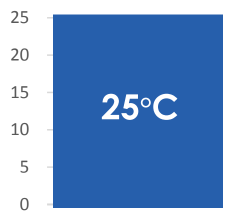


Service:

Fan Package.

Recommendations:

- Switch off the electric hot water system when not in use.
- Turn off the second fridge
- Set AC between 26°-28°C.

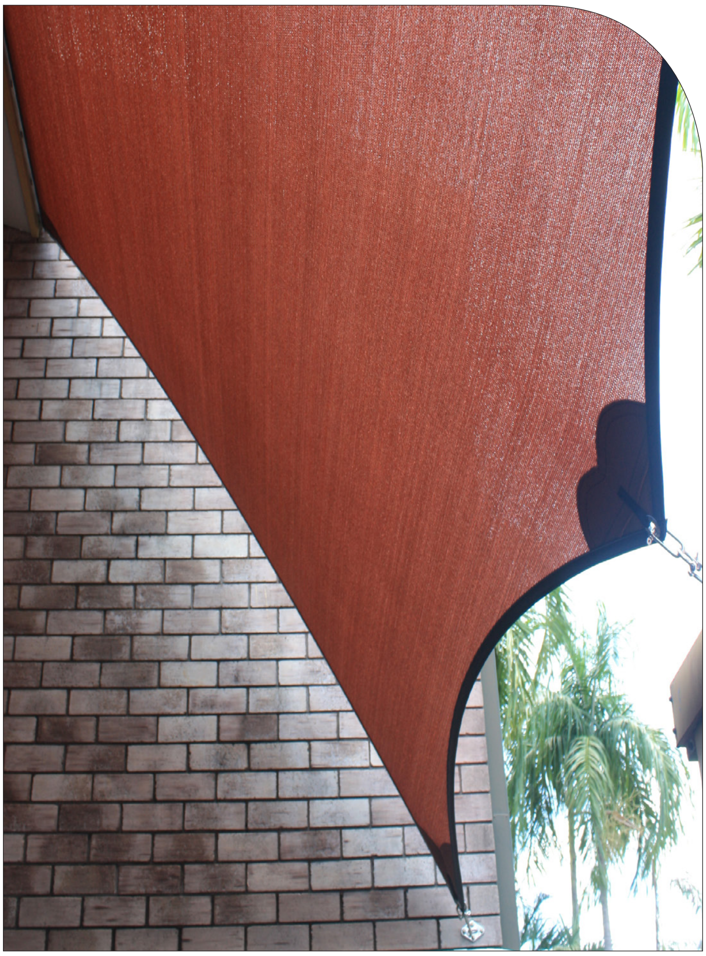
	Energy habits:	Control	Comfort:	Air-conditioner
Before:	*"I am very conscious and vigilant with my energy usage."*	*"I feel I have complete control over my energy use"*	Comfort Level:	Temperature setting: 
After:	*I am aware there is even more I can do to reduce my energy usage*	*"I still feel as though I have complete control over my energy use"*	Comfort Level:	Temperature setting: 

"My eyes are affected by the use of ceiling fans due to my condition so portable fans are perfect to prevent soreness and dryness in my eyes."

Participant response at the second home visit.

Case study E

Improved amenity



E's house was built in 1972 and is a three bedroom, ground level, brick-veneer construction with metal sheeting roof of light colour. E experienced high levels of thermal discomfort, primarily in the afternoon, when the sun hit the unprotected west-facing patio area. Smart Cooling in the Tropics installed a shade sail to reduce heat gained from the hot afternoon sun.

External shading reduces radiant heat absorbed by the dwelling structure by shading exposed external surfaces. They can provide a comfortable outdoor cool zone too.

In total 32 shade sails were installed as a result of the trial. Many of the homes assessed for the trial had insufficient, or no, shading. It was a highly valued service and one that many more than 32 participants wanted or required to improve energy productivity.

E says the shade sail has improved the amenity of her home by shading the west-facing outdoor patio area and adjacent garden area from the afternoon sun. This has extended the available living space of the home and provides a comfortable cool zone outside away from the stored heat in the high thermal mass home. This unintended benefit may result in an energy benefits too, with reduced need for active cooling systems, especially AC.

> "It (shade sail) looks beautiful and our friends say that too."
>
> 'Improved amenity' case study

Case study E

Improved amenity:

Occupants: 2 People
House style: Single storey
House age: 40-49 years
Materials: Roof: Metal sheeting, walls: brick veneer

Outstanding comfort issues:
'E' is conscious of her energy usage however, the external concrete area of her home is exposed to the afternoon sun causing high internal room temperatures.

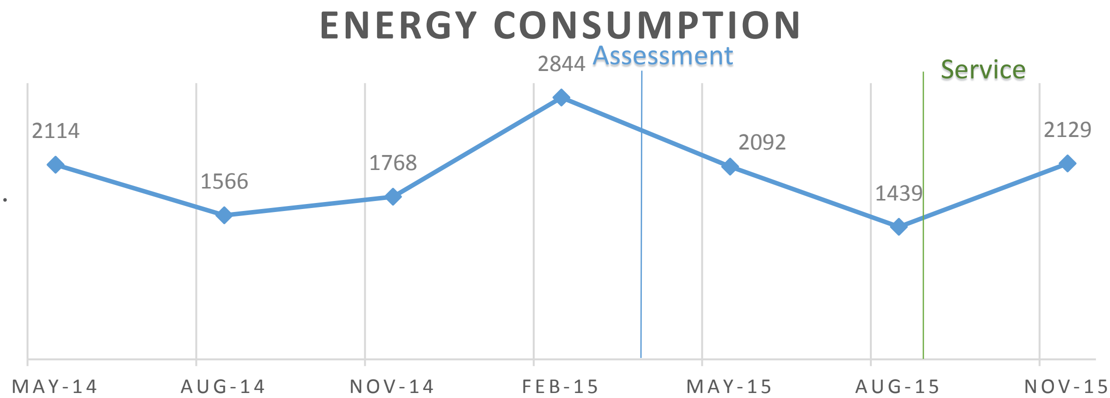
Energy use for E's appliances / day

Appliance	Quantity	Cost
AC	x5	=$4.03
Fridge	x2	= 1.16c
Lights	x14	= .28c

Calculation: see appendix D. Source: *jacanaenergy.com.au/save*

Existing billing data:

This graph shows participant E's energy use for the 11 months prior to home assessment. E has experienced a 4% increase since the assessment.

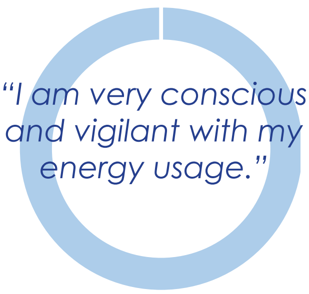
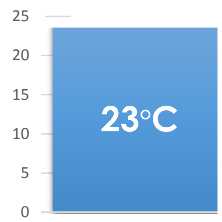
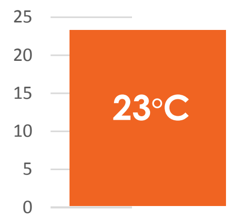


Services:

Install shade sail.

Recommendations:

- Switch to energy efficient light globes
- Turn appliances off at the powerpoint when they are not in use
- Open doors & windows to let cooling breezes into the home.

	Energy habits:	Control	Comfort:	Air-conditioner
Before:				Temperature setting: 
After:				Temperature setting: 

"We now have more space for our family and friends to spend time together."

Participant response at the second home visit.

5.0 Discussion

"We have lived in this house for over 40 years and my husband repaired the screens for years but now is unable to do them as his hands won't let him. Now, our screens look **lovely and new and clean**."

Project participant, 2015

5.1 Background Summary

The trial methodology used to deliver the LIEEP program objectives was a combination of home energy saving information, recommendations and the installation of retrofit products to targeted low income households across Darwin. 480 low income households in Greater Darwin were targeted for this project.

Community engagement was embedded into every aspect of the trial to ensure that the full range of data collection methods was used and delivered effectively. This safeguarded the data integrity and facilitated a positive consumer experience.

The energy efficiency approaches applied by Smart Cooling addressed three barriers; cost, knowledge, and motivation. The approaches used were: energy literacy, deep engagement and complimentary services. They entailed and were defined by the provision of face-to-face home energy assessments, personalised energy reports containing behaviour change recommendations, and complimentary structural modifications (e.g. shade sails, reflective roof paint) or appliance upgrades (e.g. provision of pedestal fans) to improve the energy efficiency and thermal comfort of participating households.

The trial assumed that the measures delivered, i.e. the services and the education, would improve thermal comfort, with a flow on effect to increased energy efficiency. These assumptions were proved to be correct.

The project increased thermal comfort and energy literacy amongst participant households without an overall increase in energy use. It also achieved increased capacity, knowledge, skills, and awareness amongst local energy efficiency businesses, consortium partners, and the general public.

The Smart Cooling in the Tropics project achieved significant outcomes for participants, the local community, and the broader community as well as the objectives of the Low Income Energy Efficiency program:

- Increasing energy literacy among participating low income households and building their capacity to manage the impacts of electricity price rises.
- Building the knowledge and capacity of social welfare agencies to provide long-term energy efficiency among their customers or clients.

More broadly, the project resulted in:

- reduced social costs (improved health and wellbeing, opportunities for social connectedness and increased social capital);
- reduced environmental costs (less energy consumption, GHG emissions); and
- reduced economic costs (less electricity demand, less financial burden on lower income households).

The project also generated reliable data for future research and analysis to inform government strategy, policy, and program development. In particular, the research will contribute to the evidence base to better enable policy-makers to develop effective adaptation strategies to increase the resilience of vulnerable communities to the health impacts of climate change.

5.2 Key findings

The baseline data gathered by the project (surveys 1 and 2) pertains to demographic information about low income households in the Greater Darwin region, including:

- people living in those homes; and
- their energy consumption patterns, behaviours and attitudes
- the current state of housing (and appliances);

The trial identified that:

- The majority of homes were built before 2000. This means only 16.6% were built following the formal adoption five star rating which established the minimum energy efficiency requirements for residential buildings.

> "Once the participant has the **language and literacy** they could make choices (about energy and comfort)."
>
> Smart Cooling Project Officer

- Energy consumption among the target group was 15% lower than the rest of the population. This data was reinforced qualitative data suggesting that participants are avoiding the use of air condition due to cost concerns and are already doing as much as they can to reduce energy.
- The typical participant were older, retired and owned their homes. However, and importantly, those participants not in the majority provide a good indication of who the project could not access either due to eligibility constraints, language constraints or stability constraints.

The trial demonstrated that the services delivered were cost effective and produced a range of non-energy benefits for the participants.

5.3 People

The project plan identified five sub-groups including older people, those living with a disability or chronic illness, their carers, urban Indigenous people, and refugees. Four social welfare agencies affiliated with these groups were engaged to deliver recruitment for the project from their membership or client base. It was anticipated that there would be an even split across these four agency recruitments.

Three of the contracted local agencies reported that many of their potentially eligible members were excluded because they lived in public housing. In addition, the income threshold was not appropriate for Darwin's socio-economic climate at that time. Market research of the agencies' 'reach' into the eligible target group was not available at project initiation. Accurate data about the living arrangements and locations of their members or clients was not known by these agencies.

With 70% of all public housing stock located in the project's geographic area (NTG, 2016) inclusion of Territory housing residents may have made for earlier completion of recruitment.

On average, 30% of Darwin's population fall into the low income category according to the 2011 census. This is not a homogenous group and represents diversity including ages, ethnicity, illness and level of care needed, unemployment and underemployment. The sample population matched the Darwin population in many ways, however, there were multiple categories that separated them from the general population other than by income.

Areas where sample percentages were similar to Darwin were: if they were born in Australia, education level, Indigenous status, and number of people per household.
Aside from participants being low income, characteristics where they differed substantially from the general population were: the participants tended to be much older with a median age of 64, they were heavily biased toward being female (2:1), a large portion was retired (46%), the majority of dwellings were houses and most people owned their homes outright (54.8%) or had a mortgage (19.1%).

The bias toward female participants could have potentially affected the survey results, especially questions relating to thermal comfort (Karjalainen, 2012), but most of the households had multiple people in them so energy data is not assumed to be gender biased. Being retired usually means a reduced income and that would have made them eligible for this project. It can also be assumed that retirees have more free time in general and may therefore have been more able to engage in the project. These may have been factors that enabled them to join Smart Cooling. A possible reason that many younger low income households were not represented in this project may be that many of them live in Northern Territory housing. Since this excluded them from being eligible for the project, and there was a set number of spaces, these spaces were unequally filled by older retirees.

5.4 Energy

The funding proposal set a 10-30% energy reduction target for Smart Cooling in the Tropics. The pilot phase of the project established very quickly that energy conservation was not appropriate given the low levels of energy used by the target groups.

