DHARRAY MANYMAKKUŊ PAWAW GA GAPUW

# **Manymak** Energy Efficiency Project

Indigenous Essential Services Pty Ltd, on behalf of the Manymak Energy Efficiency Project consortium

Final Report

Australian Government
Department of Industry, Innovation and Science

LOOKING AFTER OUR POWER AND OUR WATER

This activity received funding from the Department of Industry, Innovation and Science as part of the Low Income Energy Efficiency Program.

## WARNING

Aboriginal and Torres Strait Islander viewers are warned that the following report may contain images and quotes from deceased persons.

## DISCLAIMERS



## ACKNOWLEDGEMENTS

The project team and consortium would like to thank the Yolŋu people of east Arnhem and particularly the workers and researchers employed by the project for their openness, generosity, humour, enthusiastic participation and frank feedback.

Thanks are also extended to the many capable and professional contractors in the Northern Territory who assisted with community consultation and engagement, employed the workers, designed and delivered high quality training and training materials, designed and installed the energy efficiency technologies, transported people across east Arnhem Land, and helped record and report the outcomes.

The history of delivering power and water and other essential services to remote Indigenous communities in the Northern Territory has been a difficult process for the communities themselves and for government agencies. Distance, climate, cultural barriers, misunderstandings and language have all shaped the social and economic circumstances experienced by people in remote communities today.

It was in response to these circumstances that Indigenous Essential Services (IES) in the Northern Territory led the consortium application for funding under the terms of the Australian Government's Low Income Energy Efficiency Program (LIEEP). In the case of this trial, through two-way consultation with the Yolŋu people, households in east Arnhem Land communities agreed to participate.

The project embedded learnings and benefits for Yolŋu energy efficiency into the delivery of power and water to households. The Indigenous population of the Northern Territory is 30 per cent overall, and they are the

primary customers of IES, the NT Department of Housing and regional councils.[1] Our aim now is to improve and expand the knowledge gained by consortium members and governments to better engage with Yolŋu and with the many other Indigenous communities across the Northern Territory.

## PROJECT CONSORTIUM

indigenous essential services Pty Ltd

Centre for Appropriate Technology

NORTHERN TERRITORY GOVERNMENT

CHARLES DARWIN UNIVERSITY

East Arnhem Regional Council

PowerWater

[1] 1362.7 – ABS Regional Statistics, Northern Territory, March 2011

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# Acronyms and Terminology

| | |
|---|---|
| AIS | Aboriginal Interpreter Service, Northern Territory Government |
| ALPA | Arnhem Land Progress Association[2] |
| ARDS | Aboriginal Resource and Development Services |
| BACI | Before after control impact, an analysis methodology |
| BEEBox | Bushlight Energy Efficiency Box |
| Bushlight | The name of a major CAT initiative |
| CAT | Centre for Appropriate Technology |
| CDU | Charles Darwin University |
| CDEP | Community Employment Development Program |
| CDP | Community Development Program |
| CHO | Council housing officer |
| CLO | Council liaison officer, East Arnhem Regional Council |
| CoreStaff | CoreStaff NT Pty Ltd, ABN 79 129 495 263, the successful contractor for the Ramingining employment host contract. |
| CSM | Council services manager, East Arnhem Regional Council |
| DHsg | Department of Housing, Northern Territory Government |
| DoI | Department of Infrastructure, Northern Territory Government |
| EARC | East Arnhem Regional Council[3] |
| EOI | Expression of interest |
| ESO | Essential services officer |
| FaHCSIA | The former Australian Government Department of Families, Housing, Community Services and Indigenous Affairs |
| FAQ | Frequently asked questions |
| GEC | Government engagement coordinator, Department of the Prime Minister and Cabinet |
| GPO | General purpose outlet (as per AS3000), commonly referred to as a power point |
| IES | Indigenous Essential Services Pty Ltd, a wholly owned subsidiary of the Power and Water Corporation |
| ILO | Indigenous liaison officer, Department of the Prime Minister and Cabinet |
| IP | Intellectual property |
| LIEEP | Low Income Energy Efficiency Program |

[2] ALPA operates general food and goods stores.

[3] Formerly East Arnhem Shire Council.

| | |
|---|---|
| LRG | Local Reference Group, Department of the Prime Minister and Cabinet |
| MEP | Miwatj Employment and Participation |
| MES | Marthakal Employment Services |
| MRC | Marngarr Resource Centre Aboriginal Corporation (business unit of the Gumatj Association) |
| NPARIH | National Partnership Agreement on Remote Indigenous Housing |
| NT | Northern Territory |
| NTG | Northern Territory Government |
| PAWA | Power and Water Authority (historical) |
| PWC | Power and Water Corporation |
| RJCP | Remote Jobs and Communities Program |
| SIHIP | Strategic Indigenous Housing and Infrastructure Program (refer NPARIH) |
| YACI | Yolŋu Aboriginal Consultants Initiative |
| YEEWs | Yolŋu energy efficiency workers |

## General use of Phrases

| | |
|---|---|
| Consortium agreement | The formal agreement between IES Pty Ltd and the consortium for the project. |
| East Arnhem Shire | The local government region of the East Arnhem Regional Council, which was a shire council at the commencement of the project, but through local government reform became a regional authority in early 2014 with individual local authorities for each community. |
| Funding agreement | Refers to the formal agreement between IES Pty Ltd and the Commonwealth of Australia, providing up to $9.4M for executing the trial set out in the project plan, depending on the successful completion of milestones outlined in the agreement. |
| LIEEP program office | The administration team within the Australian Government department responsible for the program, nominally housed in Canberra. |
| The program | Low Income Energy Efficiency Program |
| The project | Manymak Energy Efficiency Project |

## Yolŋu Terminology

Yolŋu is the name for the Indigenous peoples of east Arnhem Land. The ŋ sound approximates to the ‘ng’ sound in English. Yolŋu Matha is the name for the group of languages spoken by Yolŋu.

In this report, the Yolŋu Matha word ‘Balanda’ is often used to refer to non-Aboriginal people or people who are outside the Yolŋu kinship system and laws, or more generally 'outsiders'. It is used extensively in this report in the context of its common use by stakeholders in East Arnhem communities to identify non-Yolŋu people. The word's origin is attributed to the Makasan word Balanda, which arose from the Dutch word Hollander.

Yolŋu people in north eastern Arnhem Land are born into one of two basic divisions, or moieties, known as Dhuwa and Yirritja. Children belong to the same moiety as their father; their mother belongs to the other moiety. In each moiety, people belong to smaller groups called clans, each having its own language. Children belong to their father’s clan (and moiety), while their mother belongs to another clan (of the other moiety). Clan members own areas of land and waters in common. The relationship is, however, much more complex than just ‘owning’ or even taking care of land. [4]

The Yolŋu kinship system is called Gurrutu, a term that also encompasses the social rules for interaction between positions in the kinship system.

[4] For information on the detailed structure of Yolŋu kinship system, see, inter alia, *www.dhimurru.com.au/**Yolŋu**-**culture***

# EXECUTIVE SUMMARY

## INTRODUCTION

The Manymak Energy Efficiency Project (referred to from now on as the project) in the Northern Territory was one of 20 around Australia trialling energy efficiency approaches as part of the Australian Government's Low Income Energy Efficiency Program (LIEEP).

LIEEP was launched nationally in 2012 to trial approaches to address barriers to energy efficiency in low-income households, help improve residents' health and comfort, and capture data to inform future policies.

The project ran in the NT from May 2013 until June 2016 and worked with six remote Indigenous communities in Arnhem Land: Milingimbi, Galiwin'ku, Yirrkala, Gunyangara, Gapuwiyak and Ramingining. All six communities are on the traditional lands of the Yolŋu—the Indigenous people of east Arnhem Land.

A five-member consortium led by Indigenous Essential Services, a subsidiary of the Northern Territory's Power and Water Corporation, delivered the Manymak Energy Efficiency Project. The other consortium members are the Centre for Appropriate Technology, Charles Darwin University, the NT Department of Housing and the East Arnhem Regional Council.

The project budget was $12.5 million, with the Australian Government contributing $9.4 million and the consortium providing $3.1 million of in-kind support.

## ORIGINAL OBJECTIVES AND DESIGN

The project's objectives were to:

- define the unique barriers remote Indigenous communities face around household energy efficiency
- form active partnerships with 500 remote Indigenous households
- encourage participation from up to 80 per cent of households in each location
- design and trial technology that is culturally appropriate and suitable for harsh climates
- design an incentive scheme to encourage households to reduce their energy consumption
- rigorously evaluate the project and develop a replicable energy efficiency engagement model.

The project's four main components were:

- energy efficiency and water conservation education delivered to residents at their houses by Yolŋu 'ambassadors'
- energy efficiency retrofits and upgrades in homes, such as stove timers, ceiling insulation, hot water system upgrades and new light globes
- installation of the innovative BEEBox, a device that measures and displays the household's daily energy use
- data collection and evaluation.

Buy-in and participation from local Indigenous people was central to the project's design and its later success. The project was framed by Yolŋu cultural protocols, and Yolŋu 'ambassadors' were recruited to help the project team engage with and educate residents in local language and in ways that were culturally appropriate, respectful and productive.

A primary goal was to educate participants so they could make choices about what they spend on energy. Households in the region were already low users of energy on a per-person basis, and the project did not urge households to use less energy or promise to achieve reductions in energy consumption.

Yolŋu Matha[5] is the common language (lingua franca) of most of east Arnhem Land. English is the third, fourth or even fifth language of most people in the project's trial region. This had obvious implications for the design of the engagement, education, data collection and evaluation approaches.

The trial also had to factor in the demographics of the highly mobile population that frequently travelled for family and ceremonial purposes and during the wet season. There are also regularly large and variable groups of visitors in households at any one time.

Although it later underwent a name change to Yolŋu energy efficiency workers (YEEWs), the ambassador program was the cornerstone of successful and ongoing engagement, employment and energy education for the duration of the trial in all communities because Yolŋu people were more readily listened to and accepted by other Yolŋu.

## HOUSEHOLD ENGAGEMENT AND EDUCATION

The purpose of the energy education process was to inform residents about their energy consumption and highlight the link between behaviours and appliance use in the home with the cost of energy at the meter. For many residents, this was a new and difficult concept.

Many of the foundation concepts of energy efficiency—such as budgets, measuring electricity and the role of the meter—are foreign in Yolŋu culture. The ambassadors' (later renamed to YEEWs) initial training and early education visits to the households involved a great deal of demystification and conceptual explanation before moving on to the mechanics of energy-efficient behaviour. The project approach focussed on minimising potentially confronting data collection and requests to sign complex agreements written in English.

Residents of outlying homelands and outstations in each of the six communities were not directly engaged; however, many were regular visitors to the participating communities. For household visits, elders were approached first, as is the proper approach in Yolŋu culture. This protocol came at the expense of time spent with younger people and children.

The project's training and education program included posters mostly produced in English. A suite of videos was also produced in Yolŋu Matha. These materials were specifically created to capture what Yolŋu people could relate to and would find engaging, and the materials received widespread attention from residents.

Education on water conservation was also included in the project because of its connection with energy consumption in the water supply system and through hot water use. Water conservation is a high priority for many of the participating communities, which rely on limited underground water sources.

The project was rolled out progressively, so the approach in subsequent communities was altered when more effective processes were identified.

The project's community engagement approach resulted in exceptional household participation, with 95 per cent of households approached choosing to participate.

[5] Yolŋu Matha refers to a group of related languages spoken by the clans of east Arnhem Land, who collectively identify as Yolŋu

## Employment and Training

As consultations took shape and engagement matured, the ambassador program adopted the employment title of Yolŋu energy efficiency workers (YEEWs). The YEEWs became the vehicle for engagement, education, project design and implementation.

As a marker of its success, the employment and engagement model stands out among elements of the project for its potential to be adapted by policy makers for broader use across the Northern Territory and beyond.

The recruitment, employment and training undertaken by Yolŋu to deliver household engagement and education was successful. That model took account of the cultural obligations of the employees while meeting the needs of the project timeline and budget.

All available positions were filled in each community. The size of the employment team increased to match the high level of interest. Larger team sizes and part-time or casual employment conditions provided flexibility, which was appreciated by the employees. This led to Yolŋu occupying supervisory and decision-making roles. The approach allowed the household engagement to be delivered through the correct ways in the kinship system, known as 'Gurrutu'.

The initial training of Yolŋu staff was designed in haste to meet project milestones. Interpreters and visual educational resources were involved from the start, but they did not achieve optimal outcomes at first. Training Yolŋu field staff initially involved delivering the training in Yolŋu language over a period of four weeks, followed by top-up training.

It was only from the third community onward that training was delivered by trainers, both Indigenous and non-Indigenous, who were fluent in Yolŋu culture and language. It is very unusual for Yolŋu to receive tailored training of this quality, and the project evaluation clearly shows that the extra investment was warranted in the workers' higher level of understanding of energy concepts and efficiency measures in those communities.

Adequate support and mentorship was especially important in the employment drive because for many Yolŋu staff, this was their first 'proper' job (as distinguished from government-supported work programs).

## Barriers

The question of equity was raised as an important consideration for Yolŋu*,* with continual emphasis on the need to ensure individual households were not excluded.

Yolŋu expressed community concerns about the inequitable treatment of Ramingining, which was initially intended to be a control community, with data collection but without the education or technology trials. However, negotiations resulted in Ramingining's inclusion in the wider household education program and energy efficiency retrofits.

Yolŋu expressed concerns about why the project was only focussed on them, with buildings belonging to schools, stores, the police and non-Indigenous residents excluded from the project by the funding guidelines. This represented a significant potential barrier to participation and engagement.

Weather events were a significant issue for the project. Cyclones Lam and Nathan in February and March 2015 significantly affected the project and its delivery. The cyclones had a profound effect on people, particularly in Galiwin'ku where residents in some 80 houses were evacuated to temporary accommodation while their houses were repaired or rebuilt.

The recovery effort consumed resources and time. It also resulted in an increased supply of appliances and support payments to affected households as part of cyclone recovery measures.

The trials were also affected by 2015 being the hottest year on record—the highest energy-consuming appliance in east Arnhem Land households is air-conditioning.

## Energy Consumption

Per capita, energy consumption is low in the typically overcrowded households of remote Indigenous communities in Arnhem Land.

When communities were approached to participate in the project, feedback showed that energy efficiency was not a high priority for them. But many Yolŋu people saw that the project would benefit their community and were keen to take part. They wanted a better understanding of energy, where it came from and its use. They also knew the project would mean employment opportunities for locals.

Average energy consumption of an Indigenous household in the participating communities was measured as around 26.8 kWh per day across 2014 and 2015. This is similar to the city of Darwin average. However, the occupancy of each community house was around nine people compared to urban averages of fewer than three people per Darwin household. The common ownership of appliances like fridges and washing machines is below the national average, and the availability of energy-efficient appliances in local stores is limited.

## Innovative Technologies

The project trialled several new technologies with participating households. The most significant were the Bushlight Energy Efficiency Box (BEEBox) in-house display and the stove timer.

The BEEBox is a device that measures and displays a household's energy use. It has a controller in the meter box and a robust display inside the home that work together to display how fast power is being used and how much has been consumed for the day.

The stove timers, custom built for the project, provided a fixed one-hour maximum run time for the stove and oven as a whole, with the household able to turn the stove off at any point.

## Project Outputs

The trials were progressively rolled out across the six communities within the timeframe determined by LIEEP, with learnings from early communities incorporated into the subsequent communities' delivery.

The project delivered on its milestone targets over its two and half years of operation in communities from July 2013 to December 2015. Outputs of the project included:

- installed 663 electricity meter data loggers to provide high-resolution energy consumption data
- conducted an initial survey with 42 households and three stores
- designed a custom household education package and poster kit
- recruited 91 Yolŋu to undertake community engagement and education across the six communities (of these Yolŋu*,* 80 completed the training and employment prior to project completion)
- conducted 2772 separate visits to households to seek participation and deliver education and technology trials

- approached a total of 564 houses to participate—89 per cent of the eligible housing—and 95 per cent of those chose to participate
- installed 252 BEEBox in-house displays
- installed 498 energy efficiency upgrades for 448 households.

The project exceeded targets set for each of the key performance measures under the funding agreement, including employing and training a greater number of ambassadors (YEEWs) and approaching more households than originally anticipated.

In addition to the milestone targets, it also:

- delivered water conservation education to 463 households
- conducted 149 interviews and discussion groups with households and project stakeholders before, during and after the trials.

## KEY OUTCOMES AND LEARNINGS

The project achieved its goal of saturation participation, with 84 per cent of all eligible households participating and an average of 4.4 community engagement visits per house. Seventy-one per cent of houses received at least one energy efficiency upgrade, and 40 per cent received the BEEBox in-house display.

The BEEBox proved to be an effective talking point and tool for understanding how different appliances use energy. It was a valued tool for many householders, who expressed concern that others in community also needed one. Analysis of the energy consumption data showed that the BEEBox appeared to assist households to make a small reduction in their consumption. It also helped reduce their apparent rate of disconnection due to loss of meter credit. Conceptually, it was difficult for some workers and householders, particularly in their understanding of how it operated in relation to the pre-payment meter and how to interpret its various informational displays. The project's educational videos, on the other hand, demonstrate the local employees' ability to understand and communicate this technology.

The solar hot water and heat pump hot water system upgrades achieved overall household energy consumption reductions of 8.5 and 11 per cent respectively. The much warmer dry season in 2015 may have resulted in lower hot water consumption, contributing to the observed savings. In contrast, some of the older pre-existing units were faulty and not drawing power. The replacement of older solar hot water systems achieved energy savings, demonstrating the importance of maintenance and timely replacement of this technology to maintain savings for householders.

Bulk ceiling insulation was retrofitted to a set of suitable houses with existing air-conditioners and appeared to provide energy savings of around 2 kWh per day on average.

The innovative but simple stove timer developed for the project was rolled out in response to strong householder interest on an opt-in basis. It achieved an average saving of between 1.3 and 2 kWh per day—one of the most cost-effective of the project's trials given its relatively low cost.

Overall, the experience shows that energy efficiency improvements can be made using novel technology approaches, but they must be suited to local conditions and able to be maintained and repaired.

The data loggers deployed by the project provided a valuable insight into energy consumption and enabled the project to meet a key goal: better understanding the prevalence of disconnection due to lack of credit in pre-payment meters. This data confirmed that Yolŋu find the process of maintaining credit supply for the meter difficult, with the average disconnection lasting 3.5 hours and occurring once every six days.

The data analysis showed that energy consumption correlates closely with the number of occupants and the number of air-conditioners, and that appliances are a more significant driver of energy consumption than the energy efficiency features of the building.

## Other Outcomes and Effects

Evaluation confirmed that household education was a valued and appreciated component. The direct, measurable effect of the education on energy consumption was minimal, but a reduction in disconnection periods was observed in the later stages of the project particularly for houses with the BEEBox technology.

That significant energy savings did not result from the education reflects the emphasis on informed decision as much as energy savings. The education was typically only delivered to one or a few of the residents and also not to the households' many visitors. The project scope covered only a portion of the population, with residents of outlying homelands and outstations not directly engaged, despite them being regular visitors to the participating communities.

The project's approach to have Indigenous co-researchers work with non-Indigenous researchers maximised local involvement and employment, allowed collaborative decision making, and strengthened local research capacity and experience in each community.

The obvious effects of vast distances, limited transport infrastructure, a climate punctuated by severe tropical cyclones, cultural complexities and the often associated chronic and acute social disadvantage in indigenous communities all imposed limits on the trials. Aside from severe weather, most of these were implicitly anticipated through the project team's experience and consultations.