The baseline data on energy use demonstrated that participating low income households were on average already using 15% less energy than the average Darwin household, so hitting the target reduction may have adversely affected the participants' quality of life.

There was sparse electricity consumption data for refugee participants, but the data available showed they had the lowest consumption with an average of 16 kWh/day. Many of the Melaleuca clients are refugees from countries where stable power supplies are uncommon, so household electricity knowledge might be expected to be low and lead to high consumption.

However, employees of Melaleuca revealed that there is a strong sense of community among the refugees, and they share knowledge about living in Darwin. With the high cost of electricity and low income levels, this cohort has learnt that air conditioners have high running costs and their use should be avoided. With consumption this low, however, there is the possibility that thermal comfort and quality of life could suffer.

Refugee participants also rated their thermal comfort the lowest with an average 3.0 out of 5, while the remaining participants had a 3.7 average. Therefore, a further decrease in energy consumption might have led to a corresponding reduction in comfort. More research is needed into energy use and comfort levels of refugees in Darwin.

COTA members were the next lowest energy users. With 85% of members (N=61, total COTA sample) being retired or unable to work, it could have been more likely for their energy use to be higher due to them being at home more often than other participants who work during the day. In addition, 84% of them own their homes outright so their cost of living would be lower and 79% of them receive concession discounts making electricity roughly 40-50% cheaper than a standard bill. With all of these factors, it was surprising that consumption was not higher than average. With their advanced age, further reducing consumption may not be advisable since it could lead to health and heat stress concerns.

Indigenous households had unique circumstances in regards to MDC. Many of them had prepaid meters where they pre-purchased electricity by swiping a card bought from the local shop. Electricity could be used up to the amount added and also a small amount into debt that allowed participants to keep their electricity on overnight even if they ran out of credit. At the next prepayment, the debt would be subtracted from the value of the credit added. About half (16 out of 31) of Indigenous prepaid users said they ran out of power because they exceeded their credit. Of those who indicated they did run out of power, they said they were without power for 7.5 hours on average.

Given Darwin's climate is outside the thermal comfort zone for much of the year, it was considered important to focus the trial's education and services on improving participants' thermal comfort instead of energy reduction. And to do so without creating a significant increase in energy consumption and associated costs. This objective was achieved with 82% of participants reporting an improvement in their thermal comfort.

The number of participants who claimed they were now using the least possible amount of energy may be a testament to the success of this project. Participants may have reached their energy productivity limit in maintaining their current lifestyle and thermal comfort levels.

5.5 Energy consumption patterns, behaviours & attitudes

Before joining the project, participants were already using substantially less energy than the general public of Greater Darwin. Data collected demonstrates that overall the participant group was using 15% less than the Darwin daily average. However, different subgroups within the sample population had different needs and consumption patterns. Project data reveals that age of the participant was a factor in mean daily consumption (MDC), with the 40-49 age range consuming the highest and older participants among the lower users. This is an interesting finding and further investigation is required to determine why this is the case.

Simple tasks like turning off lights and switches at the wall had the highest uptake. Survey 3 collected the following information:

- 62.7% of participants learnt that small changes make an impact to comfort and costs (N 83)
- 34.9% changed their AC habits (N 83)
- 38.6% had a better understanding of their electricity bill and (N 83)
- 37.3% turn off ceiling fans now when leaving the room (N 83).

These small tasks are not large influences on thermal comfort. Turning off lights when not in the room is common advice for saving energy. It was not queried if the participants did not know this was a practical energy saving measure before the project or if it was acted upon because the officer advised it. The project may have simply acted as a reminder.

Using a fan while running an AC is a good way to reduce electricity consumption while maintaining thermal comfort (Aynsley, 2007). This is only an effective measure if the AC thermostat is set to a high enough temperature to at least compensate for the power drawn by the fan. The percentage of participants who started using a fan with their AC, as recommended, was 28%. This is higher marginally than the number who raised the temperature of AC thermostats, which according to Survey 3 is 24%.

A 'cool zone' is a small area of the house designated to be used instead of a larger area when an AC is needed. The idea is to reduce the amount of space that needs climate control as a method of reducing electricity consumption. Uptake of this particular recommendation was relatively high at 14.7% given the limitations of who could adopt it based on property attributes, e.g. not having a room to set aside for such a reason.

5.6 Climate and comfort

In Darwin, the climate dominates everything. Space cooling is necessary. At the community level, there is ongoing debate regarding the appropriate housing style for cool and comfortable tropical living. While Smart Cooling in the Tropics did not seek to provide answers to this debate, it did collect data and trial approaches that can provide the evidence base needed to unravel the complexities of thermal comfort and thermal performance measurements for the Australian tropics, underpinning this debate.

Although perceptions, and expectations, around thermal comfort were varied across the participants and were not fully analysed for this report, it is likely that for some participants their thermal comfort was compromised due to financial concerns or limitations. Where there are aspects of vulnerability such as health and age, this may be a concern and requires more research. The project's baseline will provide a robust evidence base to move forward to this work.

Thermal comfort is an important factor in energy efficiency; people are unlikely to

sacrifice comfort for efficiency (Becker 1981). Not only did comfort not decrease, there is substantial evidence to show there was improvement.

76% of participants surveyed ranked thermal comfort improvement as the most significant benefit of the project.

Other comfort related areas of improvement were a self-reported reduction in heat stress (54%) and improved quality of sleep (63%).

Heat stress, especially among the elderly, is a serious worry in Darwin (Dept. of Health 2011). It can also lead to more serious conditions such as heat exhaustion and heat stroke.

One important matter is that participants did not notice an increase in the amount of noise coming into the home, which could be a large barrier for passive cooling (Santamouris, 2007). With so many of the services, as well as recommendations, having objectives to open doors and windows to allow airflow for passive cooling, an increase in noise entering the house could have been expected. It was fortunate that this was not significant issue.

5.7 Housing, appliances and cost of living

5.7.1 Housing characteristics

The housing characteristics of the homes assessed are an incredibly powerful baseline for understanding the current housing stock, its suitability to the climate and its adaptability to future changes in climate.

Most homes assessed (71.3%) were built before 2000. This was ten years before the Northern Territory adopted a five star rating tool in 2010. Only 16.6% were built following the formal adoption of this practice. Currently, the Northern Territory is the only Australian State or Territory not adopting a 6 star rating.

The baseline dwelling data relating to housing design and construction highlights that many homes in the Greater Darwin area are not designed with passive cooling in mind:

- 65% (N=357) of houses had wall materials of high thermal mass
- 41% (N=476) of houses had louvre windows
- 27.7% (N=271) of houses had bulk insulation
- 83.4% (N=271) of houses had sisalation.

This is also reflected in anecdotal evidence provided by Project Officers, that many homes visited had the following characteristics:

- high thermal mass walls (brick, concrete block);
- inappropriate orientation and aspects for good thermal performance e.g. large areas of wall exposed to the western sun;
- little or no shading from vegetation;
- little or no shading from eves or verandas;
- poor airflow; and
- large areas of paved or concreted external surfaces.

Although orientation data was collected at the home assessment, it was not accessible for analysis for the report.

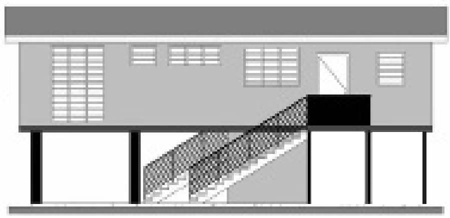
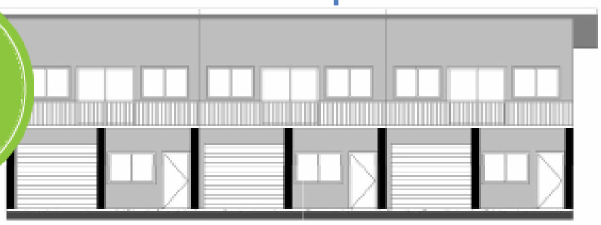
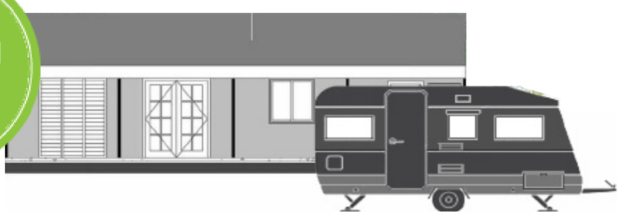
Shading was key deficit at the majority of homes. Survey 2 did not include collection fields for the external characteristics. The observations of the Project Officers was that the majority of homes had insufficient shading features e.g. eves or correctly sized eves; vegetation, shade sails or blinds. The project installed 61 shades; 32 shade sails and 29 roll down blinds. Given the high need for shading observed and the benefits reported by participants, shading is seen as an important service for ongoing rollout. It is one of the highest cost services and the cost barrier needs to be addressed. A rebate program for shade structures would assist with the cost barriers.

Based on the projects findings, it is recommended that shade sail rather than roll down blind are promoted. Participants who received a shade sail reported higher levels of comfort impro vement than those who received roll down blinds. There are two possible reasons for this. The first is mobility. Older participants or residents with mobility barriers reported that they found the roll down blinds fiddly to unclasp and left them down instead of manoeuvring them to allow for breezes. This means that the benefits associated with ventilation (cost and comfort) are minimised.

Smart Cooling demonstrated that there is a range of services that can impact thermal comfort. Sometimes this is as simple as maintaining appliances or repairing dwelling features. Project Officers identified other services that were outside the scope of the project but would assist lower income households. Including:

- BBQs to allow for outside cooking
- Replace single pane windows with louvres for increased cross ventilation
- Window tinting
- Energy efficient pool or bore pumps
- Insulation for verandas or outdoor living areas.

Darwin housing typologies:

Housing styles:	Demographic/ housing characteristics:
Single storey house  Houses assessed **304**	Average size (sqm): 100- 150 sqm House age: 30 - 39 years Average no. of occupants: 1- 2 persons Typical cohort group: Carers Ownership status: Owned (56%)
Semi-detached dwelling  Houses assessed **46**	Average size (sqm): 100- 150 sqm House age: 30 - 39 years Average no. of occupants: 1- 2 persons Typical cohort group: Cota Ownership status: Owned (52%)
Elevated house  Houses assessed **56**	Average size (sqm): 200- 250 sqm House age: 30 - 39 years Average no. of occupants: 1- 2 persons Typical cohort group: Non-affiliated Ownership status: Owned (70%)
Apartment  Houses assessed **52**	Average size (sqm): 100- 150 sqm House age: 20 - 29 years Average no. of occupants: 1- 2 persons Typical cohort group: Melaleuca Ownership status: Rented (54%)
Shed or caravan  Houses assessed **18**	Average size (sqm): 0- 50 sqm House age: 20- 29 years Average no. of occupants: 1-2 Typical cohort group: Yilli Ownership status: Owned (56%)

All information displayed was sourced through Survey 1, 2 and 3, estimated by assessors or obtained through data collected within the project.

The built environment is fundamental in supporting thermal comfort and energy productivity. A summary below outlines the common housing styles, and the typical features, assessed by Smart Cooling in the Tropics. Many of the homes assessed were a departure from the design that characterise the Top End lifestyle; elevated, shaded, lightweight and well-ventilated.

Construction materials:	Typical features	Beneficial recommendations	Recommended service	# AC
Walls: concrete/ brick Roof: metal sheeting	1. Surrounding pavement / concrete driveway 2. Pool / pool pump	Shade walls by planting trees on the Northern side of your home.	1. Upgrade flyscreens 2. Sails/ shade cloth	3x AC (21%) 4x AC (26%)
Walls: concrete block Roof: metal sheeting	1. Louvre windows 2. Pool / pool pump	Create a cool zone	1. Install ceiling fan 2. AC clean	3x AC (53%) 4x AC (22%)
Walls: steel cladding Roof: metal sheeting	1. Louvre windows 2. Vegetation / shading	Clean fans, flyscreens & louvres regularly to maximise airflow.	1. Upgrade ceiling fans 2. Upgrade flyscreens	3x AC (21%) 4x AC (33%)
Walls: concrete/ brick Roof: metal sheeting	1. Surrounding pavement / concrete driveway 2. Single glass windows	Use fans in conjuction with a higher AC settings to increase air movement and comfort.	1. Fan pack 2. AC professional clean	2x AC (20%) 3x AC (42%) 4x AC (20%)
Walls: steel cladding Roof: metal sheeting	1. Solar panels 2. Single-glass / no windows	Switch off apppliances, lights and fans when you leave.	1. Heat reflective roof paint 2. Fan pack	2x AC (20%) 3x AC (42%) 4x AC (20%)

> ‘People **felt connected** by being part of a project and part of something bigger. Particularly the elderly and unemployed, it was good for these participants **wellbeing and sense of belonging**.’
>
> Smart Cooling Project Officer

5.7.2 Appliances

Survey 2 collected data for 5,069 appliances. Of these appliances one third were air conditioners (1417).