## The Project Impact on Community

In the project's initial year (data collection commenced in March 2014), household daily energy consumption was 27 kWh, and participating households accounted for around a third of total community energy generation.

The bulk of the project's activities occurred in 2015.

The average temperatures in the Northern Territory were higher in 2015 than in 2014. This was reflected in the total energy consumption in participating communities, which was generally higher in 2015 than in 2014.

Overall, the communities saw a 2.1 per cent increase in energy consumption; however, this was a relatively low increase compared to four neighbouring non-participating communities[6] that had a total consumption increase of 3.6 per cent in 2015.

This represents a 1.5 per cent saving for the participating communities, or 253 000 kWh that could be attributed to the project's trials. Given that many of the project trials were delivered in mid to late 2015, this annual result is an understatement of the project's potential impact.

The self-disconnection time experienced by participating households in the final year of the project reduced by around five minutes per day on average. This was in large part attributable to the subset of households with a BEEBox that saw a 14-minute per day reduction on average.

[6] Refer Appendix A for details

## Cost Benefit and Cost Effectiveness

A cost-benefit and cost effectiveness analysis of the project's trials can be found in the discussion section of this report.[7] This analysis is based solely on quantifiable energy savings, on which basis the stove timer was the trial activity that showed the best cost-benefit ratio, with hot water system upgrades and the BEEBox less effective on a cost-benefit basis.

## Co-benefits

The interviews with participants demonstrated a strong perceived benefit in improved understanding of energy supply systems and of how appliances use energy and therefore consume power meter credit.

The benefits of managing the cost of energy supply are best understood by considering the consequences to individuals, families, communities and society in general. Consequences can be immediate or long term and are manifested in quality of life in terms of individual and social health and wellbeing, education and welfare, employment, the management of and connections to country, and so on. These factors are defined in this project as barriers and are well known in Indigenous society, in Yolŋu communities and at every level of government.

There is an immediate transient social benefit of the employment provided by the project. The longer-lasting benefit from this employment is the resultant increase in workers' employability and self-confidence, which is valued by the broader community. The legacy of 80 workers with improved knowledge of energy and budgeting concepts is perhaps the greatest lasting social benefit from the project.

The project also provided an economic co-benefit to Australian suppliers and manufacturers by investing heavily in products and services from Australian companies and organisations.

The project was the first energy efficiency trial of this scale to be delivered in remote Indigenous communities, and it captured valuable lessons on community engagement and the use of technology to achieve energy efficiency in remote communities.

Consortium members had the unique opportunity to improve their knowledge and capacity around community engagement, Indigenous employment, energy efficiency data capture, the effect of housing designs, and the use of retrofit technology in remote communities.

## Key Recommendations

The following recommendations relate specifically to the project context but are applicable to remote community energy and water efficiency more broadly.

**Project planning and delivery**

- Engage with and employ local people and stakeholders to be part of project planning, design and implementation
- Recognise different needs and circumstances between communities and allow for local customisation
- Allow for an iterative process with time for evaluation before wider roll-out
- Effective education and behaviour change require long-term, integrated approaches.

[7] See Table of Contents for section and page numbers.

**Employment and training**

- Engage households by employing local people who are trusted in their communities and the experts in local conditions and social-cultural context
- Use local senior mentors to help select appropriate employees
- Employ a diverse team that is representative of the community, with suitably skilled and experienced supervisors
- Design employee training based on their actual needs and with an initial focus on applying skills early and on learning by watching
- Engage trainers that are fluent in local languages and culture
- Combine energy and water efficiency education with other community engagement and education roles for economies of scale.

**Education for energy efficiency**

- Focus on productivity improvements rather than savings or conservation
- Include delivery of water and energy efficiency education to children through schools.

**Housing and technologies**

- Design houses with consideration of Indigenous needs, including provision of outdoor living and food preparation areas
- Mechanical cooling is required in the tropical climate, so include some spaces that are efficient for air-conditioning in addition to ceiling fans
- Incorporate maintenance and reliability considerations into selection of technologies.
- Listen to the requests and needs of householders when selecting technologies
- Allow for customised engagement and education to accompany new technologies
- Heat pumps and solar hot water save energy in the remote Top End housing context, but ongoing maintenance is crucial to sustained benefit
- Stove timers are an effective energy-saving tool for remote householders

# SECTION 1: INTRODUCTION

# 1 Original Trial Design

## 1.1 LIEEP Program

The Manymak Energy Efficiency Project was the largest of 20 projects to receive funding through the Australian Government's Low Income Energy Efficiency Program (LIEEP) and was defined by the guidelines and requirements of LIEEP.[8] Expressions of interest to participate in LIEEP opened to the public in February 2012.

Launched in 2012, the purpose of LIEEP was to address problems of energy efficiency in households on low, fixed and unreliable incomes. Low income households have been particularly affected by increases in retail energy prices as a result of poor quality housing stock, limited ability to reduce energy use with more efficient appliances, and the fact that while these households tend to consume less energy than average households, they spend proportionally more of their income on this essential service.

The program's initiative was to provide grants for government, business and community organisations to trial new and innovative approaches that would assist low-income and vulnerable households to overcome identified barriers to energy efficiency and better manage their energy use.

The objectives and intended benefits of the Low Income Energy Efficiency Program are to:

Objectives:

- trial and evaluate a number of different approaches in various locations to assist low-income households to become more energy efficient
- capture and analyse data and information to inform future energy efficiency policy and program approaches.

Benefits:

- assistance for low-income households to implement sustainable energy efficiency practices to help manage the impacts of increasing energy prices and improve the health, social welfare and livelihood of low-income households
- build the knowledge and capacity of consortia members
- build the capacity of Australian energy efficiency technology and equipment companies by maximising the opportunities for Australian industries to participate in the projects funded through LIEEP.[9]

The terms for the program demanded robust data collection methods together with the establishment of monitoring arrangements that would lead to the successful evaluation of all projects developed within the program framework.

Household data collection had to be based on engagement, the provision of information and the consent of householders. Privacy and confidentiality was an essential component and came with a guarantee that data would only be used for the purposes for which it was collected. [10]

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[8] See the LIEEP Guidelines February 2012, Department of Climate Change and Energy Efficiency, Commonwealth of Australia

[9] Ibid.

## 1.2 Trial Design Overview

The main elements of the Manymak Energy Efficiency Project were established during the expression of interest phase and further developed for the detailed application process for LIEEP funding. The initial project plan was submitted in October 2012 as part of the successful detailed proposal and then further refined through the drafting and execution of the funding agreement. That funding agreement was executed in May 2013 as milestone 1. The trial design evolved further with the establishment of the initial project team and their submission of project plan documents for milestone 2 in late 2013. The rationale behind the trial design, as it was envisaged up to milestone 2, is set out below.

## 1.3 IES LIEEP Project Funding Bid

The funding bid that defined the Manymak Energy Efficiency Project was led by Indigenous Essential Services (IES) Pty Ltd. IES is a not-for-profit wholly owned subsidiary of the Power and Water Corporation (PWC) and was established to provide essential services to 72 remote Indigenous communities and 66 outstations in the Northern Territory.

In March 2012, IES led the development of an application to LIEEP with consortium partners PWC, Department of Housing, Charles Darwin University, the Centre for Appropriate Technology and the East Arnhem Shire Council (now Regional Council). The project goal was to identify and overcome barriers to the improvement of energy efficiency in the east Arnhem Indigenous communities of Galiwin'ku, Gapuwiyak, Milingimbi, Yirrkala, Gunyangara and Ramingining. This was the rationale. The project's approach was to adopt an iterative community engagement model to trial and evaluate two-way energy education and engagement, a retrofit roll-out and installation of interactive in-home displays.

The project’s total budget was to be $12.53M over three years, from May 2013 to April 2016. This was intended to be comprised of $9.4M of LIEEP funding from the Australian Government and $3.13M of in-kind contributions (just over 25 per cent) from IES and other consortium partners (including $600k for a water smart metering project funded through a separate IES funding agreement). See appendix A for original budget breakdown.

The project proposal included:

- involving local Indigenous people at the centre of the design and delivery of the project
- improving financial outcomes for Indigenous residents, enabling them to spend less money on electricity, providing a greater disposable income
- engaging Yolŋu community members in two-way energy and water education with local employment focussing on house-to-house water and energy educational visits
- investing in remote housing stock with strategic retrofitting of fixtures and fittings, making them more energy efficient
- rigorous evaluation of the project leading to development of a framework and model for energy efficiency improvement to be used in other remote Indigenous communities.

[10] Applicants were to abide by the relevant provisions of the *Privacy Act 1988*, the *Freedom of Information Act 1982* and the *Crimes Act 1914*

# 2 Funding Bid Design

The project design was shaped by the consortium and community context but also the criteria of LIEEP, which were[11]:

Alignment with program objectives:

- the approach of the trial and how it will identify and overcome barriers in relation to low-income households and energy efficiency
- the data and analysis that will be derived and provided from the trial
- the consortia members and their roles and responsibilities, including applicant eligibility.

Trial type and location:

- the type of activity being trialled, e.g. appliance replacement, household energy assessments, in-house energy use displays
- the subset of targeted low-income households, e.g. Indigenous households, low-income renters
- how the proposal is new and innovative or is additional to existing government energy efficiency programs
- the geographic location of the project.

Value for money:

- the project budget including contribution amounts by the consortium members and the amount requested from the Australian Government
- the high-level risk strategy, identifying the main risks with their controls or treatments.

The key design features of the funding bid in the context of these criteria are provided below.

## 2.1 Region and Size of Project

The east Arnhem region was selected for several significant reasons:

- east Arnhem has the largest number of major remote towns in any one shire[12]
- benefits of having only one local government consortium partner (East Arnhem Regional Council) as opposed to coordinating multiple councils
- a willing and committed council, which was keen to leverage community benefit in energy education for its constituents
- strong overlap of communities facing significant water source constraints (Milingimbi) or high water demand (Galiwin'ku, Gunyangara, Yirrkala, Ramingining, Gapuwiyak)
- large population base with high percentage fitting the LIEEP eligibility criteria
- housing in each community is owned by the Land Trust specific to the community (managed by government through various forms of lease agreements)
- Indigenous peoples of east Arnhem Land have a shared language group and shared cultural understanding across the region.

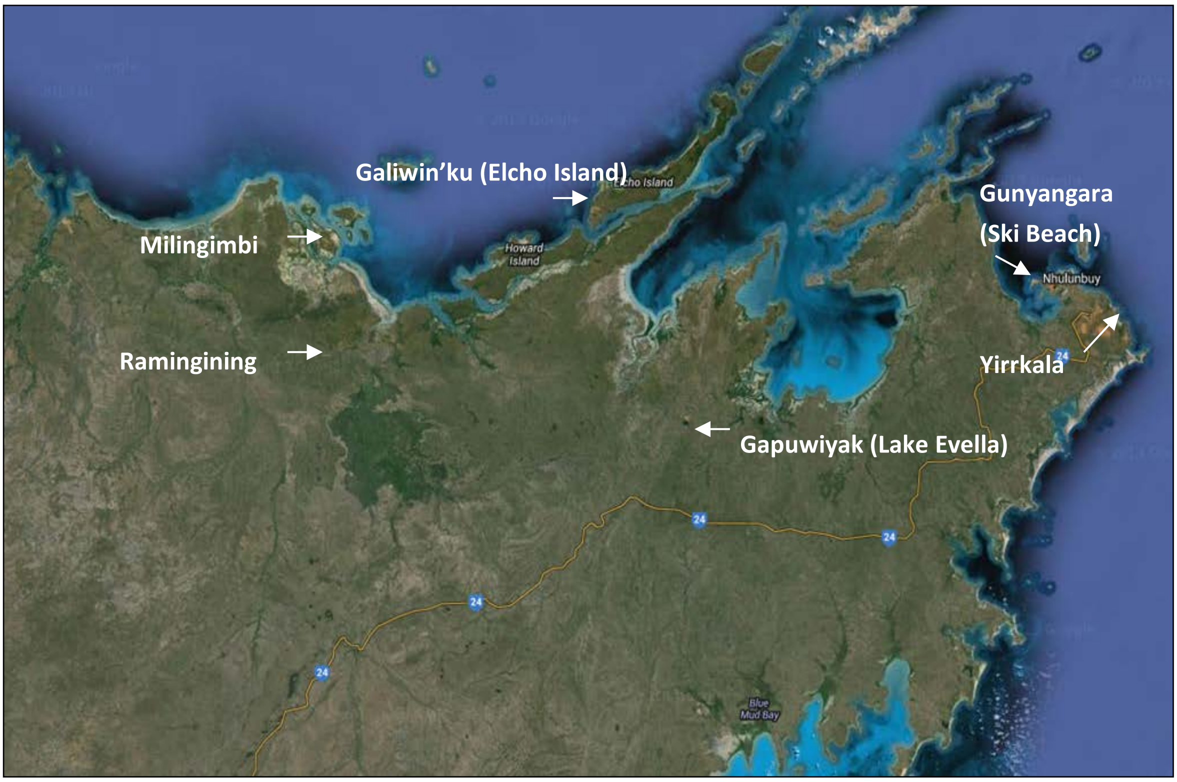
The six communities involved in the project—Milingimbi, Galiwin'ku, Yirrkala, Gapuwiyak, Gunyangara and Ramingining[13]—are pictured in the following map.

[11] LIEEP Guidelines February 2012, Department of Climate Change and Energy Efficiency, Commonwealth of Australia

[12] The term 'major remote towns' has been used by the NT Government to refer to large remote Indigenous communities

[13] The community of Ramingining was initially envisaged as serving as a control community

*Figure 1: Relative locations of the project's six communities (Image base © Google Maps)*




In making the final community selection, consideration was given to the fact that no programs or initiatives had ever been designed or implemented to address barriers to the take-up of energy-efficient technologies in these communities. Historically, east Arnhem Land residents have been provided with almost no information about or initiatives addressing the production, use and cost of energy in their communities. Due to distance, remoteness, language barriers and low levels of English literacy, these communities were and continue to be isolated from mainstream media campaigns focussed on energy efficiency. For the majority of residents across all communities, English is a second or third language.

## 2.2 Community Context

The communities of east Arnhem Land covered by the project are some of the largest of the 72 Indigenous communities supplied with energy and water services in the Northern Territory by IES[14]. Indigenous residential properties in these communities pay for electricity through pre-payment card meters. Residents power their homes by inserting power cards (purchased typically from their local community store or alternative licensed outlet) into their pre-payment meter. Once all the credit is consumed, a small debit is allowed to be built up before the meter disconnects electricity. To ensure the health and safety of the community, meters do not disconnect out of typical operating hours for local stores—the stores typically being the only way for residents to purchase power meter tokens.

Due to the social and economic disadvantage experienced in these communities, household incomes are low. Census data from the Australian Bureau of Statistics (ABS) for 2011[15] indicated that almost all households in

[14] Refer Appendix A for demographic information for the region
[15] ABS, 2011

these communities fell into the LIEEP definition of low income: household incomes are in the bottom two quintiles of the Australian population, householders were in receipt of an Australian Government concession card, household income is mainly derived from income support payments and householders were considered members of a particularly disadvantaged target group. Accordingly, every community housing dwelling in each of the target communities was to be approached to participate in the project.

It was anticipated that periodic electricity disconnection, when the credit runs out, would be a pressing issue for many of the target households[16]. There is very limited data on actual periods of power disconnection available prior to this project, so gaining a better understanding of actual disconnections experienced was also a key area of interest.

The costs of fitting energy-efficient fixtures and fittings in remote areas can be two to four times greater than what the same items cost in major centres. This significant price difference is due to a range of factors, including freight and labour costs, limited accommodation in communities, and the difficulties of mobilisation and demobilisation to remote areas.

The consortium believed that a project in east Arnhem targeting low-income households to improve energy efficiency and help them better manage their energy use had significant potential.

## 2.3 Formation of Consortium

The LIEEP funding guidelines specifically required bids from consortia. Indigenous Essential Services Pty Ltd (IES) led the funding bid as the organisation with the direct incentive for energy (and water) efficiency projects in remote Indigenous communities.

### *Lead agency strategic context*

Indigenous Essential Services Pty Ltd (IES) is a wholly owned, not-for-profit subsidiary of the Power and Water Corporation (PWC), whose sole shareholder is the Northern Territory Government.

In the NT, electricity and water are provided to remote customers at the same (uniform) tariff rate as in metropolitan areas. As a result, a high government subsidy is required to ensure the sustainable and ongoing delivery of essential services in

Community housing residents are provided power through prepayment token meters, where residents purchase power cards from their local store or other provider and apply credit to their meter, which is then consumed. Because no billing reads are required from the power meters, the information available to PWC on consumption patterns was limited to approximately annual audit reads conducted in person, typically as part of tariff changes. Very little information was therefore available on household energy consumption patterns, nor on the extent of disconnection events from running out of pre-paid credit.

In 2011, PWC developed the ‘business case for water and energy efficiency for remote Northern Territory communities’. The business case identified the financial benefits to government of investing in demand management initiatives alongside normal utility operations. PWC had delivered a number of trial water conservation projects in east Arnhem Land, building relationships and trialling approaches to engaging with communities and households that were designed in partnership with community representatives.

[16] McKenzie, Feb 2013, Pre-Payment Meters and Energy Efficiency in Indigenous Households

Energy efficiency was an area identified in the business case but not yet addressed through community trials. LIEEP presented an opportunity to obtain funding to progress demand management, addressing the knowledge gap on energy efficiency and also to integrate water efficiency where possible.

The aim of the project's LIEEP funding application was to give PWC/IES a replicable best practice customer energy efficiency engagement model to target future investment in efficiency for other Indigenous communities. The hope was that the findings of the project could inform both the residential and non-residential and Indigenous and non-Indigenous spaces. It was anticipated that this approach would result in a major contribution towards better cost control, efficiencies and greater adaptation capacity for remote communities under a changing climate.

Other potential benefits for PWC and IES identified during the trial design were:

- address constrained economic water source issues in target communities
- expansion of energy and water demand management approach to address the high cost of delivery of services
- desire to showcase the NT and NT Indigenous communities
- formation of partnerships and shared learnings between all involved parties
- support and motivate behaviour change within Indigenous communities, particularly in the area of water usage in communities.

## *Consortium Partner Selection*

The consortium partners brought the following strengths to the funding bid:

**Charles Darwin University**

Charles Darwin University (CDU) is an Australian public university with some 22 000 students. CDU was the first choice for a Northern Territory-based research partner, particularly because of the ability to leverage its experience with previous energy efficiency program such as Solar Cities (a program that significantly informed the development of LIEEP as a whole).

CDU's goals and priorities for participating in the project included:

- supporting design and data analysis for the evaluation process
- achieving results and effects on Indigenous livelihoods
- sharing management experience in consortium governance
- contributing experience with data analysis of Alice Solar City
- anticipating development of research publications in high-impact journals.

**Centre for Appropriate Technology**

Centre for Appropriate Technology (CAT) Ltd is a not-for-profit Aboriginal and Torres Strait Islander company that works with communities, organisations and governments across central and northern Australia. The consortium sought to leverage CAT's successful experience and IP in energy efficiency and energy management systems in remote communities through its flagship Bushlight program.

CAT's goals and priorities for the project identified at its commencement included:

- helping Indigenous communities to access energy services, manage them sustainably and use them to contribute to their long-term livelihood
- increase sustainable energy in Indigenous communities
- create positive and successful working relationships between consortium partners and communities

- increase energy and water efficiency education within communities
- reduce energy use
- trial the BEEBox in-house display technology.

#### *East Arnhem Regional Council*

As per the region selection discussion above, the East Arnhem Regional Council (EARC) represented a willing and committed regional partner, governed by local Indigenous people and with an 'on the ground' presence in each community.