The condition, age and use of air conditioners was of particular interest to the project. The use of space cooling in the Top End is extensive and the project design focused on uncovering opportunities to avoid its use or improve its use. One aspect of data collection was dedicated to collecting AC use data to increase the knowledge of how residents use air conditioners.

On average, assessed homes had three AC units. Over a quarter (38%) of the units were eight years old. 11% of AC units were over 20 years old. Energy Star rating was not collected largely due to the absence of the label.

On average project participants increased the thermostat by 1.7 degrees from 23.8 degrees Celsius at the time of the home energy assessment to 25.5 degrees Celsius after the assessment.

This is a good outcome and demonstrates that small habits were indeed leant and actioned by participants.

A before and after comparison of participant daily and seasonal usage patterns was not possible due to data gaps. The following results were taken from Survey 3, which was delivered after the assessment. Other interesting data that emerged through Survey 3 related to seasonal use of the air conditioner. 61% of respondents (N 149) reported not using the air conditioner at all during the dry season. Usage increases significantly to use 7 days a week for over half of all respondents in the build-up (51%) and 41% during the wet season. The most common time air conditioning was turned on was from 5pm onwards.

For a subset of participant (30) who received the AC clean service (Table 10), there was almost a 9% increase in consumption. This may have been caused by the so-called rebound effect (Berkhout, 2000): Participants thought their AC units were costing less to run and usage patterns increased. It may also be attributed to the season. Services for this group of participants were delivered over the end of the wet season and the beginning of the build-up. Data collected in Survey 3 suggests that usage during these seasons is typically higher.

Although this information is not conclusive it is a useful starting point to catalogue patterns of use. Further data collection over time could provide useful insights for designing demand management programs.

5.7.3 Cost of living

In early 2014 Darwin was the most expensive capital city to rent in, with Northern Territory households spending proportionately more of their income on housing than anywhere else in Australia (NTCOSS, 2013:2). The median weekly rental price for a three bedroom house in Darwin, in the suburb with the lowest rental prices, was more than the total weekly income for a sole parent, with two children, on Newstart and Family Tax Benefit A & B (NT COSS2013:2).

Modelling undertaken by NTCOSS for its cost of living report revealed that welfare payments were not keeping pace with the increase in housing costs and were leading to extreme housing stress. The rapid increase of costs in housing put significant pressure on the public housing stock in Darwin. Many of the same payments, as outlined in section 3.2.2, were indicators for the projects own eligibility parameters. Project Officers indeed witnessed the difficulties experienced by many eligible residents to apportion their limited income to home comfort behaviours or improvements.

The Northern Territory Government's Housing strategy consultation identified a significant shortfall in available and suitable public housing stock, noting that the greatest number of low and very low income households still rent from private landlords (NTG, 2016).

The experience of the project supports this finding, having engaged and delivered services to participants living in sheds or caravans and many in built-in flats underneath the elevated family home. The condition of housing at urban Indigenous communities varied widely between communities. Some homes were in serious disrepair, and in some instances overcrowded. A small number of homes were completely abandoned by the time contractors arrived to complete services.

Demographic data collected for Smart Cooling in the Tropics demonstrates that over half (59.1%) of all project participants were aged 60 or above. Additionally home ownerships rates among this group was very

high. Only 25.4% of all project participants were renters compared to 73% who owned or mortgaged their homes. Based on analysis of the demographic data and anecdotal evidence from Project Officers, the project found that the majority of eligible participants recruited were long term Darwin residents who bought a house when property prices were lower and who were now retired and living on a pension.

It was evident very early in the project that the initial income threshold was not appropriate for Darwin based low income households living in private accommodation. Consortium members, particularly the local social welfare agencies responsible for recruitment, expressed concern that the income levels were not suitable, given the cost of living in

Darwin at that time. In 2013-2014 Darwin had the highest costs of any capital city in Australia (NTG, 2016).

The eligibility parameters were changed twice during the course of the project's delivery. During the delivery of the pilot phase, the income level was increased to meet the Department of Human Services income brackets. The increase made a moderate impact on recruitment. However, it was the second eligibility change that gave the social welfare agencies greater scope to recruit across a broader cross section of their client base. These changes saw an increase of the income levels in line with the National Rental Affordability Scheme (NRAS), the inclusion of the New Start allowance and the expansion of the geographic zone to include the major townships in the Greater Darwin area.

The expansion of the geographic zone to include townships and properties in the Greater Darwin area had a positive impact on recruitment, leading to 85 more participants. It also demanded a modified approach to assessment and service delivery.

Given the distances, assessments were delivered in batches (day trips for pairs of Project Officers). Recommendations were made with logistics and contractors in mind. In some cases contractors supplied in-kind services by delivering fan packages to participants before, on the way or after their own services were delivered in these areas.

Owing to the distances of some locations, contractors delayed services to allow for more jobs to arise before sending teams into these areas, minimising their costs and therefore costs to the project. Although the majority of participating residents in these areas were comfortable with the delay, it did require additional administration from the project team to track and communicate with residents. Residents in the harder to access areas were particularly grateful for the services, regularly being excluded from opportunities to participate in studies, or even energy efficiency services -

"This is great, we never get anything like this (project) down here, it's always just for Darwin".

5.8 Deep engagement model

The project designed a centralised customer experience interface to integrate with each social welfare agency. The premise for this model came from the common identified barriers for the project: financial constraints, information failures and limited motivation.

This model delivered deep engagement through one-on-one case management. Initially, each Project Officer was appointed to engage with a specific agency and their individual members. This worked to identify and develop detailed knowledge of appropriate approaches for each group. Importantly, it transferred the existing trusted relationship with the agency onto the Project Officer.

Establishing trust between the participant and Project Officer was fundamental for ensuring data integrity as it meant people gave honest feedback. Trust was important for acceptance of the recommendations made in the tailored report and set the scene for the Works Coordinator and the contractor's site visit.

The deep engagement model needed to be tempered by professional boundaries, staff training, and a team culture of support. The project's practical focus of managing household energy and improving comfort created a non-threatening environment and at times led to broader conversations about health, security, social isolation, and financial worries. Project Officers reported feeling compelled to provide information to other referral services or assistance around the home. The project's operational procedures limited this. Consequently, it left Project Officers unhappy as they had generated genuine rapport and trust and felt that the project was not addressing the whole need of the participant. The one referral that was within scope and provided to some households, was to seek the electricity concession. Over half of all participants (54.4%) already received a concession. The project did not collect data to establish the number of people who ended up on the concession as a result of their participation as it was not part of the original data collection scope.

The Project Officer's relationship with the participant in most instances commenced at the home energy assessment. The link was maintained throughout the project. Project Officers managed all aspects of the participants' interactions with the project, did the data entry, record keeping, billing analysis, and wrote the tailored report. They also liaised with the Works Coordinator to finalise services, monitored the progress of the services, and provided ongoing support though email, phone, workshop opportunities, and events.

Five workshops were delivered. These were not considered a successful element to the engagement model due to the low numbers of attendance from participants. All participants were invited to attend each workshop. In total only eleven participants attended the workshops. Participants often stated that they received such good personal advice at the home assessment that they didn't think they would gain more from the workshop.

The case management approach evolved as the project's recruitment strategy changed and the volume of participants increased. The increase in non-affiliated participants meant that assigning Project Officers to only a specific demographic group was not feasible. The peak in recruitment numbers required the data management and record keeping to be centralised to an operations team. All other aspects remained.

Post assessment evaluation with participating households highlighted the success of education as a tool for energy productivity. Participants loved knowing more, the knowledge gained was new, interesting, and helpful.

Education and services were exclusively focused on effective cooling activities. Through dialogue and observation, Project Officers delved deeply into the participants' cooling practices. The project collected detailed and multifaceted information about thermal comfort, energy behaviours and practices, condition of appliances, and the thermal performance of the dwellings. They developed a multidimensional impression to inform their recommendations for services and advice for practical changes. Although the timeframe for evaluation was too short to analyse the depth and breadth of data collected, it was used directly by the Project

Officers to inform their recommendations for services and advice for practical changes for each participant.

Education played a major role in the methods to help participants be more energy productive. At the very basic level, 74% (N = 88) of participants said they had a 'better understanding of electricity use/efficiency'. This knowledge was also the second-most highest ranked benefit by participants. Many participants gained a better understanding of their power bill as well. Moreover, many participants learned that changing habits can lead to a reduction in consumption; this awareness led to 80% (N=136) of participants making behaviour changes to be more energy efficient.

5.9 Recruitment and communications

A community engagement approach was used to facilitate recruitment. The four social welfare agencies contracted were responsible for delivering recruitment. Working with local trusted agencies was considered the most direct approach and one that would ensure sufficient support for the specific subgroup targeted. Although this approach was ultimately not successful the involvement of the agencies proved to be important in brokering trust.

Initial recruitment from the social welfare agencies quickly ran into challenges. Eligibility parameters were changed in February 2015 to improve further recruitment through the social welfare agencies. Eligibility amendments, including the adjustment of the income threshold, the addition of the Newstart allowance to the approved payments and the expansion of the geographic zone, contributed to improvements in recruitment, but alone would not have achieved the recruitment targets, certainly not within the timeframe of the project. A change in strategy was required.

The entire recruitment approach was reoriented in early 2015. This change ultimately achieved the 480 target in the time remaining.

The project team, led by a newly appointed Recruitment Coordinator designed and delivered an intensive five month recruitment campaign April to August 2015. It was successful and produced over half of the total recruitment target within these short five months.

Motivation to join the project was nearly always related to achieving cost savings or avoiding large energy bills. Interest to reduce energy consumption invariably aligned with the seasons, which unfortunately did not align with the project's recruitment targets. This meant that the communications needed to create the conversation relied on the memory of the build-up and wet seasons, leveraging off concern about electricity bills and the never ending heat.

The three successive print advertising campaigns drew on this motivation promoting the free services and the benefits of cooling and lower bills. The print media campaign also included three media releases in local and regional newspapers on 27 February, 8 July, and 23 September 2015.

In addition, the project was promoted through the COOLmob webpage on the ECNT website where people could request to book an assessment by completing an online form. A total of 89 people requested assessments through this medium (though not all were eligible).

Social media activities included a Facebook campaign during the final weeks of the recruitment phase (July-September 2015). In all, 11 advertisements were posted resulting in a total of 13,794 views, 24 shares, and 104 likes.

Word of mouth and advertising were the most effective recruitment pathways. Figure 25 below describes the successful channels used to gain recruitment into the project. It depicts the progress of the two primary stakeholders, the project team and the group of social welfare agencies responsible for recruitment. Importantly, it demonstrates the rapid growth in recruitment numbers coinciding with the period in which the project team reoriented the recruitment strategy.

Peak energy use in Darwin typically coincides with the build-up and wet seasons. Many participants were concerned about the costs associated with keeping cool even though their usage was low in comparison to the average Darwin household.

Smart Cooling provided eligible participants with services and support at no cost. This strategy was important in attracting the target group to the project. Providing anything at no financial cost can create suspicion and can also generate power imbalance and expectations. Project Officers delivering home energy assessments or coordinating contractors encountered a range of expectations from acceptance, confusion that there was no cost, and expectations that they could ask for more.

Some participants experienced service envy, wanting the exact same service that their friend, neighbour etc. received. Repetition of the project's aims and the rationale behind the recommended service was, in the majority of cases, sufficient to satisfy these queries. There were a number of services on offer that needed to be technically feasible. For example there were many residents who wanted roof paint, but owing to the existing insulation in their roof (bulk insulation) this treatment would had limited impact.

There were a few participants who wanted more than one service and expressed feeling that they deserved or were entitled to more. This may have arisen because the process of identifying the pros and cons of dwellings during the assessment created knowledge. Some participants stated that they wanted to move into a better home, or knew what they'd look for if and when they moved, so that they could be more comfortable.

Some households were not afraid to ask for more. Contractors were often pressured to do more that their work order or make changes to the work order. The role of the Works Coordinator was pivotal in these cases, both in ensuring accountability from the contractors and in managing and reiterating the premise of the project and their particular report. There were times when the assessing Project Officer, or the social welfare agency in some cases, was recalled to provide support for the Work Coordinator on managing participants' expectations.

Overall, the findings of the project highlight the need to support ongoing education programs and housing services to achieve comfortable, affordable, and energy efficient homes.

Table 33 Delivery timeframe

	Project plan estimates	Operational timeframes
Home energy visit	A home energy assessment will take approximately one hour to complete in the home	On average the length of a home energy assessment was 1.3 hours.
Assessment	Household recruitment, reminder phone calls, post-assessment presentation of recommendations, follow up visits etc. will mean each assessment takes several hours or even several days.	This was proved correct, on average the entire length of time dedicated to all these aspects was three days.
Support	Behavioural advice and simple energy saving products will be given at the time of the assessment.	Each participant received a starter pack with reminders, an appliance based energy monitor, COOLmob's guides to sustainable tropical living and simple fact sheets detailing the running cost of household appliances.
Follow up	Follow-up liaison regarding appliance upgrades and investigating larger-scale retrofit and hardware installation will take place as soon after the assessment as possible between two to four weeks.	This was proved correct, on average participants received their report and/or were contacted by the Technical Works Coordinator within two weeks. During the peak delivery phase, this average was harder to maintain.
Services	Installation of larger-scale products by tradespeople to take place over three to six months.	Structural modifications were delivered on average between one to four months.
Evaluation	Behavioural changes and billing data will be evaluated at three, six and twelve month intervals to determine differences in behaviour in different seasons, i.e. the wet and the dry when householders' energy consumption patterns vary.	This was very difficult to do, partly owing to project's database limitations, retail data provision arrangements and resourcing. Accessing billing data and then analysing it is time consuming.
Assessment target	A total of 480 assessments to commence May 2014 and conclude December 2015.	A total of 476 assessments were delivered. Since December the team has received 17 requests for assessments.

5.10 Overcoming barriers

5.10.1 Vulnerability

Smart Cooling in the Tropics worked to better equip vulnerable residents with knowledge to manage energy and finances and to provide other benefits, particularly thermal comfort that otherwise would be unavailable.

The three identified barriers of cost, knowledge and motivation were all addressed through the delivery of trial measures (complimentary services and education).

The Smart Cooling trial worked with households in the community who are most affected by changes in energy pricing. At the commencement of the trial, electricity prices in the Northern Territory had recently increased by 20%. This was a significant increase and combined with other cost of living increases, such as rent, was causing financial distress. Power and Water, at that time the state energy retailer, reported a spike in hardship for customers as residents struggled to pay their electricity bills. Over the course of the project, residents across the Top End experienced five rate changes in electricity tariffs.

In 2013 NT households had the highest expenditure on electricity in the country (NTCOSS, 2013). The trial design was informed by the overwhelming need to help support low income earners adjust to the power price changes. The project found that for many participants, although energy and comfort were important, it wasn't their greatest priority when considering other areas of cost and health. But the tools, information, and services helped 82% of participants who reported an improvement in their thermal comfort and 83% of respondents reported feeling in control of their electricity use. The delivery approach removed or reduced barriers to improving comfort, or managing energy consumption and had the added benefit of generating additional benefits such as improved sleep, reduced heat stress, and increased financial control (87%).

Health constraints and mobility issues were identified as motivation barriers by 9.4% of participants. Based on Project Officer's feedback maintenance of dwelling characteristics, in particular ceiling fans, louvres, flyscreens and air conditioners were not possible for many of the participants owing to health and mobility barriers. The health concerns of participants were clearly the highest priority. Advice for people in this group was to reduce electricity consumption as much as possible without interfering with the participants' health or sought opportunities to overcome a mobility barrier, for example shade sails instead of roll down blinds, or flyscreen cleaning service.

The success of the Smart Cooling project was demonstrated by the small number of barriers left to overcome. The educational aspect of the project probably helped participants identify what barriers remained as well. The barriers that did remain should be investigated further to see if higher energy productivity is achievable.

Cost, knowledge and motivation barriers were assumed at the beginning of the project. It was not until after participants had received their services that they were actually queried by Project Officers as to what they perceived to be the barriers. The trial identified cost and knowledge as the barriers preventing the target group from improving energy productivity. All barriers were addressed through the delivery model. The project established a successful delivery model that supported participants through the project process to establish knowledge and provide beneficial and appropriate feedback. In conjunction with education, the provision of fully funded services overcame the financial barriers.

5.10.2 Information barriers

The information/knowledge barriers identified related to:

- **financial literacy** (e.g. understanding electricity bills, reading meters, understanding kWh);
- **technical literacy** (e.g. how to adjust air-conditioner settings, building and garden design and how it affects thermal performance and comfort);
- **language literacy** (e.g. accessing available information where English is a second language);
- **cultural barriers** (i.e. Indigenous people, recent migrants)
- **access to information** (e.g. lack of internet access, or difficulty accessing accurate

information relating to energy consumption i.e. misinformation in the community).

Financial literacy was addressed by focusing time at the first home visit on identifying and familiarising participants with the tools to measure their energy consumption: electricity bills and energy meters. The metrics (kWh) was stressed in the tailored report to reinforce the behaviour of utilising these tools. This approach was successful with:

- 38.6% (N 83) reporting a better understanding of electricity bills
- 83% (N 89)of respondents reported feeling in control of electricity use
- 87% (N 89) reported feeling in charge of how their money is used.

The tailored report was widely read with 87.5% of participants stating they read their report. Furthermore this tool led to change: nearly 80% reported changing a habit based on the report advice.

The delivery model was modified for the urban Indigenous participants living in Yilli Rreung properties where electricity was prepaid. Specific access to information barriers for Yilli residents included:

- Restricted (physical) access to meter box and
- Restricted knowledge of how to check credit on prepaid meter box
- Yilli residents do not receive mail, have limited access to internet and intermittent phone access so all communication had to be completed in person. Booking assessments was difficult so Project Officers instead visited communities on a regular day each week to engage with participants.

This required a nimble delivery system for the project activities.

The trial managed these communication challenges by spending a day a fortnight at each community. Project Officers went prepared with everything for recruitment, data collection (Survey 1 and 2 and 3), workshops, consent forms, and reports for any assessments already complete.

Technical literacy for all participants was addressed at the assessment by identifying the dwelling characteristics and appliances associated with comfort and energy consumption. Assessors spent time at the assessment demonstrating how to use the AC remote control, particularly how to set the timer or sleep mode. The information pack provided at the assessment had easy to read information about the running cost of household appliances. For some there was an information and knowledge gap between the turning on of a switch, the use of power, and corresponding use of money. The single appliance energy monitor was useful for demonstrating this connection between behaviour, energy use, and energy cost.

Interpretive services and the support of the social welfare agencies ensured that language was not a barrier at the home energy assessment. Provision of the report and supporting information in language was cost prohibitive. Largely this was due to the uncertainty of which language groups were likely and eligible to participate.

The most recently arrived refugee groups were Congolese. The Congolese refugees were more likely to be living in Territory housing leased to the social service providers like Melaleuca Refugee Centre, Anglicare etc, excluding them from the project. Other refugee groups were not well represented among participants. This was a direct result of national policies at that time regarding refugee arrivals. Melaleuca Refugee Centre's funding was reduced, cutting jobs and adding strain to the organisations recruitment commitments.

Cultural groups who were more settled, and more likely to be in privately owned or rented accommodation (e.g. Nepalise, Somali, Sri Lankan, Liberian, Hazar, Persian and Rohingyan), were no longer in contact with the affiliated social welfare associations so the project's communication pathway to these groups was limited. This is reflected in the numbers of people who came through t he project's referral channels, only 8.2% of all participants were recently arrived.

Cultural barriers were identified as the project

> ‘It was good that we could **implement the complimentary recommendations** for the participants’
>
> Smart Cooling Project Officer

was commencing. Refugee affiliated social welfare agencies provided the biggest advantage by brokering relationships with the early adopters or easier to reach cultures. The association with the housing provider for urban Indigenous groups was not always an advantage. Residents at Bagot Community for example associated Yilli housing officers with formal and complex relationships regarding services and tenancy arrangements. This did not establish trust with residents there. Other methods used to overcome cultural difficulties, particularly with the Indigenous participants, included sending a male and female Project Officer. Using plain English, easy to read and understand illustrations and suitable colours were also factored into the development of the education materials.

5.10.3 Financial barriers

The cost of making structural changes and/or appliance upgrades in order to reduce energy use was often prohibitive.

Although the project addressed or removed many of the identified barriers, cost for appliance upgrades or structural modification continues to be a barrier for 36.5% of participants.

Clearly the interaction with Project Officers could have affected participants' answers, e.g. they may have recognised barriers they did not realise before. It was an oversight to not collect this information upfront but many of the identified barriers after services were similar to those assumed in the project design.

Because the participants were on a low income, it was expected that financial barriers prevented participants from making energy productive changes to their homes. A quarter of participants (N = 96) identified the cost of a structural retrofit as an impediment to further reducing electricity cost even after receiving their service. Smart Cooling did help to somewhat overcome this barrier for many residents by supplying them with retrofits free of charge. The cost of structural retrofits was the most expensive of the services provided in this project. The security screen service in particular addressed the issue of covering the cost of the retrofit while also tackling the barrier of security as identified by some participants. However, with such a high percentage still identifying retrofits costs as a barrier, this is an area where more work should still be done.

An additional 12% of participants stated that the cost of energy efficient appliances prevented them from their purchase. Smart Cooling was aimed at low income households, so it was not surprising that high upfront costs were a factor for many participants in becoming more energy productive. Lower income households can least afford to spend their money on more costly energy saving devices like solar panels or energy efficient washing machines or fridges, which all require significant financial outlays. Replacing appliances was not within the scope of the trial. Costs associated with maintaining and repairing dwelling characteristics or appliances was another barrier with 25% of respondents reported cost as a barrier to maintaining and upgrading the dwelling.

Many participants did not have the available disposable income to make repairs that would enhance the passive cooling features of the dwelling.

Many participants still indicated that thermal comfort was a barrier to a further lowering of their electricity consumption. Based on the rated importance of comfort, further energy reductions should not be sought, nor would they likely be successful, without keeping comfort levels at least steady.

5.10.4 Motivation

The majority of participants appeared motivated to reduce their energy consumption.

A comparison of baseline attitudes and post-trial attitudes to saving energy reveals that participants continue to be motivated to reduce energy consumption. Although based in the data the education provided has enabled participants to have stronger knowledge of how to save energy. Motivation to join the project was nearly always related to achieving cost savings or avoiding large energy bills. Interest in reducing energy consumption invariably aligned with the seasons, which unfortunately did not align with the project's recruitment target schedule. As noted earlier this required communications to rely on the memory of the build-up and wet seasons.

For some participants with difficult personal circumstances motivation was influenced by personal factors. Data was collected to measure changes in participants' behaviours and attitudes to help determine energy efficient actions in a home.

These results told us that participants were already doing everything they could to manage their energy and comfort. Positive reinforcement through the energy report was valuable and motivated participants with 80% changing a habit based on the advice received in their energy report.

5.10.5 Physical barriers

9.4% of participants identified health, disability (physical or mental), age, and mobility constraints as key barriers to improved energy efficiency.

Physical issues were other barriers for some participants. These participants had higher needs and is likely the reason why homes with carers had the highest electricity consumption of all cohorts. Clearly health concerns are paramount, so recommendations needed to address these concerns and provide alternate solutions. Because of these needs, these particular participants would likely always have a higher energy demand.

Examples cited by Project Officers include:

- leaving the door open for wheelchair access even when the air-conditioner is on;
- running the air-conditioner constantly to keep a disabled child calm;
- closing windows and doors to keep smoke and dust out (asthma sufferer);
- people recovering from cancer treatment who have difficulty regulating their body temperature needing to keep cool;
- elderly people or people with mobility constraints being unable to reach or access fans, fly screens, and

5.10.6 Environmental barriers

9.4% of participants could not open up windows and doors to improve air-flow due to privacy and/or security concerns.

- Project Officers observed that privacy was a particular concern for some Indigenous households where space was shared by many people.
- Security was often a concern for elderly people and prevented them from opening up the home to cooling breezes. Many also kept lights on at night for security reasons.
- Noisy neighbours were also cited as a reason for keeping doors and windows closed. As this was outside the scope of the project's objectives there was very little that the project could do to address this concern. However it was an important observation in understanding the different types of barriers to utilising passive cooling.

5.11 Project administration, operation and process

5.11.1 Resourcing

The trial was managed internally by the Environment Centre's COOLmob program.

air-conditioners to clean them.

Signing of the funding agreement was delayed due to the caretaker period and change in Government. The project operated over a compressed timeframe from 3.5 years to 2.5years. The project was delivered between 2014 and 2016. No changes were made to the Milestone deliverables or the budget. All Milestone deliverables were met within the reduced timeframe and according to budget.

A Project Manager was appointed to manage a team of five (5) Project Officers and one (1) Administrative Support Officer. A Technical Works Coordinator was engaged mid-project to supervise the contractors and the delivery of the project's services, in particular the structural modifications and the appliance upgrades. This position was not planned but a necessary addition as the project moved towards peak delivery. A Recruitment Coordinator, Promotions Officer, additional assessment officers and an advertising budget were appointed into the project team as the recruitment strategy changed.

The Environment Centre NT provided general administration services (in the form of office and finance management) and in-kind support.