EARC's goals and priorities for the project identified at its commencement included**:**

- achieving savings for residents
- encouraging Indigenous community members to take ownership of and influence how the project was designed and delivered.

#### *Northern Territory Government Department of Housing*

The Northern Territory Government Department of Housing (DHsg) delivers social housing programs, including public housing, supported accommodation and home ownership. The department manages tenancy and asset maintenance for community housing in the project region. DHsg was an essential partner, particularly for the household liaison and energy efficiency retrofits aspect of the project.

Its goals at commencement included:

- supporting the two-way approach to see community members participate in the program design and delivery and benefit from the results
- understanding the energy and comfort of the different existing housing styles
- testing new energy efficiency technologies and measuring their impact on energy use.

### *Consortium Roles and Responsibilities*

The roles and responsibilities of each consortium member were agreed to at the commencement of the Manymak Energy Efficiency Project as presented in Table 1.

*Table 1: Roles and responsibilities of consortium members as part of original trial design*

| Member | Roles | Responsibilities |
|---|---|---|
| IES | Consortia lead, technical guidance, overall project management | Establishment of program office, including employment, finance, legal and similar provisions.<br>Effective governance of the consortium.<br>Assist in education, awareness and participant identification.<br>Management of partners and sub-contractors, including procurement.<br>Procurement and contract administration. |
| CAT | Culturally and climatically appropriate training, research and development | Contribute to the design of barrier and stores surveys.<br>Conduct barrier surveys.<br>Co-develop education and training and materials for the project with IES staff in the project team.<br>Co-deliver the program's 'Energy Efficiency Ambassador' training.<br>Mentor Indigenous staff.<br>Provide the BEEBox in house display.<br>Provide technical support for installed in-house display units |

| Member | Roles | Responsibilities |
|---|---|---|
| | | over the life of the program. |
| EARC | Advocacy, physical works in participating households | Project advocacy and raising awareness of the project and its benefits with eligible participants.<br>Assistance with identification of eligible program participants.<br>Commitment to participate obtained from identified low-income households that meet the program criteria.<br>Potential involvement in implementation of retrofits across target low-income households (as part of housing maintenance agreement). |
| CDU | Evaluation, monitoring and research expertise | Design of social survey instruments.<br>Design of efficiency audit instruments.<br>Design of data collection methodology and templates as necessary.<br>Design of collection datasets.<br>Design of research frameworks.<br>Development of database(s).<br>Evaluation of data and reporting on targets and progress and the over all project.<br>Measurement, collection and reporting of knowledge outcomes. |
| DHsg | Strategic property management and tenant liaison | Recommending, reviewing and approving efficient fixtures and fittings for installation in community houses.<br>Supplementary liaison with households and local reference groups.<br>Provision of data on existing housing stock and current and future works programs.<br>Ongoing maintenance and upkeep of retrofitted fixtures and fittings after project completion.<br>Consider inclusion of innovative retrofits successfully trialled through the project into general practice.<br>Consider incorporating relevant water and energy efficiency resources and knowledge outcomes into life skills officer programs. |
| PWC | Strategic project support | Provision of participant consumption and billing data.<br>Use of marketing materials from previous efficiency programs to modify and adapt to this project as necessary.<br>Linking with urban energy efficiency programs (possibly also LIEEP funded), including joint procurement and systems support where appropriate and cost effective.<br>Provision of license for Alice Solar City database (if required). |

## 2.4 Risk and Compliance

IES is subject to a wide range of legal requirements as a result of its diverse operations. This includes compliance with both the Australian Government's and the Northern Territory Government's legislation, regulations, licences, standards, codes and other legal instruments. The PWC recognises that legislative compliance is an integral part of good management and effective corporate governance. The project utilised these well-established systems to maintain compliance.

At the project commencement, the project team produced a compliance plan and a risk management plan, which contained detailed compliance and risk registers designed as working documents to be reviewed and added to throughout the project.

Safety was a key consideration in all aspects of the project. A separate safety management plan was produced by the project team, which identified key safe work methodology and procedures.

This stipulated that all contractors engaged as part of the household retrofits, data logger, BEEBox in-home display or incentive programs provide Job Safety and Environmental Analysis (JSEAs) or Safe Work Method Statement (SWMS) in order to identify and categorise safety risks and their likelihood of occurring and detailed measures that would be put in place to mitigate these risks. Spot checks were to be conducted to ensure compliance. Contract payments would also be linked to provision of compliance documentation.

## 2.5 Barriers and Innovative Solutions

Barriers to energy efficiency in low income, English-speaking households in urban and regional areas are reasonably well studied, with a large number of projects and publications. Barriers to household energy efficiency in remote Indigenous communities, however, have been poorly studied, with largely anecdotal evidence to support identification of the key barriers in this context. Housing, lack of standards, inappropriate infrastructure policies and service delivery that doesn't suit residents in remote communities have all contributed to conditions experienced by people in the region.

The project proposed to target four specific barriers to low-income household energy efficiency in line with the LIEEP guidelines: information failure, capital constraints, remoteness/accessibility and split incentives. The rationale for targeting these four barriers is explained below.

### *Information Failure*

Low-income Indigenous households in east Arnhem Land do not have accurate and consistent information about energy efficiency, including appliance energy consumption and efficient use, appliance energy ratings and appliance lifetime costs. Reasons for this information failure include:

- no or limited exposure to energy efficiency concepts
- exclusion from previous federal government programs to enhance energy efficiency awareness
- isolation from mainstream media campaigns on energy efficiency due to remoteness and low levels of English comprehension and literacy
- no or limited internet access—no ready access to energy efficiency information
- no or limited choice when purchasing appliances due to remoteness
- no information about historical energy use—households are unable to track their energy consumption over time due to pre-payment metering used in remote communities.

The project was originally designed to overcome information failure barriers to energy efficiency through developing and delivering targeted, accessible information to low-income Indigenous households in East Arnhem Shire. The method of information delivery was to be developed in collaboration with community residents to ensure it was culturally appropriate, building on previously demonstrated Indigenous engagement practices.

The first step was to develop resources in both English and Yolŋu Matha, and train local Yolŋu people to conduct the residential audits and education. Printed and visual materials were to be developed to use in other communities in the future.

Information failure was seen as a barrier for the project consortium members and stakeholders, with very little information available to decision makers on household energy consumption patterns, pre-payment meter disconnection patterns, and the real-world efficiency of different house construction and energy appliance choices.

### Capital Constraints

Low-income Indigenous households in East Arnhem Shire face capital constraints to energy efficiency. Reasons for this include the fact that household income is mainly derived from income support payments and the high cost of purchasing new, more efficient appliances in remote outback stores.

### Remoteness and Accessibility

The remoteness of Indigenous communities in East Arnhem Shire presents another barrier to energy efficiency and exacerbates the barriers identified above. Accessibility-related issues include:

- high cost of travel, which affects many aspects of life
- lack of availability of energy-efficient appliances, fittings and fixtures in these very remote locations
- limited exposure to mass media communications and promotions related to energy efficiency
- limited internet connectivity (which hinders the development of energy efficiency awareness and education)
- limited access to skilled labour and/or tradesmen (which hinders the implementation of energy-efficient improvements which require licensed tradesmen).

There were difficulties accessing available information relevant to how low-income Indigenous households living in remote communities use energy. This is partly due to their exclusion from the Australian Bureau of Statistics Energy Use and Conservation Survey conducted in March 2011.

### Split Incentives

Numerous stakeholders are involved in the delivery of essential services to low-income households in remote Indigenous communities, including IES, EARC, DHsg and other consortium partners. These organisations have different roles and responsibilities, which, when operating in isolation, do not encourage household energy efficiency. As a consequence, there is a split incentives barrier to household energy efficiency.

There is also a split incentive in respect to the NT Government policy of applying a uniform domestic electricity tariff across the NT with the provision of utility services via IES subsidised by the NTG.

The aim was to improve cooperation between these organisations. Benefits were expected to accrue and be enduring into the future once these relationships had been built and once the evidence base was demonstrated to all parties through a successful project and effective evaluation.

# 3 Funding Agreement and Detailed Project Design

The project was formalised by the execution of the funding agreement, constituting the first milestone. The activity description and budget in the original funding agreement is provided in Appendix E.

The design of the trial was captured in the project plan, a key document required by and referenced by the funding agreement. The trial approach of the Manymak Energy Efficiency Project as per the original project plan is outlined below.

## 3.1 Governance and Administration

The project delivery and governance approaches were to:

- Fund a project team: project director, senior project officer, community engagement officer and CDU research officer.
- Establish and operate a consortium management committee to manage the consortium.
- Establish and operate a stakeholder advisory group to ensure effective consultation in design and operation.
- Install energy data loggers to address the information gap on consumption and disconnections. Refer to the data collection section below for more details.

## 3.2 Community Engagement and Education

Community engagement and education were central to the original design, and included:

- design and carry out a barrier survey in target communities (the initial project design was inherently to be flexible and responsive to the findings from these surveys and from analysis of the energy data—see full survey scope below)
- design and deliver the culturally appropriate materials and approaches in partnership with local Indigenous people
- develop a project-specific identity and brand to be used in lieu of any one consortium member's brand
- broad communications and marketing messages to encourage energy and water efficiency
- energy efficiency ambassador training materials (see detailed scope of ambassador program below)
- a voluntary incentive scheme (households to be rewarded by the scheme towards the aim of reinforcing energy-efficient practices).
- household education materials and education delivery strategy

The household education program was a voluntary participation program for local residents and included the following initiatives:

- general media and marketing messages to be distributed at the community level
- delivery of audio, visual and practical participatory energy and water efficiency education materials (to be staged over various visits)
- include the voluntary take up of a daily budget energy monitor in the form of an in-house display (see detailed scope below).

## 3.3 Ambassador Program

The ambassador program was to be the cornerstone of the community engagement and household education plan. The intention was to recruit local residents and train them as Yolŋu energy efficiency workers (YEEWs) to deliver the household education packages in the participating communities.

- YEEWs recruited from the local community would engage with households.
- Male and female members recruited to conform to the necessary cultural protocols.
- The duration of employment would cover between six to nine months in each community, with possible extensions.
- Training would be carried out by community engagement officers (CEO) and additional trainers as required.
- YEEWs to be directly employed by a local host organisation in each community for the project duration. The local host organisation would take responsibility for day-to-day supervision and administration functions of the YEEWs.
- Ongoing mentoring was the responsibility of the community engagement officer, along with the local supervisors.
- YEEWs would have a role in collecting data and conducting surveys.

## 3.4 In-House Displays (IHD) Installations

The plan was to install robust, interactive in-house displays showing electricity consumption in remote Indigenous low-income households that are culturally appropriate and accessible to those who speak English as a second, third or fourth language. IHDs were to give residents access to real-time information about energy consumption and provide information such as daily or weekly energy usage. IHDs that were not designed to interact with 'powercard' pre-payment meters would not display information relating to remaining credit. The IHDs were to be deployed in 250 houses by PWC-appointed contractors.

The households that were invited by YEEWs to opt-in would receive in-home displays. A rollout pilot program of the IHDs would be installed in Yolŋu energy efficiency workers' houses as part of the pilot program. Finally, IHD technology would be presented to local reference groups in order to foster buy-in.

## 3.5 Household Retrofit Program

The initial project bid included a target of providing 550 houses with an energy efficiency retrofit or upgrade. The project plan clarified the retrofits trial as being separated into two main components: major retrofits of significant cost that fall within the scope of service delivery of DHsg (structural changes and major appliances supplied by DHsg) and minor retrofits that would be offered to households on an opt-in basis.

- A number of low-income households across the participating communities were to receive energy-saving devices and energy efficiency retrofits based on findings from the barrier survey findings.
- Specific and actual retrofits would depend on the results of the initial barrier surveys, detailed scoping and expert review, with an implementation plan to be submitted for milestone 4 after these activities were completed.
- Procurement and project management of the major retrofits component anticipated to be undertaken through either the Northern Territory Department of Infrastructure (DoI) or Department of Housing (DHsg).
- Minor retrofits would be managed by PWC.

Retrofits were not intended to include:

- routine maintenance and building repairs

- the provision of air-conditioners
- items that are not likely to directly reduce household energy consumption.

## 3.6 Inclusion of Water Smart Metering and Water Efficiency

Water supply sustainability is also a critical issue for many remote communities. Many of the 72 Northern Territory communities serviced by IES are water stressed and up to 20 per cent of community-wide energy consumption may be linked to excessive household water use.

Installing water smart metering of household water usage in Milingimbi as an in-kind contribution to this project would enable evaluation of the relative contribution of household water usage to household and community energy use. By including water efficiency in the project's education program, community knowledge and the impact of education on water efficiency could also be evaluated.

The program sought to integrate water efficiency messages into the household education material to promote a holistic approach to efficient household utility use.

## 3.7 Data Collection and Reporting

### *Data Loggers*

Energy data loggers were to be installed in all participating households (including in Ramingining, which was originally designated as the baseline community) to allow the consortium to record and report energy consumption and to evaluate the impact of the project.

The loggers were to be installed in addition to and, where practical, independently of the existing pre-payment meters. Logged data was to also allow for identification of power outages due to insufficient pre-payment credit tokens. Data loggers would be purchased and deployed by PWC contractors and then installed in all houses in the five treatment communities and the baseline community. Data loggers were not intended for billing.

### *Surveys*

- Energy barrier surveys were designed as an early step in the project to identify the key barriers to energy efficiency and to confirm validity of targeting barriers that have been assumed based on anecdotal evidence.
- Community stores surveys were designed to determine the energy efficiency rating and cost of appliances available for purchase. Opportunities to increase the stocking rates of more efficient appliances were to be identified and investigated.
- Household and store surveys collected demographic information, barriers to energy efficiency, knowledge of energy efficiency, power card usage and attitudes on energy efficiency.
- Additional surveys were anticipated to be designed after further qualitative research was conducted to determine the priority areas where a structured survey would be of benefit.
- Data from these surveys was to be used to build a dataset to understand the breakdown of energy consumption in remote Indigenous communities.
- All surveys were to be produced by CDU and the LIEEP project team and then delivered to households by the LIEEP project team, the YEEWs or contractors as appropriate.

### *Database and information system*

The project design included establishing a secure database and information system specifically to meet the operational and reporting needs of the project, including the Australian Government's data collection requirements. The design was to be built on IP provided by PWC from its involvement in previous similar projects.

### *Monitoring and Reporting*

Data storage and reporting were to be set up to meet the needs of monthly progress reports to the consortium and stakeholders as well as quarterly milestone reports and data uploads to the Australian Government.

## 3.8 Evaluation and Research

Evaluation outcomes were central to the design and operation of the project. The ultimate goal of the project was the development of a best-practice framework that could be adapted to other remote Indigenous communities. More generally, strategies were to be put in place to tailor the knowledge created by the project and its evaluation activities to the needs of likely adopters of that knowledge. The design and implementation of the evaluation framework was to continue to be refined throughout the program. IES planned to commission an independent evaluation of the project at completion.

## 3.9 Project Targets

In the first agreed project plan, the various trials were summarised into high-level activities for the purpose of key performance indicators and budgeting. The table below provides the key performance table as per the first approved project plan[17].

Milestones 1 and 2 are not included in the table: milestone 1 was the signing of the funding agreement and milestone 2 was formation of the project team and submission of project plan documents.

*Table 2: Original project performance measures per milestone*

| **Milestone** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **Total** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Activity** | **Sep 2014** | **Dec 2014** | **Mar 2014** | **June 2014** | **Sep 2014** | **Dec 2014** | **Mar 2015** | **May 2015** | **Sep 2015** | **Dec 2015** | |
| Data logger installs | | | 300 | 250 | | | 70 | | | | 620 |
| Barrier surveys completed | 40 | | | | | | | | | | 40 |
| Stores surveyed | | 2 | | | | | | | | | 2 |
| Ambassadors trained | | | 0 | 10 | 0 | 0 | 0 | 10 | 0 | 0 | 20 |
| Households approached to participate in education program and incentive scheme | | | 10 | 40 | 40 | 40 | 40 | 90 | 90 | 90 | 440 |

[17] It must be noted that the first agreed project plan was finalised in Feb 2014 after six months of operation and therefore incorporates changes in that period, including reduction of the retrofit target to 440.

| Milestone | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Activity** | **Sep 2014** | **Dec 2014** | **Mar 2014** | **June 2014** | **Sep 2014** | **Dec 2014** | **Mar 2015** | **May 2015** | **Sep 2015** | **Dec 2015** | |
| In-house display installs | | | 0 | 0 | 50 | 50 | 50 | 50 | 0 | 0 | 250 |
| Households receiving retrofit | | | | 0 | 90 | 90 | 0 | 100 | 100 | 60 | 440 |


***Launch of the Manymak Energy Efficiency Project in Milingimbi, July 2014. Certificates were presented to the first YEEWs to be employed on the project.***

# Section 2: Project Methodology, Implementation and Results

Due to the nature of the project delivery and its evolving methodology, the trial methodology, implementation and results are presented in a combined format per activity area. Further qualitative and quantitative analysis results are also presented in the discussion section with additional detail provided in the appendices.

# 4 Community Engagement

## 4.1 Introduction

From the outset, it was clear that the success of the project would depend on effective community engagement. Without genuine interest and engagement from Yolŋu*,* the project would not meet its objectives. Of the LIEEP barriers discussed in the introduction of this report, the project's community engagement approach primarily sought to overcome the barrier of information failure.

The project's community engagement goals can be categorised into three overlapping areas.

1. Garner broad community support for the project from key stakeholders and Yolŋu residents.
2. Through two-way education, training and employment in the ambassador program, equip the Yolŋu energy efficiency workers (YEEWs) to facilitate informed conversations about energy and water efficiency with households.
3. Equip and motivate household residents to make informed choices about their energy and water use.

The original design of the community engagement approach for the project was informed by:

- The Centre for Appropriate Technology's extensive experience in delivering energy efficiency information to Indigenous people through the Bushlight program's installation of renewable energy systems in 130 remote homelands.
- Indigenous Essential Services' experience in delivering utility services to the six communities and in delivering water demand management educational programs in Arnhem Land communities.
- Consultation by the project team with community members and stakeholders at the commencement of the project, including the barrier survey.
- Feedback from community consultation in Galiwin'ku and Milingimbi commissioned by the project through Aboriginal Resource and Development Services (ARDS).

In order to achieve the engagement goals, the project developed a community engagement plan that laid out the following trials and strategies:

- identify and reach all stakeholders with a vested interest in efficient power and water use to play a champion or leadership role
- ensure residents know who to talk to in their community about the project
- ensure residents know who to talk to about problems with the power or water in their house and how to contact them
- encourage relevant service providers to respond in a timely manner to issues such as water leaks
- build understanding of the social, financial and environmental benefits of adopting more energy and water-efficient behaviours

- generate a shared sense of responsibility for efficient/responsible water management
- ensure the engagement approach informs good decision making
- develop a training kit to train local people as YEEWs
- utilise local skills and experience by employing Yolŋu in real jobs in their community
- YEEWs to deliver household education on energy and water efficiency with the assistance of an educational poster kit and other materials.

Many of the project components were delivered on an opt-in basis by households. This ensured that efforts were targeted at those households that were interested in potentially changing behaviour in some way.

Other components were to be assigned to houses without individual household residents opting in. These included the installation of data loggers into all meter boxes at commencement of the project, which formed part of the PWC metering system, and the installation of major retrofits, which were part of the scope services provided by DHsg as landlord for the community housing. Consultation and engagement for these components was also included in planning.