5.11.2 Data collection, collation and integrity

Data collection was a significant investment for the trial. A team of FTE 7.4 Project Officers and a full time Administration role were required for the necessary data to be collected and entered. The trial collected a rich and unique data set and paid particular attention to data integrity. This was done to ensure that robust evidence was developed. Although the compressed timeframes have meant that complete analysis of all the available data has not been possible

Data quality issues were not a significant concern, however format of data collected was a barrier in making a full and timely analysis of the data collected. This is particularly true for the data collected to establish thermal comfort parameters notably from the thermal cameras and the anemometers.

Survey 2, delivered at the first home assessment, collected qualitative and quantitative thermal comfort data. The evaluation phase did collect a very rich qualitative data set that clearly outlines the improvements to thermal comfort experienced as a result of participation in the project. Due to time constraints this data could not be fully analysed for this report.

Housing orientation data was also problematic to include in the analysis as it was collected as a drawing at the home energy assessment and not easily transferable into the audit files.

A conclusive and seasonal comparison for all project participants was not possible. A comprehensive baseline evidence base was developed to make a conclusive comparison that accounts for seasonal variations and another 12-18 months is needed to collected sufficient energy and comfort data.

5.11.3 Consortia model

The consortium held specific delivery responsibilities. Charles Darwin University as the research partner held responsibility for data management and evaluation. The remaining four social welfare agencies were responsible for recruitment, promotion, and support for their members. All consortium members participated in a steering committee and provided additional services in-kind.

The delivery model relied on formal cooperation between the grant recipient and external organisations and businesses for specific services. This approach was largely effective when engaging commercial stakeholders, but significantly less effective when working with non-commercial stakeholders.

Commercial stakeholders were engaged to deliver their core business. Their role was clear and their delivery, administrative, and management costs were covered effectively. Non-profit stakeholders were not engaged based on their core business, but on who they provided core business for. Their role was to be the trusted broker. The resourcing for these stakeholders did not sufficiently cover the true costs of their role in the trial. Allocating in-kind resources to critical delivery elements, such as report writing, governance, planning, and strategy were not covered by the financial remuneration. This created a serious impediment for consortium members, undermining their involvement despite their genuine interest and support for the project's aims and benefits. For the social welfare agencies provision of these services in-kind added significant strain to their own limited resources.

The limitations of the partner organisations to deliver recruitment exclusively through their client base became clearer as project recruitment numbers hit a stalemate during the pilot project and continued into the delivery phase. A review of eligibility and a proposal to reorient the recruitment approach was approved by the Department and the Consortium. This change of strategy modified the role of the delivery partners and the project team. Over half of all participants (57%) recruited were not affiliated with the social welfare agencies. Eligible non-affiliated participants began registering for the project in February 2015. This coincided directly with the third revision of the eligibility criteria and the first newspaper advertisement to test the pathway's viability.

This reorientation of the recruitment altered the role of the delivery partners in the trial. In some instances their engagement in the project progress decreased due to the limited benefit to their clients. Despite this all, and recognising the limitations for recruitment were not through lack of activity, the delivery partners remained committed and involved in the project working to promote the project through their existing channels, but without expectation of referrals.

Centralising all operational elements to the project team did improve the trial outcomes. It behaved as a small business but did not have this architecture, some core systems especially financial and communications were not fit for purpose and led to some operating inefficiencies. However, it improved the efficiency of the engagement approach and the participant experience was clearer.

5.11.4 Project Budget

Table 34 provides a summary of the project budget including LIEEP funding and other documented contributions (in-kind).

Table 34 Project Budget

Expenditure Item	Project budget	Project expenditure	Difference	Other contributions (in-kind)	Other expenditure	Difference
Staff	**$1,140,083.00**	$1,130,295.48	$9,787.52	**$112,320.00**	$209,355.18	-$97,035.18
Consultants	**$179,520.00**	$132,654.85	$46,865.15		$0.00	$0.00
Equipment	**$11,650.00**	$47,023.29	-$35,373.29		$0.00	$0.00
Training, travel, conferences	**$30,000.00**	$31,180.45	-$1,180.45		$3,000.00	-$3,000.00
Education, measuring devices and behaviour change tools	**$68,000.00**	$17,016.42	$50,983.58		$0.00	$0.00
Travel to urban households, venue hire, catering	**$95,120.00**	$44,412.84	$50,707.16	**$6,000.00**	$12,070.00	-$6,070.00
Project administration	**$356,360.00**	$397,993.42	-$41,633.42		$14,735.00	-$14,735.00
Communications	**$34,000.00**	$62,112.61	-$28,112.61		$0.00	$0.00
Evaluation	**$345,447.00**	$345,447.00	$0.00	**$269,464.00**	$148,623.82	$120,840.18
Energy efficiency hardware/appliances	**$470,000.00**	$522,043.64	-$52,043.64		$0.00	$0.00
Total	**$2,730,180.00**	$2,730,180.00	$0.00	**$387,784.00**	$387,784.00	$0.00

5.11.5 Budget discussion

The project was achieved within budget. The final operating budget was congruent with the approved budget. Changes were made to the budget to reflect changes in the trial model. Recruitment barriers and delays reoriented funds to support a change in operational activity. Specifically for Smart Cooling in the Tropics this entailed allocation of funds to support a change in recruitment approach (advertising).

Advertising was an unexpected cost. A rapid recruitment approach required an investment in community wide media channels. A total of $40,000 was allocated to support the recruitment campaign. This approach was successful.

GST was not consistently accounted for and/or applied correctly; this led to reporting challenges in the later stages of the project. Financial maturity developed as a result of the project – handling interest and GST were growing pains for the Centre.

The nature of the trial did create some budgetary issues. Large milestone payments up front of the project accrued interest. Interest earned during the course of the project, although not a cost, it was an unexpected income stream and one that needed to be identified and managed in order for it to be returned on completion of the project.

In-kind contributions were problematic from a reporting point of view, but also ineffective. The full remuneration paid to co-contributors for their services would have acknowledged and compensated the actual level of service required of the trial approach. The burden of in-kind on under-resourced social welfare agencies undermined their expertise and limited their engagement with the aim of the project.

Tracking and management of in-kind contributions was very difficult. These agencies did not get sufficient remuneration to report effectively.

The timing of the Milestone report was particularly at odds with organisational reporting periods. A Milestone aligned with financial year reporting periods would have made the acquittal of funds and co-contributions far easier.

The Environment Centre NT made in-kind contributions of $43, 200 over three financial years for Staff Management, Governance and Risk, internal team meetings, and some travel.

5.11.6 Value for money

The timeframe for evaluation of energy benefits is too limited to make a full assessment of the trial's value for money. Certainly the project trialled important and climate appropriate retrofitting responses, however the full benefits require longitudinal evaluation.

The cost-effectiveness analysis represents a first step in identifying and quantifying the effectiveness of the services delivered. It indicates that the services delivered were effective when using the measures of improved comfort, reduced heat stress, and improved sleep.

The cost benefit analysis alone does not demonstrate a strong value proposition. But when combined with the demonstrated non-energy benefits the overall picture is one of significant value to the future research for health, housing and climate adaptation planning in Northern Australia.

The cost-benefit and cost-effectiveness analyses provide useful information about the costs of delivering a project of this type and the individual services within the project. As the main aim of this project was to maximise energy productivity rather than further reduce energy use of an already low energy using demographic, it is not surprising that the cost-benefit analysis resulted in costs exceeding the monetised benefits.

5.11.7 Lessons learnt

- Review and fine tune contractual obligations early i.e. reset Milestone timelines and deliverables with the Department early.
- Research and logic test the operating parameters early i.e. eligibility match to local context.
- Do not run other contributions/in-kind contributions. This is confusing for reporting and is not a fair reflection of the resource requirements to deliver large projects.
- Commit adequate resources for governance and developing strategic relationships.
- Secure endorsements from other strategic stakeholders particularly Power and Water, Jacana and NT Government for facilitation through its relevant agencies e.g. Department of Health, Centrelink.

5.12 Project Benefits

5.12.1 Participant benefits

Participants experienced a broad range of benefits from their involvement in the project including improved education, energy productivity, thermal comfort, and energy literacy.

5.12.1.1 Education benefits

Improved energy literacy is a major achievement of the project and makes a significant contribution to LIEEP program objectives.

Education itself was seen as a highly valued outcome and was the second highest ranked benefit after thermal comfort.

One of the more interesting findings was that having a better understanding of electricity was the second highest chosen benefit and second highest in rankings. Education itself was seen as a highly valued outcome. With a better understanding of consumption, energy productivity advice may be more readily acted upon. More than 80% (N=98) of participants also said that they felt more in control of their electricity use since joining this project. This suggests information packets and energy assessments were fruitful and may give evidence that an information campaign in the future would be favourable. This is supported by data collected in ***Survey 3 which reveals the high extent to which education provided was consumed, with more than 87% of participants claiming to have read at least some of the information provided (N= 64).***

The personal Energy Report was effective at changing participants' habits in regards to electricity use. 80% of participants said they changed some of their habits based on recommendations in the report (N=136).

The survey results indicate that energy literacy is an important first step in improving energy productivity among the residential sector of low income households. Even within a low-use group, information and education increased their range of responses to energy management. Without understanding power bills and how they relate to the energy consumed, it was difficult for participants to know what they could do to reduce their bills. By having this knowledge, they were then able to take the recommendations to improve their comfort and understand what potential effects those actions would have on their energy use.

Mechanical fans are found in almost every home in Darwin and are used frequently for their cooling effect on people. Many participants did not know that fans do not cool down rooms, and it was often found that fans were always left on. At the end of the project, participants were aware that fans should be turned on to cool down people, and only when rooms are occupied. By understanding that making small changes to personal habits can have a measurable effect on an energy bill, participants were likely to change their habits. The habits that were easiest to action and that had little effect on lifestyle or thermal comfort had the highest amount of uptake.

Through the education component of the project, participants gained a better understanding of electricity use and bills and, as a result, reported feeling more in control of their electricity use. The project also contributed to behaviour change by providing knowledge about what makes a difference to energy consumption and cooling. With a better understanding of energy productivity, advice was more readily acted upon. As such, education can be seen as a valuable tool for improving energy productivity through behaviour change. Nearly 80% of participants said they changed some of their habits based on recommendations in the report. These changes were estimated to save 80 kWh per year.

The education approach of the Smart Cooling project involved deep engagement with participants through the one-on-one home energy assessment and the provision of a personalised energy assessment report. The deep engagement approach was a cornerstone in improving energy productivity, thermal comfort for participants, and providing quality data for the project's research.

5.12.1.2 Energy benefits

Energy productivity was achieved and is expected to continue.

Data was sought from the electricity retailer from 1 January 2013 until 1 January 2016, as that was the date range specified on the participant consent form. In all, consumption data was available for 394 out of the 476 participants enrolled in the project. However, very few participants had continuous data over the requested date range. Not all reasons are known for missing data, but some of the known reasons were participants moving into and out of dwellings, numerous estimated readings as explained earlier, and the participant not always being the same person whose name the electricity retailer had as owner of the account.

The proportion of energy use decreased (on average by an estimated 1-10%) and other benefits such as comfort and energy literacy increased. The total estimated energy savings over the lifetime of the services combined is nearly 21 MWh, which equates to about $4,000. Individual services will have a higher or lower saving.

The estimated energy savings would also result in 16 tonnes of CO_2 equivalent avoided emissions.

Smart Cooling initially aimed to reduce participants' household energy use by 10-30%. However, the households ultimately recruited turned out to be already using significantly less energy than the general population (on average 15% less).Given the already low energy consumption amongst participants, encouraging behaviour change which would cause additional large reductions in energy consumption could have had the undesirable result of householder comfort being compromised.

The majority of participants were retirees and carers who spent much of their time at home and this, coupled with their age or infirmity, meant that maintaining thermal comfort was important to their health and wellbeing. As the ultimate aim of the project was to maximise energy productivity not further reduce energy consumption by an already low energy using demographic, it can be considered a success.

Further, it is anticipated that the project will continue to produce benefits over the lifecycles of the structural modifications and appliance upgrades while they remain in place and operational.

5.12.2 Non-energy benefits

In addition to achieving overall energy savings, participants reported a range of non-energy benefits which increased as a result of their involvement in the project, such as comfort and greater sense of environmental responsibility.

5.12.2.1 Thermal comfort improvement

Participants valued their comfort more than any other benefit produced by Smart Cooling and they also indicated this was the area of greatest improvement. Increased comfort was also reported in survey 2, where

56% of participants claimed an increase in comfort while less than 4% found themselves to be more uncomfortable (N = 144). The difference in the answers between the surveys is largely due to the variation in individual participants. Participants who responded to Survey 4 only made up 42% of those who responded to Survey 2; those who completed both surveys largely answered in a similar way.

The results of the participant surveys, conducted before and after the services were provided, show that participant comfort improved as a result of the project, and that participants valued the improvement in their comfort more than any other benefit. The importance attached to improved comfort is not surprising, given that participants are living in a climate which sits outside the thermal comfort zone for most of the year. These findings are particularly significant because the majority of participants were elderly and there were also a significant number of participants who either had a health condition themselves or were caring for someone with a health condition or disability.