### *Principles Guiding Effective Engagement*

To ensure an effective relationship between the project and Yolŋu, the project had to establish and constantly revisit a raft of guiding principles. These principles, listed below, were embedded in the Community Engagement Plan and Facilitators Training Guide, two key documents that were developed early in the project.

*Table 3: The project's guiding principles*

| Principle | What this means in practice | How |
|---|---|---|
| Respecting culture | Acknowledging the differing mainstream (Balanda) and Yolŋu cultural values/worldviews.<br>Accessing communities through the appropriate cultural and administrative channels and being invited into the communities.<br>Allowing space for cultural business ahead of project business as appropriate, e.g. Yolŋu workers are not available due to cultural obligations, such as attending sorry business. | By tailoring training and education materials to be in line with Yolŋu cultural values.<br>By ensuring relevant community groups and leaders were consulted prior to work starting in each community.<br>By employing local Yolŋu mentors who were able to advise on appropriate cultural protocols. |
| Genuine two-way learning | In parallel to sharing mainstream project knowledge, delivering education that actively sought out knowledge and stories from Yolŋu residents and employees to help inform the approach and the content of the education program. | By explicitly embedding this two-way learning approach into the training delivery.<br>By working closely with and mentoring local Yolŋu workers, we encouraged them to amend materials and delivery methodologies to ensure content would make sense and 'fit with' Yolŋu worldview. |
| Actively valuing existing knowledge and starting where people were at | Established existing knowledge and build from that. Ensuring education built on people's existing knowledge of energy and water and its conservation rather than overlooking what people already knew and did in this space. | The engagement process incorporated documentation of residents' existing energy and water conservation practices.<br>One outcome of this approach was that this information provided a baseline and helped inform the project evaluation. |
| Making information accessible | Using feedback from communities, and through trialling different approaches, delivering education in the most accessible formats for the target audience. As the project evolved, this included: delivery in Yolŋu Matha, using multimedia, hands-on activities and | Internal project reporting captured feedback from existing engagement and education methods, and through an iterative process the most effective methods were retained and refined for |

| Principle | What this means in practice | How |
|---|---|---|
| | developing additional resources in communities in plain language rather than jargon. | the life of the project. |
| Flexibility and continual learning as a project | Recognising that the approach to education was iterative and adapted during the course of the project. Delivering education was paced to meet the needs of the learner/s. | The project approach to education was reviewed on a regular basis and adapted to reflect accumulated feedback from Yolŋu workers, residents and staff. |
| Tailoring information to the participants | Ensuring the education was tailored to the specific interests and needs of householders and being aware of what was and was not in people's control. | YEEWs were trained to ensure the actual situation of households was captured, including what appliances people use. |

### *Community Stakeholder Engagement*

The degree to which community stakeholders in each of the six communities needed to be informed and engaged varied greatly between different groups. Table 4 presents the stakeholder groups that needed ongoing engagement and the necessary strategies employed for this purpose.

*Table 4: Community engagement stakeholders*

| Stakeholder group | Engagement strategy |
|---|---|
| Yolŋu community leaders | Ensure more than one meeting occurs more than a fortnight and less than five weeks before project commences in each community. |
| Residents of participating communities | Household engagement through Yolŋu energy efficiency workers (YEEWs), barbeques at appropriate times e.g. community festivals, project start-up. |
| Local reference group and local authority | Regular meetings attended by project staff to keep engaged and informed about project progress. |
| East Arnhem Regional Council staff in community | Consortium partner and employer of YEEWs in Galiwin'ku, Milingimbi, Gapuwiyak and Yirrkala. Regular meetings attended by project staff to keep engaged and informed about project progress. |

## 4.1 Project Naming and Branding

A key part of the community engagement approach was to create a unique and distinctive name for the project that would reflect the consortium nature and its energy efficiency goals.

Two names were chosen for the project to reflect the two-way approach to the Yolŋu and non-Indigenous collaboration: one in Yolŋu Matha and one in a combination of English and Djambarrpuyngu (the most commonly spoken dialect of Yolŋu Matha):

1. *Dharray Manymakkuŋ Pawaw Ga Gapuw* (meaning 'looking after our power and our water' in Yolŋu Matha language)
2. Manymak Energy Efficiency Project (a combination of Yolŋu Matha and English languages, meaning 'good energy efficiency project').

The Yolŋu Matha project name was developed during a workshop in Darwin with ARDS Yolŋu consultants and subsequently tested by ARDS at early consultations with Yolŋu elders in Milingimbi and Galiwin'ku. Djambarrpuyngu represents four of the six language groups present in the project communities, with the other two language groups predominant in Yirrkala and Gunyangara. For those two communities the YEEWs' work shirts were re-issued and translated into the relevant local language group.

The project name in Yolŋu Matha captures the goals of the community education and engagement and included reference to water, recognising that water efficiency education would form part of the project's education. The project logo was designed in response to this understanding of the project.

*Project logo*

The English language 'formal project title' reflects the funding program but ties to place, people and project approach with the key word 'Manymak'.[18] The exclusion of water from the English language title reflects the funding program priority and the need for a concise form. It is a complement to the Yolŋu Matha name rather than a direct translation.

## 4.2 Development of Educational Resources

Prior to the employment and training of the ambassadors, which were the core of the community engagement approach, the project was to develop an ambassador training kit and householder education materials as part of milestone 5.

This section explains how the educational resources were designed and developed for the project, including an overview of the research and scoping stage of the development and an explanation of the poster kit and facilitators' manual.

### *Community Consultation Process*

The project team, through initial community and stakeholder engagement and the barrier survey process, identified that additional support was required to design the training and household education with Yolŋu. ARDS was identified as the organisation best placed to provide this support and was engaged to facilitate a community consultation process.

CAT staff accompanied ARDS staff to Milingimbi and Galiwin'ku for a week each during February and March 2014. These initial community consultations sought feedback from community elders and others interested in the project on how best to approach the employment and education components of the project. The results of that consultation then significantly informed the final design of the community engagement, including confirmation of the project name and logo, education design, ambassador employment and the incentive scheme.

[18] 2013, Consortium Paper 3: Project Name and Logo, p3

### *Building a Yolŋu Connection to Electricity*

The challenge faced early in the project was to sculpt a Balanda story of energy efficiency into one that would be 'felt' by Yolŋu. The clear message from Yolŋu was that electricity was a Balanda thing that has no connection to the rules and law that govern traditional Yolŋu life. Yolŋu utilised the energy services that access to electricity provides (refrigeration, cooling, lights and so on) but without ownership and without any existing connected cultural rules.

> *Power is a balanda thing (foreign, someone whose worldview values materialism); it's something that got introduced here. We never knew it was coming. No one explained it. We don't know how it's made or where it comes from. We don't care about it*[19]

Further to this was the understanding that the Balanda value placed on money and power cards was not shared with the Yolŋu participants. The benefit of 'saving money' or making a power card last longer as potential drivers of behaviour change held little attraction to participants early on in the project.

> *Camp leaders voluntarily described action Yolŋu households are already taking to reduce their power use, not because they value electricity or want to spend less money on power but because using power and being inside the house is an act of dependency on Balanda society and appliances. Being outside the house, cooking food on a fire and sleeping outside directly connects people with their cultural knowledge, which has a positive impact on people's wellbeing and mental and emotional health.*

Similarly, 'save' is not a concept or word that exists for Yolŋu and though other related concepts were discussed, including 'put aside' and 'for later', these also had little traction. 'Managing' was also seen as inadequate, hence the project name in 'looking after' power and water. The conclusion of this exercise was that for the project to work, ways of engaging Yolŋu to value electricity through their own worldview were required. This was seen as possible if Yolŋu could build a sense of 'Märr' (Yolŋu sense of spiritual/personal value, feeling and connection) in relationship to an electricity story.

### *Building an Entry Point for Resources*

Yolŋu feedback during these consultation visits was clear—they wanted to know the full story about the project and its drivers and about electricity and not just a 'surface' story, which may have been more expedient from a Balanda perspective. In other words, the foundational knowledge was required to enable them to understand electricity and energy efficiency. Yolŋu concern around local mining and mineral extraction was evident. There was some talk of local exploration to commence oil drilling offshore to Milingimbi. This was met with concern from residents. Alongside this were misconceptions about how power reaches communities and households; one misperception was that diesel was pumped through power lines from Darwin.

Given this background, it was clear that the educational resources had to start from the beginning, including mining and drilling for oil, all the way to the energy services used in homes. These messages included:

- the drilling of oil
- transfer of oil from barge to pipe, then into storage

[19] ARDS, Key Findings and Learning from Field Trips to Milingimbi and Galiwin'ku for the Dharray Manymakkuŋ Pawaw Ga Gapuw Project, 20/3/2014

- converting oil into electricity (using a motor vehicle analogy)
- how electricity moves around the community
- how electricity reaches houses and is measured by meters.

Connecting electricity to country through these messages enabled a connection of this new knowledge to existing Yolŋu knowledge and priorities.

### *Facilitators Training Guide*

A 'Facilitator's Training Guide' was developed by the project team as a deliverable for Milestone 5 in March 2014. The guide detailed the content and deliveryof training to the YEEWs to equip them to carry out their work engaging and educating households. It explained the approach behind the project and notes on learning activities. The guide was designed for use by a skilled facilitator who may not have had previous exposure to energy efficiency concepts.

The Facilitators Training Guide was a detailed document of 15 training sessions, with specific topics to be covered and learning outcomes. Sessions covered in the guide include:

- Introduction to the project, including purpose and background.
- Traditional power and water story and historical context.
- Where does our power and water come from? Including institutional arrangements and infrastructure.
- What does the engagement and education look like? Behaviour change, motivations, opt-in only, respect for privacy.
- Incentives and retrofit scheme, including explanation of the technology retrofit part of the project.
- How to introduce the project to a household.
- Keeping track of work undertaken, including data collection and management.
- Safety on the job, including risk analysis and OHS reporting.
- How is power used? Talking to residents about electricity and appliances, including introduction of the poster kit.
- Comparing appliance and power consumption costs, helping residents understand the big differences in how much power different appliances use.
- Ways to save power, working through the poster book to discuss saving power for different energy services.
- What's the power and money story of this house? House-specific power use, challenges and power budget exercise.
- How water is used and measured, including meters and consumption issues.
- Ways to save water, including conservation methods and reporting.
- BEEBox, including the function of the device, developing a power budget and training residents on the BEEBox.

The document was used by the project team for delivery of training in Milingimbi and Galiwin'ku and then formed the brief for ARDS to develop their training approach for the four remaining communities.

### *Poster Kit*

The poster kit was developed as the core set of visual educational resources used both for training the YEEWs and then for use by YEEWs when engaging with households. They were a series of A3 pages bound together in a booklet, with each page describing a different message around energy or water efficiency.

The purpose of the posters was that they be carried around during house visits and used to prompt discussion for issues of relevance to particular households. They were also to remind the YEEWs of key behaviour-change messages that would assist in understanding energy and water supply systems and saving power and conserving water. CAT staff observed that much of the information exchange at the household level was conducted verbally and in Yolŋu Matha. The posters supported conversations, rather than the reverse.

The suite of posters was developed by an Indigenous graphic designer, drawing on a range of visual educational materials that CAT and PWC had used in previous energy education projects. As the project rolled out, several posters were added in response to project need. The poster books were initially printed and laminated and then subsequently printed on plastic coated paper, suitable for daily use for the duration of YEEW employment.

A summary of the key poster messages includes:

- Outside and in the garden
  - outside spotlights use a lot of power
  - turn spotlights off during the day
- Keeping cool
  - close your blinds and curtains to keep the house cooler
  - keep in the shade
  - use the ceiling fan first to keep people cool
  - plant trees on the sunny side of your house for more shade
  - instructions on efficient use of air-conditioners
- Washing (in bathroom and laundry)
  - use cold water to wash clothes
  - save hot water for showers
  - only run the washing machine when it's got a full load of clothes
  - use the sun to dry clothes—it is free
  - press the booster once for hot water—it might take some time to heat up
  - the booster button should pop back up after you push it. Don't tape it down. It will break.
- Cooking
  - try and cook one big meal instead of lots of little meals
  - cover pots when boiling water and cooking food to keep the heat in
  - check the oven switches are off when not cooking
  - use a kettle to boil water instead of a billy on the electric stove top
  - only boil the amount of water you need
- Keeping food cool (fridge and freezer)
  - keep the fridge door closed as much as possible
  - set the temperature of your fridge and freezer to a middle setting
  - keep the cold air in by keeping your fridge seals clean and in good condition
  - defrost your fridge and/or freezer when it frosts up. Thick ice strains the motor
  - make sure there is a gap between the fridge and the freezer and the wall for air flow
  - choose a fridge or a freezer with a high star energy rating

- Using appliances
    - turn off the appliances when not in use
    - keep appliances away from curtains. They get hot and can cause fires
    - choose appliances with a higher star energy rating
    - limit using high energy use appliances if you can (power tools, air-conditioner and electric stove)
- Lighting your house
    - use natural light where possible
    - limit the use of outside spot lights—they use lots of power
    - replace old light bulbs (including spotlights) with new CFL (surly) bulbs. They use less power and last longer
    - if you have fluoro lights, remove a second tube to save power
    - turn off lights when you leave the room and get the kids to do the same.


***'How much does power cost' page from the poster book***

## 4.3 Ambassador Program

### *Employment of Yolŋu Energy Efficiency Workers*

The ambassador program[20] is the name given to the employment and the training of Yolŋu energy efficiency workers (YEEWs) to achieve the project's household engagement goals. The ambassador program was central to successful engagement and the delivery of the project. The program provided the main contact point between the program participants (residents) and the project delivery team.

The YEEWs were supported by the project team from Darwin with ultimately three dedicated community engagement officers and other project support staff travelling frequently to the communities. The YEEWs were employed part time at industry casual rates by a local community host organisation contracted for each community separately. The education, training and employment of the YEEWs was developed with the goal of equipping Yolŋu to make informed decisions about how to use energy (and water) efficiently in their homes. To achieve this required working with Yolŋu in a two-way learning approach to develop an energy and water story relevant to their lives and the lives of other Yolŋu living in communities.

Interpersonal relations and those between the YEEWs and the participating households were integral to the success of the ambassador program. Interaction was driven by Gurruṯu, the complex networks of kinship that link individuals and groups to each other and anchored deeply into the cultural foundations that govern relationships. Gurruṯu determined the equitable representation of people from a cross-section of families with the YEEW teams, without which perceptions of bias in the recruitment process might prevail.[21]

The project needed to operate within the context of many different clans being housed within communities, often in conflict with cultural requirements thus creating tension[22]. The building of teams of workers that could understand and collectively navigate these cultural needs and tensions within communities was central to the ambassador program design.

### *Purpose and Scope of Ambassador Program*

The purpose of the ambassador program was to establish partnerships that would enable the delivery of the project trials through the training and employment of local people in each community. The YEEWs would visit participating households up to five times and deliver a staged educational program. The YEEWs were tasked to:

- generally promote the project within the community
- approach households to voluntary participate in the project
- conduct an initial appliance survey and have the privacy notice signed by participating households
- deliver energy efficiency and water conservation education to households

[20] The term 'ambassadors' was the initial name for the local Yolŋu who were to be employed on the project. This term remained in place in the context of the funding agreement and project plan, but the positions that were created were renamed as Yolŋu Energy Efficiency Worker (YEEW) as it held greater resonance in communities.

[21] Without Gurruṯu*,* situations might emerge where it is impossible to approach some households because of an avoidance relationship, such as a poison cousin, which means both people cannot interact directly with each other

[22] See Patrick Dodson *et al*, 2009, *Our Home, Our Homeland*: *Community Engagement Report*, Outstations Policy, Northern Territory Government.

- offer households the choice to opt-in to obtain energy efficiency upgrades and the BEEBox technology
- revisit houses as required to provide further education and support to the technologies
- inform and provide contractor support for the installation of major retrofits to houses.

Within the project requirements, the scope of the YEEWs' work related to community housing only. However, initial community consultation found that many participants identified that the project targeted Yolŋu at the exclusion of non-Indigenous residents and commercial facilities. Some Yolŋu were concerned that Yolŋu were being targeted as high energy users when in fact they recognised that it is often Balanda that use a lot of power. For example, it is well known that some Balanda workers in communities have their power bills paid by their employer and therefore leave their air-conditioners running when they're not home because there is no incentive for them to reduce power use. As a consequence, PWC put in place a non-residential energy and water efficiency project of its own in parallel to the project to address this potential concern.

### *Contracting*

The project team developed a contractual scope of work for an external party to host the employment of the YEEWs in each community. The design of the contract scope evolved through each community, but in each case was a 'schedule of rates' contract with a maximum value. The contracts all had core elements of:

- provision of an office space, a computer, telephone and printer
- provision of a fully maintained vehicle
- employment of a supervisor, senior YEEW/s and several YEEWs per community, for nominally 20 hours per week over a three to six-month period.

PWC issued open tenders for each community and assessed applications against the selection criteria in the contract documents. Contracts were then issued and were managed directly by the project director. Variations to these contracts included extension of time, addition of positions, changes to levels and addition of mobile phones for the supervisor in each community

### *Recruitment*

Recruitment of YEEWs was undertaken in varying ways in the different communities. This variability stemmed from which employment provider was used, their processes and the needs and requirements of the community. Details of the recruitment processes for each community are included in the subsequent community sections.

### *YEEW Training*

**Methodology 1: Community engagement officers and interpreters**

This was the model used for the initial training of YEEWs in Milingimbi and Galiwin'ku. The training was delivered using a workshop-style format that was made as interactive and hands on as possible. Training was delivered by the Darwin-based project staff—the community engagement officer, with additional expert training provided by CAT staff especially around specific content, such as using the BEEBoxes. This training was delivered with the assistance of a qualified interpreter employed through the Aboriginal Interpreter Service (AIS).

To support the training, a suite of image-based posters was developed to help deliver key concepts.[23] The training was delivered using a ‘two-way’ approach, with the trainer actively learning from the workers as well training them. For example, the YEEWs were consistently consulted on how to word the education content with householders throughout the training in order to improve the success of household education and also gain ‘buy in’ or ownership over the process from the workers. Two-way learning is a determining principle that has been built into the framework of knowledge relationships between Yolŋu people and others for more than a decade.[24]

The approach to the delivery of YEEW training was to gradually build the knowledge and skills of the workers over a period of months. This stepped approach ensured that the workers were confident in their subject matter to carry out the household engagement and education and not overwhelmed by too much new information all at once. What this meant on the ground was that the Yolŋu workers received training in a number of ‘modules’ and started delivering this information to the households. Once some coverage was made with these topics, further training on new modules was given and this information was then delivered to the households.

The first training sessions for the YEEWs were delivered for approximately four hours a day over the course of four to six weeks prior to the YEEWs starting first house visits. The pace of delivery needed to be flexible to meet the needs of learners. CAT staff developed a training manual that was a lesson plan document covering about 15 sessions on a variety of topics and a facilitators training guide. Both of these documents were used in Milingimbi and Galiwin’ku at the start of YEEW training in those two communities.

The delivery of the initial training in Milingimbi and Galiwin’ku by community engagement officers was an important step in piloting the approach while simultaneously building the tools and role of the ambassadors within tight timeframes, with the technologies, evaluation and household data collection approaches all evolving in parallel. The resultant training was thorough and necessary given resource and time constraints, but the fact that it was predominantly delivered by non Yolŋu Matha speakers in English with an interpreter providing translation into Yolŋu Matha was quickly identified as a barrier to effective learning. In addition, scheduling of the project identified that delivery of four to five weeks of training across the next four communities was not possible within the project team resources.