The elderly are at higher risk than the general population to temperature-related health issues. Studies have found that ageing is associated with a reduction in the ability of the body to regulate temperature, including a reduced ability to sweat (Kenney, 1987). Diagnosed, pre-existing health conditions and disability also increase people's sensitivity to extreme heat (Hatvani-Kovacs 2015).

Recent research has also shown that socially isolated residents are exposed to higher risk of heat related illness and this includes people living alone and those who have immigrated recently (Loughnan 2016).

One cohort that stood out among the sample was refugees. When asked on Survey 1 about their comfort, the average ranking by refugees was 3.0 (N = 40), while the average for the entire sample population was 3.7.

In addition to the participant comfort surveys, the project collected quantitative comfort data in the form of thermal imaging camera readings from participant households before and, in some cases, after the services were provided. However, due to time constraints, this data has not been analysed other than in the context of the case studies presented in this report. It is anticipated that this data could provide insights into the thermal performance of the existing housing stock and particular housing types in the Greater Darwin region.

However, the survey data that was analysed in respect of participant thermal comfort indicated that attitudes to comfort changed as a result of the project. For example, participants were less inclined to consider that improving energy efficiency would mean that they would be less comfortable in their home (Results Chapter, Figure 17).

Closely associated with improved thermal comfort were reported improvements in health and wellbeing, reductions in heat stress, and improvements in sleep (63% of surveyed participants).

5.12.2.2 Other benefits

Other benefits reported by participants in the project included:

- increased property values
- improved home aesthetics
- greater sense of environmental responsibility
- greater connection to community
- greater knowledge of services available/ community organisations in Darwin
- customer satisfaction

Many participants surveyed considered the non-energy benefits they derived from participating in the project to be equal to, if not more valuable than, the energy cost savings.

Participants who received structural modifications to their home (e.g. shade sail, reflective roof paint) or significant appliance upgrades (e.g. ceiling fans, security screens) benefited from an increase in the value of their home. Some services altered or improved the appearance of the home. This included long-term improvements resulting from structural modifications and appliance upgrades as well as short-term improvements to the aesthetics of the dwelling e.g. clean flyscreens/fans.

A significant benefit for participants who received a shade sail was an increase in the amenity of the dwelling. In some cases it provided an additional living space for participants and had the added advantage of allowing participants to enjoy the wellbeing benefits associated with spending time outdoors, away from hot homes.

By creating opportunities for social connectedness, the project has also built valuable social capital in the communities involved. The results of the recruitment campaign indicate that a large proportion of participants were recruited through word of mouth. This highlights the extent to which the project created or reinforced existing social networks in the community and promoted dialogue around energy efficiency and cooling. The project provided some participants with greater knowledge of services available and community organisations in Darwin. For example, some participants did not know they could receive a carers discount for energy bills for a child in their care.

5.12.2.3 Customer satisfaction

Customer satisfaction was very high among project participants. This can be regarded as a significant outcome for the Environment Centre. Future project rollout will be far more effective because of the reputation and credibility developed through Smart Cooling in the Tropics.

5.13 Service benefits

5.13.1 Cost effectiveness of services

An assessment of the cost effectiveness of the identified measurable benefits has some clear and encouraging results. The subjective benefits such as reduced heat stress and thermal comfort reveal the broad benefits of the services delivered through Smart Cooling in the Tropics.

5.13.1.1 Improving thermal comfort

At the project scale, the home cleaning service and the security screen upgrade were the most cost effective services for improved thermal comfort. This is an important result. The objective of these services was to improve the function of low, or no, cost tools for airflow. The use of cross ventilation was often compromised for households because doors and windows could not be safely kept open. Installing locks or security screens for doors gave many residents the confidence to keep doors and windows open, allowing cooling breezes to provide comfort and in many cases displacing the use of air conditioning. In a similar manner, ceiling fans and pedestal fans generally offer an affordable option for cooling and comfort. In the tropics, ceiling fans can rust, especially when they are not maintained. The home cleaning service focused on cleaning the fans and windows to encourage participants to use these as tools for thermal comfort.

Interestingly analysis reveals that these same services were also important for improving the quality of sleep for participants.

5.13.1.2 Reducing heat stress

Using Level 1 the ceiling fan upgrade had the largest impact on reducing heat stress. This result indicates that air flow plays an important role in thermal comfort. Roof paint also rated very well using this methodology. The trial replaced or upgraded many ceiling fans as this was often a barrier for participants using these for cooling. Ceiling fans cost far less to operate than air conditioning so it is considered that maintaining and protecting these features will encourage their use and displace the use of air conditioning for air flow, at least for some of the year!

Roof paint was not as cost effective as the ceiling fan upgrade, but as it has a longer useful life (10 years) it could be considered a very cost effective service for reducing heat stress. Roof paint was very effective at reducing the internal temperature of households. Interval meter data revealed up to a 12 degree Celsius reduction in temperature in one home. Unfortunately due to time constraints further analysis of the interval meter data was not available.

5.13.1.3 Education and energy savings

The cost effectiveness analysis (CEA) demonstrates the important role education plays in households making energy savings. The results in Table 26 reveal that the home energy assessment, the standby saver pack and the thermostat control measures all had a positive effect on energy savings. This highlights other results, both qualitative and quantitative that ongoing education and support for households will lead to energy savings. This has important implications for energy market reform and demand management programs that may result.

5.13.2 Cost benefit

The cost benefit analysis (CBA) does not reveal a strong value proposition for the services delivered. The limitations of available energy use data prevented a determination of savings using the prescribed CBA methodology.

Cost was one of the primary barriers addressed by the project. This barrier was removed for the participating low income households with a direct benefit at the participant level. Although this is not measurable at scale using the CBA methodology, it is important to recognise that there was a cost benefit for the participant. The have received a complimentary service and education and as a direct result they have improved comfort and in many cases improved energy use. The reduction in costs associated with energy were not measurable at the time this report was published.

Using the prescribed CBA methodology, there was some indication of energy savings at the project scale though not a complete picture. The savings that were seen did not appear to be large. This was expected as the services and education were focused on thermal comfort improvement not energy reduction. The savings made at the individual scale appear to be far clearer. The four cases studies selected for this report demonstrate the scale of energy savings that were achieved and which could be measured and validated with another 12-18 months of data collection and analysis.

5.13.3 Local community benefits

5.13.3.1 Energy efficiency businesses' benefits

The project supported local businesses, including local business engagement and provided employment opportunities for local workers. The project directly utilised the services of 14 local businesses who carried out the structural modifications and/or appliance upgrades. In addition, several local suppliers provided materials to those businesses.

A total of $492,775 was paid to local businesses providing energy efficiency services through the project. This represents a significant investment in the local economy.

For some contractors the project 'filled gaps' in their existing workload whereas for others it represented a significant amount of their work during the term of the project. Contractors benefitted from the information and knowledge provided by COOLmob technical specialists and assessors regarding the energy efficiency aspects of services. The local energy efficiency industry stands to gain, too, from the findings of the project, which provide evidence to support the use of their technologies and services. One contractor even improved the administrative processes as a result of the involvement in the project (i.e. invoicing processes and information provided to customers (certificate of works)).

As well as the direct financial benefit to ocal industry, contractors and local industry more broadly gained other benefits from the project such as from households spending energy savings dollars in the community (Lazar2013). In addition, some contractors anticipated that they would benefit from the evidence base generated by the project, which could be used for marketing and promotional purposes (to support their advice and recommendations regarding energy efficiency products and services).

5.13.3.2 Consortium partner benefits

The change in role of the social welfare agencies responsible for recruitment has been well documented already in this report. Their early involvement was fundamental to any later success for the project. Their role as trusted broker gained the project credibility, and they supported the project team in designing appropriate systems for delivery. Even as the confidence and capability of the trial and the project team grew, the relationships provided an invaluable reference point.

Deeper involvement of the social welfare agencies may have been problematic owing to external factors including national policy shifts, funding cuts, and the subsequent resources constraints. The project was not large enough or aligned enough with the core business to be truly effective.
The project has collected a significant amount of data to inform future research directions by the project's research partners (i.e. CDU, CSIRO). The publication of the results of the project will also be of value to the broader research and academic communities.

Delivery partners were provided with training sessions and educational materials relating to energy efficiency (information booklets, templates for case studies, and website information) so that they could provide this information to their clients. This has contributed to their capacity, skills, knowledge, and awareness in respect of energy efficiency and cooling practices in the tropics.

This is an important outcome of the project, aligning with the overarching LIEEP program objectives to increase capacity, skills and knowledge of the energy services sector.

5.13.3.3 Broader community benefits

The broader community or societal benefits of the project include reduced greenhouse gas emissions as a result of reductions in energy consumption. The cost effectiveness analysis demonstrates 16 tonnes CO2 equivalent were reduced as a result of the project.

Other potential benefits not accounted for under this project but recognised in other household energy efficiency studies include increased employee productivity (Lazar 2013). For example, a recent study of the impacts of heat stress on employee productivity throughout Australia found that it costs the economy $6.9 billion per year equating to the annual costs of approximately AUD$728 per person (Zander, 2015). While many of the participants involved in the Smart Cooling project were not engaged in paid work, some were carers or engaged in non-paid work. It could be inferred that these participants' productivity might have improved as a r esult of a reduction in heat stress.

Further, a reduction in heat stress or improvement in thermal comfort is likely to result in a reduction in costs to the public healthcare system and other social costs associated with poor physical or mental health. Currently, an estimated two people aged over 65 years die each year from heat-related deaths in Darwin (1997-1999 average). This could potentially rise to between 37 and 126 each year by 2050 because of climate change (DoE website 2015 http://www.environment.gov.au/climate-change/climate-science/impacts/nt). An analysis of the public health and welfare benefits of the project was beyond its scope.

Another area for future research might involve measuring the benefits derived by utility companies from project activities such as these. Benefits to utilities and ratepayers are generally due to operation and maintenance cost savings; reductions in disconnections due to late or non-payment of electricity bills as well as reductions in energy requirements and avoidance of production, transmission, and distribution capacity investments (Lazar 2013). An analysis of these benefits, however, was beyond the scope of this project.

6.0 Conclusion

“Smart Cooling has kept me more comfortable and given me ideas on how to improve my home to make it **even more** comfortable”

Project participant, 2015

Smart Cooling in the Tropics

Conclusion

Smart Cooling in the Tropics was a successful trial. The project reached its main goal of increasing energy productivity among low income residents of Greater Darwin. In the tropical climate of the Top End, heat and humidity are the largest contributing factors to thermal discomfort, and space cooling is a large portion of electricity consumption. Energy productivity in this sense means having participants feel comfortable in energy efficient ways. There was a significant increase in thermal comfort with an estimated reduction in electricity consumption.

Participants were already using electricity well below the average of the general Darwin population. Further reductions could have led to participants feeling less comfortable and perhaps an increase in the rate of heat related illnesses. Therefore the initial target of electricity reduction of 10-30% for participants was not reached. Following the dictum "first, do no harm," the plan to help reduce energy consumption for most of the participants was refined in favour of methods to improve comfort without an increase in electricity use. The higher users were still given advice and recommendations about reducing their consumption that would not have a negative impact on their comfort. The results from many survey questions showed that Smart Cooling participants felt more comfortable as a result of being involved in the project and reported other benefits such as less heat stress and a greater sense of environmental responsibility.

Deep engagement and tailored education were cornerstones for improving all participants' energy efficiency and comfort and combined with the provision of fully funded services were fundamental in overcoming the identified constraints; cost, knowledge, and motivation.

The trial met the overarching low income energy efficiency program objectives. Smart Cooling in the Tropics established approaches to engaging a diverse and unique group of low income households; urban Indigenous, refugees, seniors, carers and care recipients. The data collected has formed a robust baseline and will provide sound evidence for future programs and policy.

There is scope for further research. Compressed data collection timeframes have limited the scale of data available to assess changes in energy use and the cost benefit of the services provided. The results reveal that future research can build on the thermal comfort data methodologies identified and develop a deeper knowledge of health, comfort and energy use in Northern Australia.

The northern Australian climate has defined the scope and operational framework of this trial. The requirements for creating a healthy, adaptable and productive built environment are not fully realised at the policy level. The data gathered and the knowledge gained about comfortable and affordable housing for the tropics is a major outcome for the project and a lesson for the Developing the North agenda.

The knowledge and motivation gains made in the participant group resulted in many benefits. The success of the trial model is a lesson for the broader community. Small habits create change and modest home improvements and maintenance benefit both comfort and costs associated with living in the hot, humid tropics of the Top End.

The case management approach to

engagement was the ‘x factor’ – without the deep and personal interaction between Project Officers and participants, the success of Smart Cooling may not have been so high.