**Methodology 2: ARDS engaged to train in Yolŋu Matha**

The Aboriginal Resource and Development Services (ARDS) Aboriginal Corporation was contracted to provide the training for all work teams from February 2015. The organisation provided two non-Indigenous trainers fluent in Yolŋu Matha and two to three Yolŋu trainers. All of the trainers had extensive experience in delivering complex and technical information to adult Yolŋu in east Arnhem Land. ARDS was ideally placed to deliver the training as it works in the two-way learning approach with a Yolŋu educator partnered with a Balanda educator.[25]

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[23] These have not been included in this report; visit www.powerwater.com.au/lieep

[24] See the various Key Forum Reports of the Garma Festival held at Gulkula in August each year and produced by the Yothu Yindi Foundation.

[25] “Engaging in discussion (dialogue-based learning) works best if a Balanda and Yolŋu person work together to deliver the education, each having some facility and competence in the other’s first language. In addition, each person needs to have credibility/authority on the matter they are discussing. In this way, Yolŋu mentors and officers can discuss Yolŋu matters while the Balanda (non-Indigenous) person explains electricity and other Balanda concepts.” ARDS 20/3/2014

After extensive consultation with the senior community engagement officer, ARDS was briefed on the training manual that had previously been used and developed an approach to delivering the education in language that evolved throughout deployment across six communities. The education approach grew to include delivery of employer induction, water conservation and follow-up energy efficiency and BEEBox training for each community. The delivery per community is summarised in the table below.

*Table 5: Training modules completed by ARDS in each community* [26]

| Community | Work induction (2 days) | Project content and delivery (4 weeks) | Water conservation (3 days) | Energy efficiency top up (3–5 days) |
|---|---|---|---|---|
| Milingimbi | | | ☑ | ☑ |
| Galiwin'ku | | | ☑ | ☑ |
| Yirrkala | | ☑ | ☑ | ☑ |
| Gunyangara | | ☑ | ☑ | ☑ |
| Gapuwiyak | ☑ | ☑ | ☑ | ☑ |
| Ramingining | ☑ | ☑ | ☑ | ☑ |

The resultant ARDS training methodology was grounded in Yolŋu Matha language and connected Balanda concepts to existing Yolŋu understanding. An example of this can be seen in the training reflections from the Galiwin'ku 'top-up' training session relating how the BEEBox in-house display worked:

> *Then we introduced the BEEBox. There are two parts—the brain and the story teller…The story teller tells three stories. The first is the speedo. This tells us how fast the power is being used. If there are dhapinya girri (humble/generous appliances), not a lot of power will be used and the lights might be green. When l̲alkal (more greedy) appliances are eating power, they will shovel it into their mouths and the lights might show orange. When lots of l̲alkal girri are eating all together, they mamulmamulyun (pack into their mouths too fast) and nyiw'nyiwyun (eat like a pack of dogs wanting the same bone). The light will show red and we know that the food is disappearing very fast. The last two stories are the same but they are told in two different languages. One is told in the language of lights and the other is told in the language of numbers/money.* [27]

Another example of using the Yolŋu worldview to explain Balanda concepts came from a training session at Yirrkala, where the idea of setting an 'energy budget' for the BEEBox was tackled in the following way:

> *After a break, we went back to the target/budget search and concluded that English likes to use this type of abstract noun, but Yolŋu Matha focusses more on the action. When Balanda think about aiming for a target, Yolŋu think about aiming for a fish or a wallaby etc. So we needed to understand what specifically the target is and talk about that rather than talk about budgets/targets in a general sense. I then gave an example that if I was hunting with just one spear and I was hiding and then I saw three animals, a very small wallaby that was pretty close and an easy target (but maybe not enough food for the whole family), a really big buffalo that was far away (more than enough meat, but I might miss it or just wound it so it gets angry and attacks me), and in the middle there is a smaller, young buffalo with lots of tender meat at a*

[26] Work induction modules were delivered by EARC in Milingimbi, Galiwin'ku, Yirkala and Gunyangara.
[27] (ARDS, Training Reflections EE top up – Galiwin'ku, 2015)

*reasonable distance. I drew them up alongside the target line on our graph. I explained that the analogy I was trying to use was that the wallaby might be a $50 target (easy to stay in the green, so you feel good, but maybe you're not going to save much money). The big bull buffalo might be a very ambitious target of $5 (might always hit red and feel bad that you can't do it right – but if you are a very skilled hunter that has had LOTS of practice, maybe it is possible). The young buffalo is a middle range/realistic target with an acceptable reward – maybe $20 (might hit it most times, sometimes you miss, but everyone is happy when you get it).*

The education methodology delivered concept-based education in response to 'problems' that people wanted answers to or in response to issues causing confusion.[28]

Early consultation with Yolŋu community representatives highlighted that it is important to base the training in a foundational story (Dhuḏi dhäwu) to capture people's attention and have a depth to the story.

*Explore the cultural value of power/electricity by examining where it comes from (under the ground or sea) and how/if it is of value (put there by the Creator). This foundational story still requires a lot of testing, but it is ARDS' view that this story is a critical platform from which to introduce new information. Through conversation, it is clear that how and where power is made needs to be 'close to home' and contextualised. This could occur, for example, starting with a map of Australia including the Timor Sea and discussing how power is made and where it comes from across Australia including to the north of north east Arnhem Land.* [29]

In the initial training at Milingimbi and Galiwin'ku there was insufficient time to allow for thorough training on foundational stories due to the need to cover material that would help meet milestone deadlines.

Galiwin'ku and Milingimbi had some training sessions with ARDS later in the project delivery and could compare them to the earlier training sessions conducted by the community engagement officers. In Galiwin'ku, the community engagement officer noted in her trip report of July 2015, a discussion with a senior worker that:

*… even though the earlier training [delivered by the project team with interpreter support] had been good, doing it in Yolŋu Matha was much better, especially to understand difficult things like the BEEBox.*

It was identified through ARDS' initial consultation with Yolŋu that general purpose training that did not relate immediately to work was unproductive. The project-specific training was not designed or delivered in a way that mapped onto existing accredited training. Subsequently, as the project rolled out, interest grew from EARC as the employer for four of the communities in providing accredited training for the workers in order to support their future job prospects. To this end, the project supported YEEWs to attend training with Batchelor TAFE to complete a Certificate I to III in Business Administration. This was organised by EARC with the training hours included in the YEEW duties. Eleven people took up the opportunity from Yirrkala, Gapuwiyak and Galiwin'ku.

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[28] The challenge was to not only try to identify meaningful story lines that resonate with Yolŋu worldview which can then form the basis of education with households, but to also understand the issues/problems people have in relation to power so Yolŋu energy workers and mentors can respond to these. (ARDS, 20/3/2014)

[29] 'Homelands belong to the clans. They are not outstations of a larger community where people go for a better lifestyle. They are the lands that have always belonged to the clan…They are the homelands of the people and they are the Djalkiri, the heritage of the people.' Submission extracts from written #40

*Message from Mala Leaders at Galiwin'ku to the NTG December 2008, cited in Dodson, Op Cit, 2009*

## *Merchandise and YEEW shirts*

Project-branded merchandise and promotional material was produced and purchased, primarily intended as a kit gifted to householders on the first house visit. The kit included a short brochure explaining the project, an aluminium mug, a reuseable water bottle and pens branded with the project logo. These were also distributed at project information days and at other events in each community.

A YEEW shirt was also designed to distinguish the project team in the community. The first shirt was yellow, and discussion with the Milingimbi YEEWs was that it was too close in appearance to the Walking School Bus program. A multi-colour design was chosen as the final shirt design that avoided any confusion with colours associated to Yolŋu clans.

***The Garma Festival energy and water efficiency information stall, July 2015***

## *Manymak Energy Efficiency Project Videos*

It had been the intention of the project from as early as 2014 to produce some educational and promotional resources using video in order to connect with Yolŋu communities and be played at the local ALPA stores. Having been delayed, a scope of requirement was released in May 2015 to tender for the design and production of two short promotional/educational videos aimed at a broad Yolŋu audience across six east Arnhem communities. Strong engagement and involvement of Yolŋu, appropriate technical skills and equipment, translation and subtitling was required. A Northern Territory production company was appointed to produce the videos. One video was created about the BEEBox and one provided an overview of the project.

Before filming, CAT prepared a scope of works and story board for the two films. The decision was made to film primarily in two communities—Yirrkala and Gapuwiyak—but to represent the other communities by including photos. Yirrkala and Gapuwiyak were selected because of ease of access and they also represented more than one language group (Dhuwal, Dhuwala, Dhuwaya and Dhaŋu) and therefore meant the most efficient use of resources.

Preparation for filming included discussing what to include on film, whether people were happy to speak to camera about the project and getting ideas for the film by visiting houses.

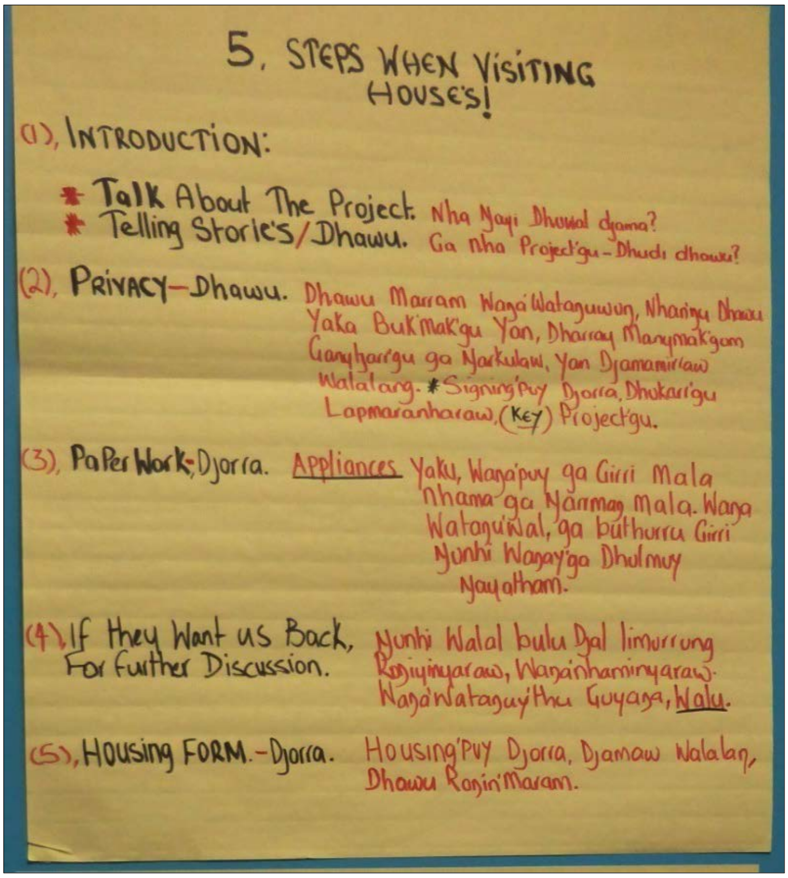
***Filming underway for the Manymak project videos in Gapuwiyak*** [30]

## 4.4 Household Engagement

After awareness in the general community was raised and project publicity underway, the starting point to engage Yolŋu households was an initial visit by a team of four to six YEEWs. The first house visit was on-the-job training for YEEWs, and they were encouraged to approach households with which they felt comfortable engaging. As outlined under the ambassador program details above, the YEEWs selected households based on ensuring they were in the correct kinship relationship. On this first visit, they described the project and sought participation. Household residents were introduced to the project and traditional stories about power and water to provide a solid foundation and understanding of the project's purpose and their involvement as participants. Education then incorporated stories about how power can be saved and why people might want to save power. Information regarding how people's information would be used and privacy was discussed and consent given by householders. Education was delivered at the house, generally in a shady area outside.

The YEEWs then facilitated the householders' choice of particular energy efficiency and water conservation topics that they were interested in or that were applicable to their house. An 'on-the-job' field guide was developed early in the project to assist the YEEWs to facilitate conversations and to remember which posters could be used to help deliver information on particular topics. However, one observation by the community engagement officers was that the field guide was not central to this process. Instead, most teams of YEEWs developed their own wall chart system in the office, noting what was needed for each type of visit. See an example below.

[30] The final videos can be seen on YouTube by searching 'Manymak Energy Efficiency Project'




***Wall notes from the YEEWs office in Yirrkala detailing the steps involved for the first house visit***

To ensure the engagement principle of making information relevant was met, YEEWs made sure to tailor the information they delivered to the circumstances of each house. For example, some residents wished to discuss or show what appliances they have. That then became the focus of the topic, and any gaps in understanding about the best ways to use those appliances were addressed. As with the YEEW training, the household engagement and education was paced to suit the needs of householders. The following was a guide used in Yirrkala and Gunyangara and then modified for Gapuwiyak and Ramingining to cover the four main energy visits. Additional visits around water conservation, stove timers, installation of major retrofits and final visits were also undertaken. YEEWs used the poster kit to support the delivery of most of the information for the household engagement.

### *Collecting Data at Household Visits*

The project relied on the YEEWs to collect data while they were engaging with households. The data collection forms were designed in consultation with the YEEWs, thereby ensuring the YEEWs were confident in their ability to accurately collect relevant information. This included the knowledge, attitude and behaviour (KAB) survey form, the household appliance survey form and the house visit form. Feedback and modification was also sought from the YEEWs and the interpreter in Milingimbi on the Commonwealth-required privacy notice. Every house visit was recorded on a form and included information about the type of visit, who attended, who the YEEWs actually spoke with and how many people were staying at the house. The accuracy of the information was important to ensure measuring and reporting the success of the project. In preparation for the data collection, the YEEWs took part in roleplay house visit workshops during initial training and also practised filling in forms when they visited one of the first houses in the community.

Every community had access to an office and a lockable filing cabinet in which the forms were stored after being processed. Most of the communities set up operational methods to cope with such requirements of the project. In Yirrkala, for example, each member was responsible for shared activities such as filing, timesheets and cleaning the car and office. Once completed, most of the data collection forms were emailed to the Darwin LIEEP office.

*Table 6: Schedule for household engagement*

| Activity | Tasks | Materials / resources |
|---|---|---|
| First house visit | The energy efficiency workers are comfortable to visit the houses in their community to tell householders about the project (what it is and why) and explain what their jobs involve. They are able to give a brief basic overview about using power and water in a good way, explain and complete the privacy notice and fill in the appliance audit.<br>Every house visited requires a house visit form to be completed.<br>Approximate time of visit is half an hour to one hour. | Project flyer<br>Promo items, pen, bag, mug to leave with the household. Plus:<br>• house visit record form Yirrkala<br>• house visit record form Gunyangara<br>• house appliance survey form<br>• privacy notice<br>• privacy notice, plain English<br>• audio file Djambarrpuyngu privacy notice.<br>Posters:<br>• LIEEP Australia locations<br>• using power in a good way<br>• wasting power<br>• using water in a good way<br>• wasting water. |
| Second house visit | Talk about the story of power generation, the costs of using appliances for cooking, cooling and hot water.<br>Target houses that have had a hot water upgrade or other retrofit.<br>Use the appliance audit to discuss air-con story. (if applicable)<br>Leave poster information about costs of using appliances.<br>Workers understand repairs and maintenance process for their community.<br>Every house visited requires a house visit form to be completed.<br>Approximate time of visit is half an hour to one hour. | House visit record form<br>Posters<br>• oil and diesel story, power to the house<br>• power is dangerous<br>• the air-con story<br>• hot water systems (cylinder, solar, heat pump)<br>• power costs - three posters. |
| Third house visit | Prior to this visit, energy workers have had a BEEBox in-house energy display installed in their houses (opt-in) and are familiar with its purpose and operation.<br>Discuss the allocation process of a limited number of BEEBoxes and how to undertake this.<br>Once determined which houses will receive a BEEBox, this visit will involve YEEWs discussing with residents what budget they want set and where to locate it in the house. Visit will also involve discussion on and measuring electricity use (data loggers). | Forms:<br>• BEEBox sign up and display location form<br>• house visit record form.<br>Posters:<br>• BEEBox x 2 posters<br>• cost of using appliances<br>• other posters as required (air-con story etc.). |
| Fourth house visit | Post-install of BEEBox.<br>More in depth energy efficiency discussion re particular household appliances<br>Recap on BEEBox information, reiterating key points:<br>• BEEBox is not connected in any way to power card, just providing information<br>• Costs 1c per day to run, or say $4 per year.<br>Approximately one-hour house visit. | Forms<br>• house visit form<br>• FAQ BEEBox form<br>• post-install BEEBox checklist.<br>Posters<br>• BEEBox posters<br>• post-install. |

### *Ambassador Program Completion*

A clear message from the Yolŋu people involved (both employees and participants) towards the end of the employment was their desire to have the program and employment extended to a longer term. To ensure transparency and build trust with the communities involved, all community engagement and project staff were up-front about the project completion schedule with project participants.

An 'exit strategy' was developed in mid-2015 to ensure orderly and respectful wrap-up of work in communities. These were written up for use in each of the communities, depending on their separate timelines. Key points in the exit strategy include:

- completion dates for finishing house visits and employment ending
- project end dates, including Darwin-based project team work, evaluation work and report writing
- why the project is ending, given set timelines and budget
- linkages to new jobs for Yolŋu staff—how the community engagement team attempted to support the YEEWs to secure further employment
- plans for the BEEBox, instructing residents that BEEBoxes were for the household to continue using but that no further technical support or replacement would be provided. Further, that with the roll-out of new power meters in the coming months/year that the BEEBoxes would likely be removed at that time
- instruction on issues arising from faulty hot water systems and stove timers—phone numbers provided for relevant maintenance staff and agencies.

## 4.5 Ambassador Program Results

A summary of the results of the ambassador program is provided, which is then followed by a detailed account of the project implementation in each community.

### *Yolŋu Employment Summary*

Table 7 summarises the number of employees, the start and end dates and the hours the YEEWs worked in each community. The number of male and female employees is shown in each community.

*Table 7: YEEW employment summary*

| | Milingimbi | Galiwin'ku | Yirrkala | Gunyangara | Gapuwiyak | Ramingining | Total/ average |
|---|---|---|---|---|---|---|---|
| Employer | EARC | EARC | EARC | MRC | EARC | CoreStaff | |
| Employment start date | 1/05/2014 | 6/10/2014 | 10/02/2015 | 13/02/2015 | 7/04/2015 | 25/05/2015 | |
| Contracted employment end date | 27/11/2015 | 4/12/2015 | 18/12/2015 | 21/07/2015 | 18/12/2015 | 10/12/2015 | |
| Yolŋu recruitments | 20 | 24 | 14 | 7 | 16 | 11 | 92 |

| | Milingimbi | Galiwin'ku | Yirrkala | Gunyangara | Gapuwiyak | Ramingining | Total/ average |
|---|---|---|---|---|---|---|---|
| Number trained[31] | 19 | 21 | 12 | 5 | 13 | 11 | 81 |
| Number of hours to date | 6333 | 6380 | 4611 | 937 | 4060 | 2550 | 24873 |
| Male employees | 10 | 15 | 6 | 4 | 10 | 7 | 52 |
| Female employees | 10 | 9 | 7 | 4 | 6 | 4 | 40 |

Table 8 shows the number of house visits conducted by the YEEWs in each community and recorded on a house visit form.

*Table 8: The number of house visits completed by YEEWs in each community*

| Community | LIEEP households | Sum of visits | Average visits per house |
|---|---|---|---|
| Galiwin'ku | 216 | 508 | 2.4 |
| Gapuwiyak | 102 | 373 | 3.7 |
| Gunyangara | 29 | 237 | 8.2 |
| Milingimbi | 115 | 848 | 7.4 |
| Ramingining | 85 | 481 | 5.7 |
| Yirrkala | 86 | 325 | 3.8 |
| **Total** | **633** | **2772** | **4.4** |

Each house visit involved one or more activities that were recorded separately, such as approaching the house owner to introduce the project and also offering a BEEBox or advising of a major retrofit. Subsequent visits may include multiple tasks such as BEEBox installation and budget discussion or offering a stove timer and related discussion. The later visits generally involved following up on the installed BEEBox and retrofit and as well as on water conservation education.

The individual tasks involved in different visits can be summarised into three broad categories: initial request to participate, visits that involved some form of energy education (power story, BEEBox and retrofit consultation and engagement) and the water education visits.

The number of houses, percentage of houses and total number of visits in each category is organised in the tables below. LIEEP households represents all those that received a Taggle data logger, which is in essence all houses eligible to participate in the project under the LIEEP guidelines.

The number of approached houses is the sum of houses that were visited to introduce the project and agreed to the privacy notice. The appliance survey count is the sum of all the houses in which the appliance survey was conducted (typically at the same time as approach to participate). Further, the tables list the number of houses that received at least one energy education visit, the total number of energy education visits in each

[31] YEEWs were counted as trained after fifteen days of attendance at the initial four week training, or through fifteen days of on-the-job training for later recruits

community, the number of houses that received at least one water education visit and the total number of water education visits in each community.

*Table 9: Total number of household visits per category*

| Community | LIEEP households | Approached houses | Appliance surveys | Energy education houses | Energy education visits | Water education houses | Water education visits |
|---|---|---|---|---|---|---|---|
| Galiwin'ku | 216 | 159 | 150 | 187 | *399* | 98 | *115* |
| Gapuwiyak | 102 | 102 | 102 | 102 | *276* | 94 | *143* |
| Gunyangara | 29 | 24 | 22 | 22 | *236* | 11 | *13* |
| Milingimbi | 115 | 114 | 111 | 114 | *686* | 110 | *208* |
| Ramingining | 85 | 83 | 76 | 83 | *385* | 81 | *109* |
| Yirrkala | 86 | 82 | 72 | 81 | *272* | 69 | *78* |
| **Total / average** | **633** | **564** | **533** | **589** | ***2254*** | **463** | ***666*** |

Table 10 shows the same information as a percentage of total potential houses (not just of those that were approached) and average visits per house in each education category. The highest percentage of households engaged was in Gapuwiyak, with every eligible house agreeing to participate. The lowest percentage of households that received house visits was in Galiwin'ku, largely because of the impact of cyclones Lam and Nathan. The average number of water education visits is roughly one visit per house.

*Table 10: Percentage of houses approached per visit category*

| Community | Approached | Appliance survey | Energy education | Water education | Energy visits per house | Water visits per house |
|---|---|---|---|---|---|---|
| Galiwin'ku | 74% | 69% | 87% | 45% | 1.8 | 0.5 |
| Gapuwiyak | 100% | 100% | 100% | 92% | 2.7 | 1.4 |
| Gunyangara | 83% | 76% | 76% | 38% | 8.1 | 0.4 |
| Milingimbi | 99% | 97% | 99% | 96% | 6.0 | 1.8 |
| Ramingining | 98% | 89% | 98% | 95% | 4.5 | 1.3 |
| Yirrkala | 95% | 84% | 94% | 80% | 3.2 | 0.9 |
| **Total/average** | 91% | 84% | 92% | 74% | 3.6 | 1.1 |

# 5 Community Ambassador Programs

## 5.1 Milingimbi – May 2014

### *Introduction*

Milingimbi Island, also known as Yurruwi*,* is part of the Crocodile Islands in the Arafura Sea just off the north coast of central Arnhem Land. It is 440 km east of Darwin and 200 km west of Nhulunbuy and only accessible by air and sea. The island's population is approximately 1259, with 116 households eligible to participate in the project. [32]

### *Scoping*

Milingimbi is one of two LIEEP communities the Aboriginal Resource and Development Services (ARDS) Aboriginal Corporation visited in February 2014 during the project's design phase. ARDS and Centre for Appropriate Technology (CAT) staff held seven sessions in Milingimbi to gather information about the most effective ways to approach households and the community about the project. The community engagement was guided by the resultant report.

Milingimbi was the first of the six communities to participate in the trial community engagement process.

### *Recruitment*

In response to the ARDS consultation in community and other feedback received, the structure of Milingimbi's team of local workers was designed to include at least two representatives from each of the five Milingimbi camps, including an elder as mentor and facilitator.

The East Arnhem Regional Council (EARC) was contracted to employ the Yolŋu energy efficiency workers (YEEWs) in March 2014. Position descriptions and job advertisements were then posted on EARC noticeboards.

The Arnhem Land Progress Association (ALPA), as the contractor for the Remote Jobs and Communities Program (RJCP), helped identify suitable workers, including the project supervisor.

Initially, EARC employed 16 workers: one supervisor, one Senior Yolŋu energy worker, five Yolŋu elder energy workers and nine Yolŋu energy efficiency workers.

Most of the workers, including the supervisor, were already employed by ALPA to conduct the school attendance program in the mornings; their positions were extended to work on the project in the afternoon. This arrangement facilitated the employment's rapid start up, which was necessary to meet milestone targets for initial household approach.

EARC provided a vehicle and office space a few weeks into the employment, creating a 'home' for the project. Before that, training and meetings were held in the RJCP training area or the council office boardroom. The benefit of having a dedicated office space was reinforced for the project team with this early experience in Milingimbi:

[32] See the ABS Census 2011, and NTG Department of Housing, respectively.

*I can't overstate how positive it is to have a dedicated space to work in in Milingimbi. Not only does it make the organisational administrative processes more efficient and secure, but the positive effect on the YEEWs is most apparent. It is our gathering place; our dedicated space with posters and photos and, most importantly, the location of our files and paperwork so that the YEEWs can come to the same place every day to attend training or collect survey forms. Prior to having the office, we needed to negotiate a space with RJCP or EARC to train in. All our paperwork, training materials and other resources were stored in the RJCP office (as a favour) and were lugged around day to day.*[33]

## Training

Training was delivered over five weeks by the CAT community engagement officer with assistance from an interpreter from the Aboriginal Interpreter Service (AIS). One interpreter—a resident of Milingimbi—consistently worked with the team and became an important member of training and group discussions.

The training followed the project's Facilitators Training Guide. The initial training introduced the project, how it fit with other LIEEP projects around Australia and the other NT communities taking part. Topics also included the origin of oil and diesel, electricity and power generation, and the energy efficiency of electrical appliances. Participants role played house visits and practised short scripts. The male workers also visited the diesel generation plant with Power and Water Corporation's essential service officer, who explained the workings of the plant (the plant is near a men's business area, so it wasn't appropriate for female workers to visit).

***Milingimbi YEEW team and supervisor with ARDS trainer and project community engagement officer***

Later in the project in 2015, Milingimbi YEEWs received top-up training—a four-day workshop on water conservation and one on energy efficiency and climate impacts of energy production, along with a discussion about the project's progress.

[33] Trip Report Senior Community Engagement officer 21-24 July 2014

## *Delivery*

Milingimbi was the first community to trial the process of how households would be approached, how a baseline of appliances data and knowledge would be captured, and how education would be delivered to households.

Household trials in Milingimbi were complicated by two factors:

- the short time between YEEWs completing their training and needing to approach households
- the requirement under the funding agreement for householders to show their informed consent by signing a privacy notice, which was written in highly technical language (the interpreter created an audio recording in Yolŋu Matha of a plain English version of the privacy notice to solve this issue).

The collection of initial data on household knowledge, attitudes and behaviours (KAB) around energy use was trialled in Milingimbi as a survey form completed by the YEEWs. Training and implementation was managed by the community engagement officer.

Extra training and group discussions were held regularly, usually with visiting community engagement officers. Sessions were also held when workers needed to deliver new information or products, such as a BEEBox, stove timer or hot water system upgrade. In this way, training was delivered as needed so workers weren't overwhelmed with too much new information.

The roll-out of the BEEBox in-house display was first trialled in Milingimbi. Training for this was conducted by CAT staff with experience in the initial trial of the BEEBox technology in Utopia, an Indigenous community in Central Australia. YEEWs attended a four-day workshop on the workings of the BEEBox, including an 'on-the-job' session in a household presented by a visiting elder.

***Milingimbi house visit to talk about the BEEBox***

The YEEWs were also trained on the workings and efficiency of new hot water systems (solar and heat pump) as part of Milingimbi's retrofit program, which they passed on to relevant households.

In September 2014, four Milingimbi YEEWs and the project supervisor travelled to Galiwin'ku to present at the project employment information session for that community.

Milingimbi was the first community to receive the custom stove timer, which was developed for the project. A total of 76 timers were installed alongside the deployment of BEEBoxes and major retrofits from October to December, 2014. The BEEBoxes deployed in Milingimbi used a default budget calculated from the average of available household daily consumption data (March to September, 2014).

Milingimbi was also the first community in which CDU trialled a direct research visit approach, with two Darwin-based researchers visiting in November 2014.

Milingimbi employment extended to November 2015, with that time devoted to water efficiency follow-up visits, re-visits to tidy up paperwork, support for additional major retrofits, extended downtime following the cyclones of early 2015, a trial of visits to high energy-use households, support for the CDU final interview process, and then delivery of final household visits, which included a repeat of the initial KAB survey.

### *Project Completion*

In November 2015, YEEWs were presented with a certificate of appreciation and work history portfolio at a lunch to mark the end of the project and employment in Milingimbi. EARC and the Darwin LIEEP team attended, along with senior Yolŋu representatives from each camp. The new Manymak Energy Efficiency Project videos were shown for the first time in Milingimbi at the event.

At that time, two workers had already found work at the local store and another was applying for a job with EARC, which was successful. When asked what work she would do after this job, one YEEW said, '*I want to wait for a proper job like this one. This work was good work—a real job working for the community*.'

### *Insights*

Milingimbi was the first community to employ YEEWs and trial the process of approaching households for participation, education and uptake of optional trials. The community's co-operation, gracious assistance and willingness to be the 'test' community meant an improved delivery approach was developed for trial in the other communities.

The team built on lessons learnt in Milingimbi and abandoned approaches that wouldn't work or proved unnecessary. In particular, it was recognised that non-Yolŋu Matha speakers using an interpreter was a useful approach to training, but it was better delivered by fluent Yolŋu Matha and English speakers with experience in cross-cultural education.

## 5.2 Galiwin'ku – October 2014

### *Introduction*

The Galiwin'ku community is on Elcho Island, 550 km north-east of Darwin and 150 km north-west of Nhulunbuy. It is the largest Aboriginal community in north-east Arnhem Land, with an estimated population of 2500. Galiwin'ku was the second community to participate in the project.

The impact of tropical cyclones Lam (February 2015) and Nathan (March 2015) was hardest felt in Galiwin'ku of the participating communities. The roll-out in Galwin'ku is discussed as pre-cyclone and post-cyclone separately.

### *Scoping*

Scoping for the project in Galiwin'ku commenced in September 2013. On the initial visits, the project team identified the main housing types to inform the retrofit program, flagged potential sites for data logger equipment and conducted safety audits. They also held stakeholder engagement sessions with local government and council organisations to garner support in establishing the project in Galiwin'ku. Galiwin'ku was also part of the project's initial barrier survey approach.

### *Recruitment*

EARC was the successful contractor for the project's employment contract in Galiwin'ku. The recruitment process in Galiwin'ku consisted of two parts: positions were advertised by EARC and through the RJCP provider, and an information session was held for interested community members. YEEWs and a supervisor from Milingimbi attended the information session to address potential workers. This approach proved engaging and successful and was adopted for all the remaining community information sessions.

Twenty-two applications were received after the information session in Galiwin'ku. The final employment contract with the EARC included 17 YEEWs, including two Yolŋu sharing the role of supervisor, with the EARC business manager for Galiwin'ku to provide administration support and mentoring.

***Some members of the Galiwin'ku YEEW team, August 2015***

### *Training*

Training for the first group of employees was conducted in October and November 2014 by the project team and an interpreter, as it was in Milingimbi.

Further training, on energy efficiency and the BEEBox, was conducted by ARDS in May 2015. Water conservation training followed in July, which was engaging for the YEEWs:

> *Then we discussed the Yolŋu water story, highlighting that all waterways, such as land, trees, people and so on, are either Dhuwa or Yirritja and can be Yirritja on top and Dhuwa underneath.*

*Other stories were shared, such as mapping along song lines. It was interesting to see the energy in the room and excitement when discussing this part of the training.*[34]

## *Delivery*

Household visits and engagement commenced as part of the initial training and was delivered in line with the need to meet recruitment targets and the project's overall milestones. As a result, offering BEEBoxes and stove timers was the first priority.

The first round of retrofit and BEEBox installations in Galiwin'ku commenced in December 2014. To the team's credit, all milestone deliverables were met by December 2014.

The community engagement officer who led the initial Galiwin'ku project delivery left the team in January 2015. A replacement commenced in early March 2015. Interim arrangements saw the Galiwin'ku team visited by several different team members for two months. This period also coincided with cyclones Lam and Nathan.

As a result of the extensive impact of the cyclones, non-essential travel into the community was strongly discouraged for February, March and much of April 2015. Several YEEWs' houses were damaged, and they had to move to other temporary accommodation. Some community residents didn't have a home for up to six months.


***Water training site visit to the Galiwin'ku production bores***

The project office was temporarily taken over for cyclone recovery work, making work on the project difficult for two months. During the recovery phase, YEEWs would attempt house visits, only to find the houses condemned or being renovated.

Staff from the Australian Government Department of Industry, Innovation and Science travelled to Galiwin'ku in May 2015 to assess the cyclones' damage and impact on the project. About 70 houses within the project

[34] Community Engagement Officer trip report, 13/7/2015

scope had been vacated or condemned—more than 10 per cent of the project's scope across all communities. Consequently, schedules for milestones 9 and 10 were revisited to account for the setback. Despite the disruption from the cyclones, the Galiwin'ku team recommenced work and supported the installation of stove timers and BEEBoxes.

There were many team changes after the cyclones. Two new senior workers were appointed, one existing senior worker stepped up to supervisor and an existing YEEW became a third senior worker. A part-time project officer also joined the team to provide admin support. A second intake of YEEWs in May and June 2015 coincided with upcoming water conservation training.

The final BEEBox for Galiwin'ku was installed 15 May 2015, after which the Galwin'ku team focussed on delivering energy efficiency education and water conservation training,  installing 70 stove timers and household visits.

### *Completion*

Employment in Galiwin'ku finished up on 4 December 2015. A celebration and farewell lunch was held at Galiwin'ku's EARC offices for past and current team members. Active workers were presented with a certificate of appreciation and an employment pack.

YEEWs expressed happiness about their experience working on the project but disappointment that it was finished. Many workers were concerned about employment after the project, so a summary of YEEWs' skills and experience was provided to the Department of Prime Minister and Cabinet's government engagement coordinator (GEC) to consider for future job opportunities.

## 5.3 Gunyangara – January 2015

### *Introduction*

Gunyangara, also known as Ski Beach, is a community of about 200 people located 13 km west of Nhulunbuy. Gunyangara is the smallest of the project's six participating communities, with 26 houses eligible to take part.

The Marngarr Resource Centre Aboriginal Corporation (MRC), a business unit of the Gumatj Association, provided employment and office facilities for the project, commencing in January 2015.

### *Scoping*

Members of the project team visited Gunyangara in late 2013 and early 2014 to conduct initial consultations and advise the community about the installation of data loggers.

Two community engagement officers then visited Gunyangara in August 2014 to prepare for retrofit installations in September 2014, ahead of establishing a team of local workers for the project. They visited 11 households that would receive a solar hot water system or roofing insulation. An interpreter from the Aboriginal Interpreter Service accompanied the officers to help residents understand the upcoming housing works.

## *Recruitment*

The employment contract tender for Gunyangara was advertised in late 2014 and awarded in early 2015 to the Marngarr Resource Centre Aboriginal Corporation (MRC).

Before employing any workers, MRC negotiated a team size of four plus an extra supervisory role in the team. It also requested two additional people attend training to then be available to cover any absences during the project.

The extra position, supervisor mentor, would spend up to 10 hours a week supporting the Yolŋu supervisor with a daily meeting and mentoring throughout the project, stepping back as the supervisor grew more confident.

Gunyangara did not run a pre-employment recruitment information session because MRC decided it would recruit from a pool of workers the members were already familiar with and who they knew were looking for a six-month work opportunity.

## *Training*

Gunyangara workers began training in early March 2015 after a delay caused by Cyclone Lam. Both Yirrkala (another community taking part in the project) and Gunyangara were starting simultaneously and are in close proximity, so it was decided to combine the training for both groups.

ARDS delivered the initial project training over four weeks, with support from the project team. Top-up energy efficiency training and water conservation training was delivered during the employment period.

*Gunyangara YEEW team*

## *Delivery*

The MRC supplied an office, a vehicle, uniforms and work safety equipment. The project provided the branded project work shirts.

In the combined training sessions, both Yirrkala and Gunyangara asked to change the wording on their shirts to their respective local dialects because the Yolŋu Matha name of the project was the wrong clan language. Also, the word gapu (water) couldn't be used at the time because it was similar to the name of someone who was recently deceased, 'ŋarkula' was the preferred alternative.

The Gunyangara team developed a plan for engaging their community and visiting households. They created a chart that plotted the timing of household visits and the type of visit (BEEBox offer, water conservation etc.), which was updated as the project rolled out. They also developed a checklist for each type of house visit.

The senior energy efficiency worker, who attended the training, accompanied the workers on the first house visit to introduce the younger workers and give authority to the project.

The Gunyangara team introduced an extra initiative to their later household visits—a voluntary '10 question quiz' to gauge how well households had understood the energy efficiency messages. When the project's community engagement officer asked one of the YEEWs about the quiz and whether the team spoke to the same people at the house when they did it, the YEEW answered:

> *…no, not always; as people move around so much, quite often it was a different person at the house. When this happened, we used the poster book so it was more like education for that person. Sometimes they knew the answer, and other times they looked through the book and found the answer and we would talk about it.*

In rolling out the BEEBoxes and stove timers, the YEEWs told the community engagement officer that they would choose which houses they felt would make the best use of the devices to reduce their power card expenses. In Gunyangara, 10 BEEBoxes and 19 stove timers were installed.

Twenty-four of the 29 houses fitted with data loggers were approached to participate, and of those 24, two declined to participate. The houses not approached were either vacant or identified as not eligible for participation.

## *Completion*

In July 2015, the Gunyangara team was diverted to assist with the Garma Festival, which is run by the Gumatj Association. The project was almost finalised by that stage, and the Gunyangara team supported the Yirrkala workers who set up a Manymak Energy Efficiency Project stall at the festival.

The household visits were finalised in September 2015 when the final stove timers were installed.

Certificates of appreciation were presented to workers at a celebration in Nhulunbuy in December 2015.

The project team reflected that the Gunyangara team demonstrated great initiative in managing the household visits and developing systems that suited their community.

## 5.4 Yirrkala – January 2015

### *Introduction*

Yirrkala is located on the east coast of the Gove Peninsula in north-east Arnhem Land, 18 km south of Nhulunbuy. As is common with east Arnhem Land communities, many people live intermittently between Yirrkala and the surrounding homelands. The project commenced recruiting and training Yolŋu workers in Yirrkala in January 2015. Besides some administrative support from the EARC, the Yirrkala team was comprised completely of Yolŋu, including the supervisor and the senior workers.

### *Scoping*

Project team members visited Yirrkala in late 2013 and early 2014 to conduct initial consultations, the barrier survey and advise the community about the installation of data loggers.