The administration and operation of the project encountered many obstacles that were unforeseen in the beginning. Without the ability to adapt, this project would have been unlikely to succeed. Recruitment was the largest impediment from the start. The number of participants recruited through consortium partner pathways was much smaller than anticipated. The flexibility granted by the Department to change eligibility criteria, such as raising the income level to be more in line with the local cost of living, working outside the initial focus groups, and expanding the geographical range, enabled this project to reach its recruitment target. Even with these alterations, Smart Cooling still delivered its core objective of improving the energy productivity of low income households in the Greater Darwin area.

“The importance attached to improved comfort is not suprising, given that participants are living in a climate which sits outside the thermal comfort zone for most of the year.”

Smart Cooling Project Officer

The Northern Territory does not have a well-established energy services sector. The Environment Centre's COOLmob program has been providing these services in collaboration with the Territory's energy retailer. Major reforms in the local essential services sector, including the splitting of Power and Water into separate entities have left a void in funding, policy, and strategy. With major reforms occurring at the national level and the absence of any formal consumer protection for residents in Northern Australia the role of a trusted and credible organisation will be fundamental to bridging consumers across to the changes in energy pricing, supply and technology currently underway. There is real concern that vulnerable households, such as those engaged in this trial, will be further exposed to the policy changes.

Smart Cooling in the Tropics was a large urban trial to establish successful elements for ongoing programs for energy conservation and energy productivity.

Smart Cooling identified the key elements influencing thermal comfort and energy behaviour in the tropics. Interactions between homes, people, and energy are complex and only fragments of data are available to comprehensively measure these relationships. The data gathered by the project provides a valuable evidence base for future policy and program development (including building design/code).

More time is needed to collect participant energy data to determine actual savings from the project.

The compressed timeframe for this project have meant that it was not possible to measure the impact of the measures delivered over time and throughout different seasons. Nonetheless the project established important baseline information and a successful engagement model for working with low income households.

7.0 Recommendations

"It helped that the services were brokered by a trusted community-based organisation."

Smart Cooling Project Officer

7.1 Successful elements of the trial

The Environment Centre's COOLmob program was successful in delivering the trial. COOLmob was well placed to deliver the trial and will be best placed to deliver new, innovative initiatives or programs in the future. The establishment of relationships, reputation, and credibility is a valuable asset for future roll out, and each one of these a success of the trial.

For future initiatives or programs to benefit from this success, and to ensure they are most cost effective in their delivery, it is recommended that a three year core funding for the Environment Centre's COOLmob program be established.

Engagement, education, and climate appropriate retrofit measures were successful elements of Smart Cooling in the Tropics. And, overall the findings of the project highlight the need to support ongoing education programs and housing services to support comfortable, affordable, and energy efficient homes.

These successful elements can be adopted to create new initiatives and programs that result in energy productivity, health, and financial gains. In summary:

- Deep engagement approach successfully established trust and facilitated benefits for the target group

- The focus on cooling and comfort meant that education and services were appropriate for the participants and appropriate for the unique climate of the Top End.

- The consortium model was valuable for ensuring that trust was transferred to the project team delivering the trial.

7.2 Pathways to innovation

The findings of the trial highlight the opportunities for new and innovative programs or schemes. Including:

Retrofit program for heatwave resilience – Improvements to existing housing stock for heatwave resilience is critical for mitigating health related costs associated with heatwaves. Smart Cooling has expanded the known retrofit measures that improve and maintain thermal comfort without increasing energy consumption. The project team strongly recommend that a detailed business case for a shade rebate program be established for vulnerable households.

Further research to identify the health impacts underpinning thermal comfort is also required and would be innovative. The relationship with the built environment and health is well established but currently lacks the inclusion of suitable retrofit measures for Northern Australia and behavioural opportunities that can assist with management of costs.

Urban Indigenous energy consumption study – a focused study to establish

differences between energy consumption patterns for power card users compared to non-power card users. This is innovative as energy information pathways are not well established within the urban Indigenous community. This scheme is unlikely to be cost effective to run, though. Given the experience of this, and other trials, all engagement would, by necessity, be in person.

Refugee energy consumption study– Smart Cooling was not able to effectively establish energy behaviours in the refugee community. The numbers were low and follow up was problematic as residents moved frequently and contact was lost. What we did glean was interesting and demonstrated strong peer to peer learning. This suggests that a train the trainer model, although not innovative as an approach, could be cost effective to deliver. Other LIEEP trials focused exclusively on this group and any future innovation would be best informed by this trial's evaluation and recommendation.

NT Housing engagement and improvement program –An energy productivity program for existing Territory housing residents would complement the existing NT Government investment into public housing infrastructure. Knowledge of suitable solutions to upgrade the existing housing stock for energy and comfort gains was established though Smart Cooling in the Tropics.

A collaboration with NT Housing's maintenance program would be innovative in that it would look at the 'at scale' cost reality and opportunities. Maintenance of appliances e.g. ceiling fans and features e.g.

security screens was such a strong finding that understanding the cost for mass roll out could inform a community wide maintenance program.

Appliance upgrade program for low income households –

This initiative is a good add on to the Energy Productivity plan. The trial surveys collected data on household appliances, particularly AC units. It found that many appliances are old. An appliance exchange program to replace old energy hungry appliances, in particular ACs and refrigerators for low income earners should be considered.

7.3 Policy opportunities

Planning Darwin's urban development

Design standards are fundamental to developing the urban landscape in Darwin. In particular, housing design standards and approaches need to be tailored to the climate of Darwin which is likely to become more extreme as the impacts of climate change are felt. Housing policy also needs to support the adaptive capacity of the people living in those houses by providing them with some degree of control over energy consumption and comfort in their homes.

Climate change adaptation policy

Vulnerable communities are expected to be disproportionately impacted by the effects of climate change. The data gathered in relation to the existing housing stock and the experiences of people living in those houses is vital to the development of climate change adaptation and mitigation strategies.

The National Energy Productivity Plan

Nationally, the National Energy Productivity Plan (NEPP) is stimulating energy market reform. The impact on the energy market including tariffs, services, and charges is not yet fully understood, but it will ultimately transform how we use, generate, pay, and store energy at the household level.

Energy literacy in vulnerable communities is already low, as is access to suitable service arrangements and trusted sources.
Future programs need to consider adequate and appropriate support to help consumers limit energy costs. Many jurisdictions already have in place market measures to increase the uptake of cost-effective measures -

including the New South Wales (NSW) Energy Savings Scheme (ESS), the Victorian Energy Efficiency Target (VEET) scheme, the South Australian (SA) Retailer Energy Efficiency Scheme (REES), and the Australian Capital Territory (ACT) Energy Efficiency Improvement Scheme (EEIS). A market based energy savers scheme for the Northern Territory, aligned with existing schemes to maximise market benefits across jurisdictions, should be considered.

The Territory has the opportunity to observe and take advantage of the progress other jurisdictions have made in energy market reforms and associated programs. In addition, the Northern Territory lacks targets on the usage of renewable energies and does not have a strong demand management goal to manage electrical consumption. Introduction of policies to address these shortfalls may assist in the development of new technologies that could lead to more energy efficient cooling systems and over time, a reduction in on grid power usage.

Smart Cooling project participants received upgrades that otherwise, they could not **afford.** With such a high percentage still identifying retrofits costs as a barrier, this is an area where more work should still be done.

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9.0 Appendices

Appendix A.

Sample home energy report

COOLmob smart cooling *in the tropics*

PH: 08 8981 3642

or www.coolmob.org

A's Assessment Report

Hello A,

Thank you for participating in the Smart Cooling in the Tropics project on 12th December 2014.

You have a delightful and airy home and I enjoyed our conversation about energy efficiency and the design features you have used to make your home more comfortable.

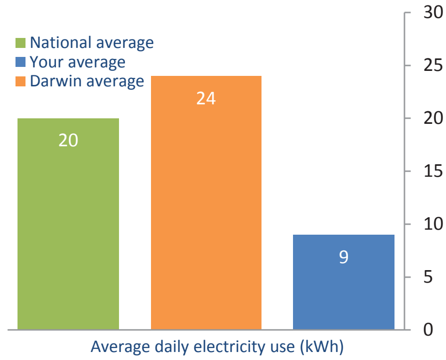
This report provides a summary of your assessment with some recommendations to help you save money on your electricity bill, stay cool, and reach your target daily electricity use we have set at 7 kWh.

Please contact us or any of the Smart Cooling in the Tropics team if you have any questions or concerns.

Maxine Atkinson
Smart Cooling in the Tropics
08 8981 3642

People in your home	Your average daily electricity use	Your target daily electricity use
1	9 kWh	7 kWh

Daily Electricity Use Comparison (daily kWh)



Google image.

Congratulations!

You are doing really well on these things

- You utilise the features of your home to their best advantage.

SWITCH OFF WHEN YOU CAN IS A *SMART COOLING* PLAN

Australian Government
Department of Industry and Science

This activity received funding from the Australian Government. It is delivered by COOLmob, a program of the Environment Centre NT, and delivered in partnership with Charles Darwin University, COTA NT, Melaleuca Refugee Centre, Yilli Housing and Carers NT. The views expressed herein are not necessarily the views of the Commonwealth of Australia, and the Commonwealth does not accept responsibility for any information or advice contained herein.

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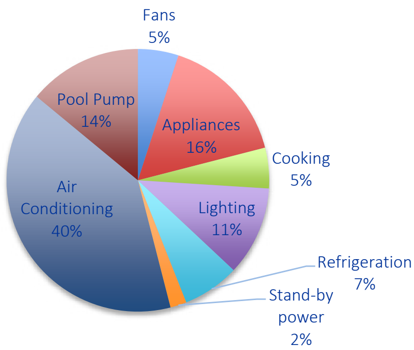
COOLmob
smart cooling
in the Tropics

PH: 08 8981 3642
or www.coolmob.org

What we found at your energy assessment

- You have extensive vegetation which provides shade and minimises heat build-up within the home.
- You have solar hot water.
- You use warm water for laundry.
- You turn off appliances at the wall.
- Appliances are well-maintained.
- You use fans in preference to air conditioning.
- Most of the lights are CFL - superb.

Average household electricity use in Darwin %



Your complimentary treatment

Smart Cooling in the Tropics will arrange for our specially selected qualified professionals to **install roof ventilation.**

This order is with our contractors who should contact you soon.

Your action plan

- Continue to open windows and doors to maximise air flow.
- If you need to use the air conditioner, set air conditioning temperatures to 27°C and use a fan to increase airflow. Every one degree increase can reduce AC power consumption by about 10%.
- Continue to monitor individual item electricity use with the Energy Monitor supplied. It is anticipated this data will provide you with information for future changes.
- Experiment with a cold wash in the laundry.

Additional comments

- **We want to hear from you!!** We have enclosed the post-assessment survey with a self-addressed return envelope and welcome your feedback.

  Thank you again A, it was a delight to meet you.
  Kind regards, Max.

Australian Government
Department of Industry and Science

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Appendix B.

Cost levels- cost benefit analysis

Cost level 1 Cost of delivering the trial approach to a participant

Concept	Amount
Evaluation	$ 34,544.70
MVR Petrol	$ 17,737.61
Retro Fit Products	$ 13,104.58
Subcontract Services	$ 472,562.36
Wages	$ 456,388.57
Subtotal	$ 994,337.82
Total without Treatment costs	**$ 521,775.46**

Cost level 2 Cost Associated with recruitment and maintaining a participant

Concept	Amount
Advertising & Promotions	$ 39,007.41
Catering & Hospitality	$ 442.51
Communication	$ 23,105.20
Consultants	$ 119,389.37
Design and Artwork	$ 8,675.67
Evaluation	$ 310,902.30
Meeting & Events Expenses	$ 3,511.86
Postage, Courier and Freight	$ 291.73
Project/Events Materials	$ 23,272.12
MVR Petrol	$ 4,434.40
Retro Fit Products	$ 13,104.58
Wages	$ 337,492.78
Subtotal	$ 883,629.92
Total	**$ 883,629.92**

Cost level 3 Cost of running an organisation

Concept	Amount
Administration Fees	$ 308,962.25
Bank Fees	$ 1,096.98
Computers & IT	$ 2,286.69
Consultants	$ 13,265.49
MVR Insurance	$ 1,560.22
MVR Repairs & Maint	$ 598.97
OH&S	$ 595.11
Other	$ 69,853.27
Printing	$ 4,431.75
Superannuation ECNT	$ 84,426.09
Wages	$ 134,270.40
Major Asset Purchase - car	$ 16,127.27
Major Asset Purchase-computer	$ 15,322.50
Office setup	$ 47,203.29
Staff Recruitment	$ 6,295.15
Staff Training	$ 10,738.25
Thermocameras	$ 3,909.00
Subtotal	$ 720,942.67
Total	**$ 720,942.67**

Cost level 4 Cost of participating in a government funded trial

Concept	Amount	In kind Amount
Travel, Accommodation & Costs	$ 13,551.94	$ 6,000.00
Evaluation		$ 269,464.00
other		$ 10,000.00
Wages	$ 117,717.64	112320
Subtotal	$ 131,269.58	$ 397,784.00
Total	**$ 131,269.58**	

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Appendix C.