Yirrkala was scheduled to receive some household retrofits prior to a local team being established. Two community engagement officers visited Yirrkala in August 2014 to prepare for retrofit installations in September 2014, with an interpreter from the Aboriginal Interpreter Service helping communicate with householders about the upcoming works.

The employment contract tender for Yirrkala was advertised in late 2014 and awarded to the EARC in early 2015, which included a dedicated, separate office space in the EARC's Yirrkala offices.

### *Recruitment*

Job advertisements were advertised in mid January 2015, and a recruitment information day was held in late January.

The Miwatj Employment Program (MEP) helped the EARC identify suitable registered job seekers and help them with job applications. MEP also promoted the project in Yolŋu so all clan groups and elders could understand the employment opportunities. In the lead up to the information day, ARDS ran advertisements on Yolŋu radio.

Three Yolŋu workers from Galiwin'ku were flown in for the information day to speak about their employment experience and introduce the BEEBox in English and Yolŋu Matha. CDU research team members and an interpreter from the AIS also attended.

Nine people applied for YEEW positions, and five applied for the supervisor role. An EARC interview panel selected 10 workers to employ.

### *Training*

Cyclone Lam slightly delayed the start of training for the Yirrkala team, which was combined with training for the team at nearby Gunyangara, another community participating in the project. ARDS delivered training for four weeks.

***ARDS training for Yirrkala YEEWs***

One issue during training was the project's paperwork requirements. The Yolŋu workers were unfamiliar with it and couldn't see why it was necessary. By the end of the training, however, Yolŋu recognised that paperwork it is an important part of the project and a necessary part of their duties. [35]

As part of training, workers learnt about power being supplied by the nearby refinery, and visited the community's water tanks and bores. The activity was well received by the group, with many saying it was the first time they'd heard the information and learnt about things like chlorine in water.

In the third week of training, Willem Westra van Holthe, the then NT Minister for Essential Services, visited the Yirrkala group and heard from the Power and Water Corporation and the Yirrkala supervisor about the project and their desire for more permanent ongoing employment in Yirrkala rather than short-term jobs.

## *Delivery*

The Yirrkala team (and the Gunyangara team) decided to change the wording of the project title on their work shirts into their respective dialects to be more locally appropriate.

By mid-April 2015, the team had visited 13 houses. In allocating BEEBoxes to households in the community, the team initially thought a 'lottery' approach would be the fairest method, but they later decided allocating them along Gurruṯu (kinship) lines would be fairer.

[35] ARDS Trainer, Week 2 training reflections, 2/2/2015

Two team members had a BEEBox installed in their own houses early on to familiarise themselves with it. A funny story came from a senior worker:

> *Not long after the BEEBox was installed, the smoke alarm went off late one night and she woke thinking, 'Oh no, it's the BEEBox, we must have gone over the budget' only to find there was some late-night cooking happening.*[36]

Some workers left the project and three new Yirrkala YEEWs were employed in May 2015. The existing YEEW team introduced them to the power story and agreed to help them learn on the job until more ARDS training in June 2015.

A YEEW made a presentation on the oil/diesel story in Yolŋu Matha, which was seen to be highly engaging for the audience. She was asked if she told the story on house visits and said,

> *'Yes, we tell it on the first visits, and people are very interested, especially the old people who have not heard this before, this is a new story for them'.* [37]

The EARC Indigenous liaison officer was very supportive of the project and would often come and speak to the workers and support them in getting their job done. He encouraged the workers to step up to their jobs and start taking on responsibilities in these positions so that Yolŋu are in responsible jobs. [38]

The Yirrkala team worked very hard to organise their work schedule and understand their job. After a discussion about this, they came up with the key message that:

> *People worked together as a team, working in a 'two-way' manner, respecting Yolŋu culture and values while meeting Balanda work requirements. Everyone in their job is responsible for:*

- *education about energy efficiency*
- *collecting information*
- *helping with the householders when contractors are working at the house*
- *working as a team – helping each other*
- *learning more – attending training and workshops and keeping learning so that everyone can help the community know more about energy efficiency and not wasting water*[39.]

The team had three days of top-up energy efficiency training with ARDS in July to prepare them for installing BEEBoxes and stove timers.

The Yirrkala team also helped set up and staff a stall at the Garma Festival in July 2015, where they handed out project merchandise and talked to passers-by about it.

They also took part in filming for the project's educational videos, providing segments on community perceptions, visiting houses and providing energy training, and explaining about BEEBoxes. In October 2015, the Yirrkala YEEW team attended the project's Gulkula forum, travelling 40 minutes each day.

After the Gulkula forum, the team focussed on finishing up the project and finalising the incentive scheme. Most team members in Yirrkala were studying towards a Certificate in Business Administration, which was arranged by EARC and formed part of their project work hours.

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[36] Snr Community Engagement Officer, Trip report April 2015.
[37] Snr Community Engagement Officer, Trip report, April 2015
[38] (Snr Community Engagement Officer, Trip report 5/5/2015)
[39] Snr Community Engagement Officer, Trip report, 20/5/2015

### *Completion*

The team completed the household engagement and education in December 2015.

The completion of the YEEWs' work was marked with a small gathering with Yirrkala YEEWs, project team members and representatives from EARC.

The Yirrkala project achieved all milestones on time and managed the workload while observing cultural obligations (funerals and ceremonies). They completed house visits for most of the houses; some houses couldn't be visited because of sickness, death or families being out in the homelands for long periods of time. The Yirrkala team showed great initiative in running the office professionally and organising themselves well.

***Yirrkala YEEWs, June 2015***

## 5.5 Gapuwiyak – April 2015

### *Introduction*

Gapuwiyak is a mainland community approximately 500 km east of Darwin and 120 km west of Nhulunbuy. It is adjacent to Lake Evella and is often referred to by this name. The community has around 1000 Yolŋu people from 19 different clan groups.

The project was launched in Gapuwiyak in April 2015. It is distinguished in the project by achieving 100 per cent household participation and as the first to incorporate a school visit.

Ten workers were recruited in March 2015 to form the initial team, and the project concluded with five active workers in December 2015. On top of delivering the core program activities, such as installing BEEBoxes and conducting energy efficiency education house visits, the Gapuwiyak team also spent two weeks conducting educational forums with students from the school.[40]

## Scoping

The project director made scoping trips to Gapuwiyak in November 2013 to introduce the project. The CAT community engagement officer visited again in February 2014 to seek feedback from key stakeholders on the design and approach of the program in Gapuwiyak and to meet potential workers. The project director reported in his initial trip that *'Community members were happy with the project and interested in learning about energy.'*[41]

During the scoping period, data loggers were installed in Gapuwiyak houses, a safety audit was conducted and initial household retrofits were installed. The council housing officer also sent a letter to 102 community houses about the retrofit installations and made himself available for households' questions.

The final scoping activity was in March 2015 when two CAT community engagement officers and a representative from EARC visited Gapuwiyak to prepare for employment and project commencement.

## Recruitment

The EARC was awarded the employment host contract for Gapuwiyak. With office space at a premium in the community, the EARC negotiated with the Goŋ-Ḏäl Aboriginal Corporation to lease the former police station as the project's base in the community.

There were 11 positions on the Gapuwiyak team. Advertisements were posted on public noticeboards and an information day was held on 20 March 2015 at the new office site. Three YEEWs flew in from Galiwin'ku to speak to people at the information session in Yolŋu Matha about their experience working on the project. The recruitment process in Gapuwiyak was challenging. This was partly because Cyclone Nathan affected Gapuwiyak during the recruitment period, which understandably distracted the community and restricted travel. As a result, much of the recruitment work for a project supervisor and YEEWs was done over the phone.

The initial project team comprised a Yolŋu supervisor, a female and a male senior worker and seven YEEWs. Fifty per cent of that initial workforce was younger workers in a bid to encourage work experience. Some younger workers left the project, so there was a second intake of workers in June 2015, with four new workers employed. The final intake was in September 2015.

In addition to balancing experience, gender, age and seniority in the recruitment process, a priority for the recruitment process was to achieve representation from the three camps in Gapuwiyak: Top, Middle and Wharf camps. It was important to ensure equal representation of people from a cross-section of families to avoid perceptions of bias in only representing some families from the community.[42]

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[40] Email correspondence from teacher at Gapuwiyak school to Gapuwiyak community engagement officer after the first school visit by the team (29 July 2015):

… they were awesome! Such clear speakers with knowledge and authority; they engaged me and the students. I understood a lot of what they said because of the pictures they were using even though I did not understand the language! Very interesting for me! My TAs were very engaged with them and the students

[41] 22 Nov 2013

[42] Without Gurruṯu, situations might emerge where it is impossible to approach some households because of an avoidance relationship, such as a poison cousin, limiting interaction.

*Gapuwiyak YEEW team and ARDS trainers*

## *Training*

Most training was conducted by ARDS in Gapuwiyak, with some additional training sessions conducted by the community engagement officer. The first round of ARDS training began on 7 April 2015 and ran for four-and-a-half weeks. The training was conducted in Yolŋu Matha, which meant the new Yolŋu workers clearly understood the content. This was well received by workers, with a YEEW from Galiwin'ku sitting in on the training commenting:

> *It was good for the training not to be in English—if this happens, people are usually quiet, not engaged, not responding to questions, and they often will say they understand when really they are still confused. It's good that it's in Yolŋu Matha so people can answer and respond, walal ga buku-bakmaram (they are talking and responding), working in Yolŋu Matha, manymak dharaŋanharaw (it's good for understanding).*

## *Delivery*

Project delivery started in Gapuwiyak on 11 May 2015. The team was inspired by the ARDS training and from practising visits at each other's houses the week before.

The first tasks were to set up the office and project systems. The community engagement officer worked with the team to set up a system to deliver house visits that listed each of the 102 households and all the initial delivery milestones of the project in Yolŋu Matha on large sheets on the walls. This important organisational tool ensured a streamlined approach to house visits.

Forms for house visits were also colour coded to help identify each one and address literacy challenges.

The team split into two groups and did 17 house visits in two days—a speed characteristic of the Gapuwiyak team. A stand-out achievement in this community is that all of the 102 households were visited and signed up to the project within three weeks.

The first BEEBox was installed in one of the senior worker's homes on 21 May 2015 by electricians who flew to Gapuwiyak. The team used these installs as a training exercise—the workers watched the electricians carefully, asked questions and practised explaining how the BEEBox worked and what their budget meant. The electricians worked very well with Yolŋu on this occassion.

By early August, the team had completed second house visits and visited the school, presenting sessions to students about energy and electricity.

In late August, BEEBoxes were installed in 35 households in two weeks. A video was made at Gapuwiyak after BEEBox house visits were conducted and water training was completed, all within a month.

Stove timers weren't offered to participating houses in Gapuwiyak because there was no electrician in Gapuwiyak, so if something went wrong, the risk that households would be without a stove was too great.

ARDS trainers, with a PWC efficiency officer, conducted water training over four days. The team then commenced water visits, which took place until late November.

The team then visited 27 houses to explain the retrofit installation program and whether they'd receive a solar hot water unit or roof insulation. YEEWs distributed an explanation sheet on the time taken by the contractor, how the household would benefit from new retrofits and contact numbers. Eighteen solar hot water systems were installed and nine houses received insulation.

By early November, discussions were underway to wrap up the project by 18 December. Work was completed on water visits and training for final visits was underway. Final visits took place for most households in late November.

## *Completion*

A final lunch celebration was held on 16 December. Workers were presented with certificates and work information folders.

***Gapuwiyak team with community engagement officer and project director at the end of project certificate presentation***

## 5.6 Ramingining – June 2015

### *Introduction*

The community of Ramingining is located 560 km east of Darwin. It has a transient population of about 800 and provides services for many smaller outstations nearby. Ramingining is renowned for its arts and crafts industry. Ramingining was the sixth and final community to participate in the project.

Eleven local Yolŋu workers were recruited in May 2015, forming the Ramingining YEEW team that delivered education about energy efficiency to 85 households over six months, finishing in December 2015.

### *Scoping*

Ramingining was initially intended be a 'control' community in the project's design, which would see data loggers installed on all household energy meters and data used as a baseline to compare the five other participating communities with. The consortium subsequently decided that for the sake of fairness and equity, Ramingining would be included fully in the project, and the required approvals were obtained to do so.

During late 2013 and early 2014, meetings were held with local stakeholders to ensure they understood the project's aims and were happy to support it. These groups included EARC, the Department of Prime Minister and Cabinet, Bula Arts and Arnhem Land Aboriginal Progress Association (ALPA).

### *Recruitment*

The successful tenderer for the employment contract at Ramingining was CoreStaff Pty Ltd, which was contracted in April 2015. This was the first use of a private-sector employer in the project. Two CAT community engagement officers and two CoreStaff employees travelled to Ramingining in early May 2015 to meet stakeholders and community members and identify suitable office space for the project. CoreStaff later leased office space for the project from the EARC.

A community barbecue was held in mid-May to promote the jobs and take expressions of interest from potential workers. Three YEEWs from Milingimbi also attended to explain the workers' roles. The event was well attended, with one resident noting:

> *It's good that we are hearing this story about power; we know about the water story, that's why we moved here from Milingimbi… I think it's manymak that Yolŋu will be working and telling the community about using power better.*

*Ramingining YEEW team and ARDS trainer*

Twenty-three applications were received. Senior cultural advisors were employed to help review expressions of interest to ensure a culturally diverse group of workers that could approach all members of the community in a culturally appropriate manner. Eleven Yolŋu staff were selected, and all 11 stayed until the end of the project.

## Training

ARDS conducted the initial training over five weeks in Yolŋu Matha, covering the employer's induction, the project background, energy efficiency training and developing a schedule of events.

Because Ramingining was the last community to participate in the project, lessons learned in other communities were implemented into the training for Ramingining staff, including ARDS having refined approaches to relating concepts back to a Yolŋu understanding.

***Site visit to the power station as part of the energy training***

The community engagement officer reported that workers constantly spoke highly of the training and how it was conducted in language and in relation to the Yolŋu stories of power and water. Workers felt involved in how this 'new power and water story' should be developed and told to the community.[43]

## *Delivery*

The project delivery in Ramingining was driven by a collaboration between the Yolŋu workers and participating households. The project timeline, objectives and delivery goals were drafted and developed in consultation with the workers.

The project's milestone targets did not require any rapid uptake in Ramingining, and the project's delivery was able to be structured around a logical progressive house visit plan. In the initial visit, householders were introduced to the project and if they agreed to take part, forms were signed and the household appliance survey conducted. On subsequent visits, households were given in-depth energy efficiency education tailored to its behaviour and needs. On the fifth house visit, an FAQ form helped communicate the process for the project completion.

An allocation of 26 BEEBoxes was identified for Ramingining. As in other communities, five BEEBoxes were installed and trialled in workers' houses first. Two weeks later, the community engagement officer ran a 'post BEEBox workshop' to discuss the workers' thoughts about their BEEBox, which were very positive.

The remaining 21 BEEBoxes were distributed equally among the five camps and installed over two days. Staff showed integrity in identifying that BEEBoxes should go to houses with the most need, particularly those with high energy consumption.

[43] 24-25-26 June 2015, community engagement officer trip report

***Ramingining YEEWs in front of an installed BEEBox in-house display***

Under Ramingining's retrofit program, 35 houses would receive a new solar hot water system and 12 houses were assigned ceiling insulation. As in other communities without a resident electrician, it was decided stove timers would not be rolled out in Ramingining.

YEEWs hand delivered flyers to households two weeks before the retrofit installation to explain the purpose of the equipment and how long the installation would take. All major retrofits were installed without issue.

The workers identified the need for the project to have a greater profile and exposure in the community, so a presentation to the school was arranged, which had been a success in Gapuwiyak. Although shy at first, the workers presented information about the project and had great interactions from students. Of note is that the students recognised, without prompting, that the visitors were the '*Manymak Pawa ga Gapu* workers', illustrating the community's knowledge of the project and engagement with young people in the community.

## *Completion*

Finalising the project in a respectful and positive way was very important to the project team, especially seeing as Ramingining was the final community to roll-out. The two-part exit strategy communications would first make the community awareness that the project was coming to an end and secondly make sure the workers' needs and issues were addressed before completion.

An FAQ form delivered on the final house visit explained that the project was coming to an end and listed contact information should households need help later on. These quotes were recorded during the final visits:

- *This project has helped us to use power more wisely.*
- *Pawa ga gapu workers have been very helpful for the work they've done, explaining/talking about new ideas of solar power and BEEBox and why and how it operates.*
- *Workers help us to use power in good way.*

During the final two weeks of the project, RJCP staff ran information sessions with the workers about transitioning back into RJCP and possible job opportunities they could apply for.

### *Insights*

Ensuring an appropriate and representative team were recruited to deliver the objectives and supporting those people throughout the project was critical to its success in Ramingining. Giving workers flexibility and encouragement to take ownership of the project delivery was also a contributing factor.

Establishing teams of workers (both male/female and various ages) on a casual basis was extremely valuable in delivering the project's objectives. This allowed for other team members to cover for people that were absent due to personal reasons or cultural obligations. The team model is also important for support and encouragement of members and the pressures of the job are not solely on one person.

When working with external contractors, ensuring they're aware of the importance of respectful community engagement is critical. This sometimes takes time. Contractors will cost their competitive quotes based on a time-efficient approach, which means they aim to complete the job and leave. Managing expectations in this area is critical—ensure there is explicit provision for community engagement stand down-time in contract pricing so they're aware of the expectation.

Arranging important add-on activities, such as presentations at schools and other organisations, is valuable to explain the project and profile the workers in the community.

Regular ceremonies and funerals are a reality in remote communities and can override a scheduled activity or work program. Being aware of this when developing a schedule is important, and providing extra time for objectives to be met will allow workers to meet their cultural obligations.

## 5.7 Newcastle LIEEP Forum – August 2015

In August 2015, the CSIRO held a two-day LIEEP forum in Newcastle, New South Wales, and representatives from all 20 projects around Australia were invited to attend.

The Manymak Energy Efficiency Project director and lead researcher attended from the NT team, and senior Yolŋu workers were also invited to address the conference. This was a wonderful opportunity for Yolŋu workers to show evidence of the 'two-way' process of the project in the NT and of Yolŋu and balanda working together in partnership.

A senior Yolŋu co-researcher from Gapuwiyak also attended.

The Yolŋu supervisor from Galiwin'ku prepared and delivered a presentation on the project delivery and the situation in Galiwin'ku post cyclones. This was followed by the lead researcher and co-researcher's presentation about the pre-interviews and the story about Yolŋu understanding of power and water before the project commenced.

These presentations were received exceptionally well by the audience—some feedback was that they were the best of the conference. The presentations were subsequently delivered to some staff in the Power and Water Corporation and to consortium partners.

## 5.8 Gulkula YEEW Forum – October 2015

In October 2015, the project held a forum over three days at the Garma Festival in Gulkula, a 45-minute drive from Nhulunbuy. The forum was envisaged to bring together, for the first time, representatives of the Yolŋu energy efficiency worker teams from each of the six communities to share their experiences of the work, what went well and what could be improved. Representatives of the consortium and the Australian Government also attended.

Twenty Yolŋu workers from across the six communities were involved in the event, along with members of the project team, ARDS facilitators and CDU researchers.

***ARDS trainer at the Gulkula forum facilitating a session***

The forum was facilitated by ARDS staff as part of their training contract for the project. On day one, the facilitators quickly responded to the Yolŋu participants' request to change the linear agenda to a more culturally appropriate method.