Assumptions and calculations assessment savings – cost benefit analysis

1. Turn off lights when leaving the room

The count of different types of light bulbs (fluorescent tube, CFL, halogen, LED and incandescent) in each house was recorded during the assessment. Each bulb was assumed to be an incandescent 60 W equivalent. The average wattage of light bulbs of all participants was found to be 23.1 W. Estimating that this behaviour led participants to turn off three light bulbs for an extra two hours per day, and Survey 2 showed that 40% of participants did make the change, then the total average energy savings per person for this behaviour was 20 kWh/year.

2. Turn off appliance at the wall

Savings for this behaviour change were estimated assuming that participants turned off the equivalent of an entertainment system that included a television, DVD player, and sound system to eliminate standby power. If the devices were used for 5 hours/day that meant standby power would be wasted for 19 hours/day. With a 40% uptake, and assuming each device uses 1 W in standby, an average savings results for each participant of 8 kWh/year.

3. Turn off second fridge

On average, participant households had 1.5 refrigerators with an average age of 8 years. A full size fridge manufactured in 2002 consumes about 600 kWh/year (DEWHA, 2008). The second fridge was often a bar fridge or an older full size one as observed by the project officers. Actual types of fridges were not always recorded so estimates are used here. A value of 300 kWh/year was assumed to adjust for efficiency and sizes of different fridges. If the fridge was turned off for five out of seven days per week with a 9% uptake, average savings for each participant would be 13 kWh/year.

4. Create a cool zone

Savings for participants that designated a cool room would be the change in energy used to cool a smaller space. Savings for this change were calculated in assuming participants went from using a 5kW output energy AC to a 3 kW output energy unit. A COP of 3 was used and a factor of 1/3 was used to compensate for the thermostat (PWC, 2013). If the AC was run for 5 hours/day for 250 days of the year and with an uptake of 15%, average savings per participant was 40 kWh/year.

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Appendix D.

Case studies energy consumption calculations

Case studies
Energy consumption Calculations

Case study A

	Quantity	Estimated energy consumption	hrs per day	% of appliance working	tarrif	$
Ceiling Fans	7	80	4	0.3	0.2688	0.18
Fridge	1	450	24	0.3	0.2688	0.87
lights	15	30.67	4	0.5	0.2688	0.25
					Total	1.30

*Lights	Quantity (a)	Estimated Energy consumption (b)	Total Estimated Energy consumption (c)
CFL count	8	23	184
halogen count	0	50	0
LED count	0	10	0
incan count	1	60	60
tube count	6	36	216
Total	**15**	35.8	**460**
Average estimate energy consumption			30.67

Case study B

	Quantity	Estimated energy consumption	hrs per day	% of appliance working	tarrif	$
AC	6	2500	6	0.3	0.2688	7.26
Fridge	3	450	24	0.3	0.2688	2.61
lights*	27	39.41	4	0.5	0.2688	0.57
					Total	10.44

*Lights	Quantity (a)	Estimated Energy consumption (b)	Total Estimated Energy consumption (c)
CFL count	4	23	92
halogen count	0	50	0
LED count	0	10	0
incan count	6	60	360
tube count	17	36	612
Total	**27**	35.8	**1064**
Average estimate energy consumption			39.41

Case study C

	Quantity	Estimated Energy consumption	hrs per day	% of appliance working	tarrif	$
AC	6	2500	6	0.3	0.2688	7.26
Fridge	2	450	24	0.3	0.2688	1.74
lights*	32	43.06	4	0.5	0.2688	0.74
					Total	9.74

*Lights	Quantity (a)	Estimated Energy consumption (b)	Total Estimated Energy consumption (c)
CFL count	6	23	138
halogen count	8	50	400
LED count	0	10	0
incan count	8	60	480
tube count	10	36	360
Total	**32**		**1378**
Average estimate energy consumption			43.06

Case study D

	Quantity	Estimated energy consumption	hrs per day	% of appliance working	tarrif	$
AC	1	2500	6	0.3	0.2688	1.21
Fridge	2	450	24	0.3	0.2688	1.74
lights*	9	44.00	4	0.5	0.2688	0.21
					Total	3.16

*Lights	Quantity (a)	Estimated Energy consumption (b)	Total Estimated Energy consumption (c)
CFL count	0	23	0
halogen count	0	50	0
LED count	0	10	0
incan count	3	60	180
tube count	6	36	216
Total	**9**	35.8	**396**
Average estimate energy consumption			44.00

Case study E

	Quantity	Estimated energy consumption	hrs per day	% of appliance working	tarrif	$
AC	5	2500	4	0.3	0.2688	4.03200
Fridge*	2	300	24	0.3	0.2688	1.16122
lights*	14	37.43	4	0.5	0.2688	0.28170
					Total	5.47492

*Lights	Quantity (a)	Estimated Energy consumption (b)	Total Estimated Energy consumption (c)
CFL count	4	23	92
halogen count	0	50	0
LED count	0	10	0
incan count	3	60	180
tube count	7	36	252
Total	**14**	35.8	**524**
Average estimate energy consumption			37.43

*Type of fridge	Total Estimated Energy consumption (c)
Fridge two doors	450
Small Fridge	150
Average estimate energy consumption	300

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Appendix D.

Case studies energy consumption calculations

Percentage of reduction calculation

(blue)	Electricity bills same period of time after assessment but 1 year before
(green)	Electrity bills after assessment

Participant ID 21011011 **Assessment Date** 4/09/2014

						Average Cosnumption
Before Assessment (a)	Dec-13	Mar-14	May-14	Jun-14	Sep-14	
	5943	7646	6275	2426	6330	5724
After Assessment (B)	Dec-14	Mar-15	Jun-15	Sep-15		
	5509	4220	2421	1497		3411.75

% of Reduction = **(a-b)/a**
% of Reduction = **40%**

Participant ID **21021037** **Assessment Date** 12/12/2014

					Average Cosnumption
Before Assessment (a)	Feb-14	May-14	Aug-14	Nov-14	
	770	810	607	586	693.25
After Assessment (B)	Feb-15	May-15	Aug-15	Nov-15	
	570	516	389	474	487.25

% of Reduction = **(a-b)/a**
% of Reduction = **30%**

Participant ID **21061008** **Assessment Date** 8/12/2014

					Average Cosnumption
Before Assessment (a)	Mar-14	Jun-14	Sep-14	Dec-14	
	2526	1848	2006	3263	2410.75
After Assessment (B)	Mar-15	Jun-15	Sep-15	Dec-15	
	1178	1611	2674	2876	2084.75

% of Reduction = **(a-b)/a**
% of Reduction = **14%**

Participant ID **21061085** **Assessment Date** 26/05/2015

				Average Cosnumption
Before(a)	Jun-13	Sep-14	Dec-13	
	3499	2620	4176	3431.67
Before(a)	Jun-14	Sep-14	Dec-14	
	2619	860	4047	2508.67
After (B)	Jun-15	Sep-15	Dec-15	
	4902	3189	4965	4352

% of Reduction = **(a-b)/a**
% of Reduction (= **-73%** **% of Reduction =** **-27%**
*Electricity bill after treatment Vs electricty bill 2014 — *Electricity bill after treatment Vs electricty bill 2013

Participant ID **21061053** **Assessment Date** 27/04/2015

				Average Cosnumption
Before Assessment (a)	May-14	Aug-14	Nov-14	
	2114	1566	1768	1816.00
After Assessment (B)	May-15	Aug-15	Nov-15	
	2092	1439	2129	1886.7

% of Reduction = **(a-b)/a**
% of Reduction = **-4%**

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Appendix E.

Deemed savings – assumptions and calculations

Timer package savings

Savings are based on the plug-in timer being used on a bedroom AC which turned it off two hours prior to when the participants awoke. AC power input is set to 1 kW. Since the AC has a thermostat, the average power over time is divided by three because the compressor only runs about one third of the time (PWC, 2013). An 80% uptake is assumed based on the percentage of participants who said they made behaviour changes based on their energy reports. Energy savings per year is therefore estimated to be 260 kWh.

Home cleaning package savings

This treatment was very much a trial so little is known about what type of savings might have been realised. It was hoped that by analysing the energy data from the project, these savings could have been determined. Unfortunately, as explained earlier, the energy data was not complete enough to evaluate the savings. As an approximation, the cleaning of fans and flyscreens allowed extra airflow through the house and perhaps participants were able to keep their ACs off for an extra hour per day, for 250 days of the year. That would have been an 88 kWh/year savings for participants who received this service, but more research is needed to determine actual savings.

Standby saver package savings

The participants who received the standby saver package were mostly instructed to use it on their home entertainment appliances. The savings is based on removal of standby power for a system with one television, one DVD player, and one sound system, each with standby power of 1 W (DEWHA, 2008). It is estimated that the system is in use for five hours per day, so the appliances would be using standby power for 19 hours per day. The saver package would therefore lead to a savings of 20 kWh. An uptake of 80% of participants who received this service was assumed.

AC cleaning service savings

Looking back at Table 10 these deemed savings may not be reflective of actual savings. However, the number of participants who received this service was low and the large increase was mostly due to one household jumping 17 kWh/day. There is little information available on the energy saving potential of professional AC cleans. Participants had an average of 3.5 ACs cleaned, and it was assumed that not all of them ran at once or continuously. Savings here were based on the lower range reduction of 10% on AC consumption (Ergon Energy, 2011). For two 1 kW input power ACs run for 10 hours/day for 250 days/year, savings would be 166 kWh/year.

Thermostat control pack savings

Participants that received this service had AC units that did not have a numeric thermostat and instead relied on a dial with qualitative markings. It was not known what actual temperatures these thermostats were set to, but without knowing, participants were not able to follow energy savings tips by COOLmob on appropriate settings. On average, two plug-in thermostats were given to a participant. Assuming an 80% uptake of using one thermostat on a 3 kW input power AC run for 10 hours/day for 250 days/year, and that the participants raised the thermostat temperature by 1°C, savings of 83 kWh/year were calculated.

Reflective roof paint savings

Having a roof with a more reflective roof has been shown on many occasions to reduce the indoor temperature and the cooling demand of buildings (e.g. Akbari, 1998; Synnefa, 2007; Cheng 2005). Savings reported cover a large range of space cooling savings. The value of a 10% reduction was chosen because it was on the lower end of the range and this treatment was not always used on houses that were the best candidates. This treatment should only have been used on houses with dark roofs exposed to direct sunlight for most of the day and whose attic space did not have insulation or ventilation for the highest benefit. Savings were based on a 10% reduction of two 1 kW input power ACs run for 10 hours/day for 250 days/year, leading to savings of 166 kWh/day.

Shade sail and window shade savings

Up to 40% of house heat gain is through uncovered windows (EERE, 1994). Shade sails were often used to cover windows as well as walls. Savings of 10% were calculated based on the windows of a single room with an AC being covered. For a 1 kW input power AC run for 5 hours/day and 250 days/year this means a savings of 42 kWh/year.

Attic ventilation savings

Attic ventilation was used for the similar purpose as roof paint, to prevent heat gain from entering the living space of a house through the ceiling. Attic ventilation is not as effective as reflective roof paint (EERE, 2001), so savings were halved from the roof paint savings for a conservative estimate.

Security screen and flyscreen savings

Security screens and flyscreens were installed in houses to promote airflow. The particular treatment chosen depended on the individual household needs, but the savings should be the same for either service. Like the home cleaning package, these treatments were a trial and the benefits were meant to be determined by the project. As a starting point for estimations, savings were calculated based on participants using AC two hours less per day because of the increased airflow. Savings calculated were 175 kWh/year for a participant.

Reinstall AC unit savings

If a window-wall AC unit was installed following the manufacturer's guidelines, savings of up to 7% could still be found by upgrading the install (EERE, 2013). Since this service was provided for participants that had extremely poor installations, i.e. large gaps between the house structure and AC unit, savings were expected to be much higher. The households that received this service were also known to be high AC users and two ACs were reinstalled on average. A 20% savings was estimated for two 1 kW input power AC used for 10 hours/day and 250 days/year. This would have led to savings of 334 kWh/year.

Fan package, wall-mounted fan and ceiling fan savings

These services were mostly given to participants more as a thermal comfort measure than an energy savings one. The fans were mostly put inside homes where conditions were very warm and a high amount of discomfort was seen. Many ceiling fans were even installed on verandas to allow participants to seek more comfortable conditions outside the home instead of inside. Since these participants were not displacing electricity used by ACs, and their consumption was expected to increase due to the extra appliances, these services were not included in the CBA calculations. They were included in the cost-effectiveness calculations.