> *At this point, when I [ARDS facilitator] started to talk about a topic on the agenda, Yolŋu took it and 'marrtjin bala djalkirilil' – went straight to the foundation, to the heart of the issue …Yolŋu wanted to start right in the deepest part of the story and then fill in the gaps. This was a difficulty in a lot of the discussions that were had, but I think we got through it and got a productive cross-cultural discussion.* [44]

A number of the invited guests arrived early on day two, and Djäwa Yunupiŋu, a Gumatj elder from Gunyangara, gave a welcome to his country for all the attendees. Then each of the invited guests introduced themselves and their organisationto the Yolŋu group and the facilitator gave a summary of the introductions (in Yolŋu Matha) adding each person's name next to the project/consortium map, asking them to raise their hands as they were added in and explaining again how each organisation fitted in to the project. This was

[44] *. ARDS, LIEEP Forum Reflections, 6/11/2015*

often the first time the YEEWs had met people from the consortium; in the past they had just heard about them.

When the time came for the story recorded from the day before to be shared, the Yolŋu were reluctant and instead let the facilitator relate the key points for the guests. The following topics were discussed (from ARDS, LIEEP Forum Reflections, 6/11/2015):

- *This project has been great, but it is not enough.*
- *There are other problems that make this job difficult, like overcrowding in houses. Also, we worry for old people who are getting sick in some of the houses; it's hard to talk about power and water when people are getting sick when there are too many people in the house and lots of noise.*
- *We want to be able to do this project for longer because the community wants to learn more and they want more BEEBoxes and stove timers for houses that didn't get one.*
- *We now have a lot of new knowledge for the balanda ways of power and water, and it is a lot of work explaining it to our family in the community. Just because the project ends and there is no more money, it doesn't mean people stop asking us questions. We're obliged to keep working in this way because of Gurruṯu [kinship] - whether there is money to pay us or not.*
- *We could also work in maintenance roles for housing or for Power and Water. We can learn and we can work and we can do that job too.*

There was a lot of discussion regarding the broader question of the project ending and why this decision was out of Yolŋu hands.

> *Yolŋu remember the days not very long ago when they ran the councils, they ran the housing and other aspects of the community life. Lots of people remember Yolŋu people who did that work, and now they work for the dole instead. It is a bitter pill to swallow, and the bitterness showed.*[45]

The forum became an avenue for Yolŋu to express their perspectives on the project, provide feedback and recommendations to the guests, and invite the guests to take these messages back to their organisations.

Out of discussions on the first day emerged the story that the Yolŋu energy efficiency workers wanted to give clearly to the invited guests on day two of the forum. Key points included:

> *Yolŋu have djalkiri (a solid foundational base from which their whole world is built). This works through a Gurruṯu (kinship) system that encompasses all legal, economic, social, spiritual and material aspects of the world.*
>
> *While the project is a good one, it is still based in a balanda world where there is no kinship. There is no djalkiri. It is very obvious to Yolŋu that this project has been initiated by people outside of the community, who don't have and don't understand Gurruṯu. It is not Yolŋu making decisions in their community about how things are run. Colonisation came up a few times—*

[45] Ibid.

*foreign laws made by far away people that claim jurisdiction over Yolŋu and their land—this is a very obvious problem in all aspects of life, and this project was not an exception...*

*Now this project is ending and it is all decided by people far away. Yolŋu think multiple generations ahead and look back through many generations. This project has only been for three years; they've only been employed for six months or maybe a year and now it's finished and there isn't anything they can do about it because Yolŋu have no power. Their governance systems have been stripped of assets and they are now at the whim of foreigners who have taken over.*

*In general, Yolŋu want to plan things by going to the foundational point. In this instance, Yolŋu want to learn to run and manage and maintain their power and water systems. This means a long-term plan, learning what they have learned, learning more, mentoring young people to understand how it all works and taking on the maintenance roles that Yolŋu used to have. Instead, we have a pilot project that teaches Yolŋu a bit about the system and how it works, but at the end, it's done and there are no ongoing roles for Yolŋu. From a Yolŋu perspective, this is not a long-term vision, and is part of a broader system that lets Balanda have permanent jobs in communities so they run everything, while Yolŋu get a temporary job and don't move towards having decision making power. 46*

The event included a presentation from a representative of the other NT LIEEP project—the Darwin CoolMob project—which was well received:

*Everyone was happy to hear about the other project... This gave everyone a real look at the scope of the project as a national one that was happening in lots of places and not just targeted at Yolŋu.* [47]

On the final day, speakers discussed the possibility of future employment opportunities for YEEWs in their communities.

The forum was held close to the end of the LIEEP project in the six communities. A key discussion among Yolŋu during the forum (and back in their communities) was about ongoing meaningful employment in their communities. The facilitator spoke at the closing of the final day about the sadness many of the Yolŋu feel that the project and employment is coming to an end:

*At the same time, I acknowledged that it was a sad time, but I know we are all sad because it has been a really good project, which makes it even more sad that it is ending. We're all looking for opportunities to make something like this happen again, and we all look forward to finding it and working together again.*

The facilitator summarised the impact of the forum in his report back to the project team.

*Overall, there is no question that the forum was a good thing to do. I am aware that a lot of what was spoken about, and what I have written about is critical in nature, but that is why I am writing it. I'm also aware that there are a lot of very heavy and negative thoughts and feelings that were expressed in regard to the broader historical/political/social context in which Yolŋu (and this*

[46] Ibid.
[47] Ibid.

*project) sit. In a way, it is outside of the project's control to influence colonialism, the recognition of Yolŋu law, authority and social organisation frameworks; however, it is also essential for anyone and any project to understand if they are going to be working on Yolŋu land and with Yolŋu people. For this reason, as well, it was good to have the forum because it allowed a rare opportunity for those feelings to actually reach people face to face—people who are usually far away in an alien world. I think this meant that the story got to a few people. Yolŋu needed to say it, and we needed to hear it.*


***Gulkula YEEW Forum group photo***

# 6 Water Metering, Education and Training

Water supply and sustainability are critical issues for many remote communities. Many of the 72 NT communities serviced by IES are water stressed and up to 20 per cent of community-wide energy consumption may be linked to excessive household water use. As a result, PWC negotiated inclusion of water conservation into the project education approach and provided smart water metering of the community of Milingimbi.

Installing water smart metering of household water usage in Milingimbi enabled the evaluation of the relative contribution of household water usage to household and community energy use. By including water efficiency in the project's education program, community knowledge and the impact of education on water efficiency could also be evaluated.

## 6.1 Water Meters – Installation History and Use

PWC currently has automatic water meter reading technology ('smart meters') installed in two communities in east Arnhem Land: Milingimbi and Galiwin'ku. Itron technology was installed in Milingimbi in June 2013 with a total of 184 smart water meters installed (covering 100 per cent of the community). The smart meter installation in Galiwin'ku was staged over two periods using Taggle technology. Stage one was in August and September 2014, with the final installations completed from June to August 2015. There are 348 Taggle meters installed across the community, which represents approximately 71 per cent of the community.

The smart water meters record each lot's hourly water consumption and communicate the data to a centralised server. Smart meter data is analysed by PWC on a fortnightly basis to find potential water leaks. Connections that display a continuous minimum flow over a 24-hour period are identified as having potential leaks. Lots with identified leaks that are above specific volumetric thresholds are reported to the customer, or in the case of public housing, the landlord (Department of Housing) in order to investigate and if necessary, repair the identified water leak.

Smart water meter data is used to develop a detailed water balance across the community whereby the bulk water demand is disaggregated to identify the proportions of water use and loss attributed to customer groups, proportioning unaccounted for water to the supply distribution system and unregistered connections.

Throughout the LIEEP program, smart meter data was used in Milingimbi to identify lots with excessive water use (>4 kL/day) or behaviour-related water loss. Identified lots were reported to the YEEWs in the form of a fortnightly water loss report. The reports enabled the YEEWs to target water education visits to those residents that would benefit the most. The YEEWs provided a report back with detailed information on the causes of water loss or high use and any identified maintenance requirements. All identified maintenance issues were then reported to the Department of Housing for actioning. At the completion of the YEEWs education work, a total of:

- Four formal water loss reports were provided to the Milingimbi YEEWs. Formal reporting commenced on 5 October, with informal emails sent to the YEEW Milingimbi supervisor prior this this.
- Thirty-seven targeted education household visits were completed in response to the water loss report. An additional 208 water education visits were completed across Milingimbi as part of the wider project scope.

Overall, using the smart meter data was found to be an effective and efficient method to target houses with excessive water use or behavioural-related water loss. Analyses of the information provided by the YEEWs and smart meter data is discussed in further detail in the results below.

## 6.2 Key Messages and Training Materials

PWC's demand management project officer supported the water training component of the LIEEP project as the water expert. The project officer worked with ARDS to plan and deliver the water training in the community.

To ensure consistency in key communications across all six communities, key water conservation messages were developed based on an analysis of water supply data on customer use, PWC's experience working on previous water conservation and demand management projects in remote communities. These key messages were used in the water training and water education house visits. They were:

- If you see a leak in your house, report it to the Housing Maintenance Officer (HMO) or call 1800 104 076.
- Turn off running taps and showers.
- Ask children not to play under the hoses and fire hydrants.
- Water the garden for a short period in the evenings.

- A key message developed by the YEEW's. This was a community-specific message the YEEWs developed in the training and was unique to that community's water loss issues.

The identified wasteful uses of water were developed into four or five clear and concise key messages that the YEEWs could educate the community on during their household visits. The YEEWs consistently came up with the same four key messages developed by PWC in the water training brief, plus one message unique to that community (e.g. Gunyangara came up with the message 'don't leave the hose running while cleaning fish', and Gapuwiyak had 'wash your clothes when you have a full load of washing').

The project officer developed a brief for ARDS on each community prior to the training. The brief included detail on the history of water demand in the community, the water and wastewater infrastructure in place, local geology, roles and responsibilities of PWC personnel, desired key learning outcomes of the training and resources available to assist with training. Prior to the commencement of water training in each community, the project officer met with ARDS to go over the training brief, answer any questions and develop a training plan. The project officer attended community water training and provided technical assistance where required throughout the training.

A community water visit checklist was provided to the YEEWs at the end of the training. The checklist summarised the training topics and was used by the YEEWs during household visits as a reference tool for managing the water training structure and delivery method.

ARDS delivered water management training in each community with technical assistance from a PWC project officer. The training was delivered over three to four half days and generally followed the same structure in each community.

## 6.3 Training Delivery

### *The Yolŋu Story*

ARDS staff introduced the water training to the team, wrote down everyone's name, including Malk (skin name, which is a family group designation related to Gurrutu) and what relationship they had to one another. The first component of the training was to go through the Yolŋu water story. This includes identifying Yolŋu Matha words related to water, traditional uses for water, connection of people to water and the traditional dreamtime stories for that local area. This session was led by ARDS but always developed into a passionate discussion among the YEEW team.

***Galiwin'ku YEEW team explaining the water songlines to the ARDS trainer during the water training***

### *Site Tour*

During the training, the YEEWs were given a tour of PWC's infrastructure by the essential services officer (ESO)—the contractor living in the community and managing the community water, sewerage and power systems. The tour began at the production bores, where the ESO showed the YEEWs how the water is extracted from the underground aquifer. The YEEWs then moved on to the water storage compound, where they learned about water storage, the importance of chlorine dosing, gravity feeding and/or pumping the water throughout the community, and water quality monitoring. The illustration below depicts the YEEW team at Gapuwiyak with the ESO touring the water compound. The tour ended by exploring the community sewage pump stations and the wastewater treatment ponds. The tour was structured to give the YEEWs an overview of the whole water and wastewater cycle in a community. Throughout the tour, ARDS personnel were present to translate information provided by the ESO.

### *The Balanda Story*

Following the site tour, ARDS explained the balanda view of systems. This included a more detailed look into the infrastructure systems in place in the community to deliver healthy drinking water and manage wastewater.

The geology and relationship to the underground aquifer for each community were also described for each community.


***Diagram drawn during the water training in Galiwin'ku to explain the geology of the island and the groundwater movement***

### *Good Versus Wasteful Water Use*

At this point, the team was divided into groups, provided with paper tags and asked to write or draw their ideas about water use. This proved to be an effective way to encourage team work and to think about water use. The notes were pinned on a board and then the ARDS trainer arranged the notes into categories: drinking (Ŋulkthunharaw), cooking / kitchen (Bathanharaw), playing (Lupthunharaw), washing / cleaning (Rurrguyunharaw) and for the garden (Gät'niw). The ARDS trainers then repeated the activity but asked the YEEWs to think about wasteful ways to use water. Ideas varied across the different communities but some common themes were broken and leaking pipes and taps, watering the garden for a long time, playing with the hose and leaving the tap or hose on.

## 6.4 Household Visits

The last session in the training was to go through what a water education household visit involves. The ARDS trainer went through the house visit checklist, which highlighted key points from the training to be used as a reference during a house visit. Material was given to the YEEWs to hand out to residents and help with the house visits, including a 'where to report leaks' poster and a flowchart outlining what happens when you report a maintenance issue to housing. Arrangements were made with the Department of Housing (DHsg) for the group to make a pretend maintenance request call to the DHsg 1800 maintenance number. The purpose of this activity was to ensure the group understood the process of reporting a maintenance issue to DHsg and ensure they were confident to explain this process to a resident if they found a maintenance issue during their house visit.

Throughout the water household visits, PWC provided technical support to the YEEWs and followed up on any questions the YEEWs or residents wanted resolved.


***YEEW team in Milingimbi using a poster to explain the island's hydrogeology***

## 6.5 Results

### *Household Education*

Overall, the water training and water education house visits were successful, with more than 660 water education house visits completed across all communities. During the house visits, YEEWs identified water maintenance issues with the resident and went through the process of calling DHsg to report the maintenance issue. Seventy-five water-related maintenance issues were identified as a result of the water education visits[48].

[48] Calculations do not include water-related maintenance issues identified during energy-related house visits

Gapuwiyak and Ramingining did not have any comment records but this does not necessarily indicate that there was not a water-related maintenance issue.

*Table 11: Summary of LIEEP water education house visits*

| Community | Duration of house visits | Total number of water visits | Number of water-related maintenance issues identified |
|---|---|---|---|
| Milingimbi | April - November 2015 | 208 | 50 (24%) |
| Gunyangara | July 2015 | 13 | none recorded |
| Galiwin'ku | July - December 2015 | 115 | 24 (21%) |
| Yirrkala | September – December 2015 | 78 | 1 (minimal comments recorded) |
| Gapuwiyak | September - November 2015 | 143 | No comments recorded |
| Ramingining | November 2015 | 109 | No comments recorded |
| | **Total** | **666** | **75** |

# 7 Incentive and Reward Scheme

## 7.1 Evolution

The project included an incentive/rewards scheme in the original IES LIEEP funding bid. The purpose was to encourage participation and provide incentives for energy saving. This was described as:

- development and implementation of a culturally appropriate rewards scheme (funding bid application form)
- implementation of a rewards scheme specifically involving Indigenous households to positively reinforce energy-efficient practices (funding bid project plan)
- funding bid budget: rewards scheme $250,000.

The transition from a concept into a practical scheme was incorporated into the project's deliverables for milestone 3.

Following establishment of the project team, an initial plan was submitted for milestone 3, which was developed further for Milestone 5 (31 March 2014) following community consultation on the incentive/rewards scheme.

Community feedback garnered by ARDS and the project team communicated the Yolŋu perception that individual incentives were not desirable nor necessary for engagement and that communities would prefer an investment that benefited the whole community. Individual incentive items were found to have negative associations for some Yolŋu.

> *During in-depth discussion about the idea of 'incentive', one Yolŋu colleague quickly made connection with mission times when people worked hard for little payment, namely tea, flour and sugar.*[49].

[49] ARDS, 20/3/2014

It was noted that if individual 'incentives' were to be given out, that power cards offered to the elder in the household could be one appropriate approach.

By late 2014, the incentive/rewards scheme was informally reframed as a whole-of-community 'gift' for successfully contributing to the project meeting its milestones. The guidelines for selection of appropriate items were:

- can be completed by the end of the project
- can be completed within the allocated budget for each community
- is likely to have broad community appeal and is culturally appropriate
- does not result in a significant increase in energy or water in the community and/or demonstrates high energy and/or water efficiency
- ownership and ongoing maintenance of any assets installed is taken on by a consortium member or third party.

The total budget of $250 000 was reduced to $220 000 in the October 2015 budget review and was divided among the communities in rough correspondence to relative population size.

*Table 12: Division of costs for the incentive scheme*

| Community | Budget (GST ex) |
|---|---|
| Milingimbi | $35,000 |
| Galiwin'ku | $40,000 |
| Yirrkala | $35,000 |
| Gunyangara | $20,000 |
| Gapuwiyak | $35,000 |
| Ramingining | $35,000 |
| CAT support | $10,000 |
| Contingency | $15,000 |
| **Total** | **$225,000** |

Discussions were then initiated by the community engagement staff with YEEWs and community members to consult on ideas of what would be an appropriate reward or gift for the community. Initial ideas received from communities included a range of infrastructure-related projects, which required technical knowledge to be able to further inform the discussion.

Additional consultation with each community was undertaken across all six communities, meeting with key stakeholders to identify projects that could be done in budget and within a relatively short timeframe. These ideas were then handed to the project team to confirm cost estimates and obtain a formal community selection and approval for the shortlisted preferences.

The formal approval process depended, to some extent, on community circumstances, with the default being to obtain sign off from the EARC local authority in each community (with the exception of Gunyangara).

The following incentives were based on the community gift priorities that emerged during extensive consultation led by the project team.

## 7.2 Milingimbi

Discussion with CSM, YEEWs and the EARC sports and recreation officer led to the identification of the shade and seating for the community oval as being the preferred incentive/rewards scheme option. This proposal was then presented in a local authority meeting and was officially endorsed in February 2016. In mid-February 2016, local RJCP workers were contracted to install two skillion roof shade structures and two tiered seating stands, with construction completed at the end of June 2016.

*Construction of seating and shade at the Milingimbi sports oval by local RJCP workers*

## 7.3 Galiwin'ku

After consideration of a number of options identified during consultation, the upgrade of the Galiwin'ku community church stage was identified as the preferred priority in a meeting with the Galiwin'ku GEC and taken back to the YEEW team. The Galiwin'ku church group council was approached to provide a letter of official approval/support for the project.

The existing stage was demolished and replaced with a combination of LIEEP funding and cyclone recovery funding from the NT Department of the Chief Minister.

*Galiwin'ku stage*

## 7.4 Gunyangara

Community consultation in Gunyangara identified that contributing to the Gumatj Association's planned upgrade of the playgroup/preschool facility was the preferred option. It was proposed that an additional covered deck be built out the front to extend the safe play area for the combined preschool and playgroup facility. The deck would use timber milled by the newly established timber mill facility at Gunyangara, and local workers would be employed to construct the deck and shade.

***Project and Gumatj representatives on the new deck***

It was proposed to use LIEEP funding to partially fund the project, with Gumatj Association providing the remainder of the funding. In addition, extra funds were identified to produce a *Welcome to Gunyangara* sign.

The deck was completed in early April 2016 using local timber milled in Gunyangara.

## 7.5 Yirrkala

The YEEWs in Yirrkala identified that an upgrade of the community stage meeting area behind the Yirrkala church was the recommended priority. A letter seeking formal support of the project was taken to the church and community representatives and was signed off in late 2015.

The upgrade construction was completed in June 2016 and includes a new slab adjacent to the old stage area along with a skillion roof to cover the stage.

***New covered stage in Yirrkala***

## 7.6 Gapuwiyak

The incentive scheme was introduced in Gapuwiyak in May 2015 following the completion of training. The consensus by the team was to install power and water to the cemetery. During further consultation in early October, it became apparent that connecting power and water to the cemetery site would be cost prohibitive and thatNorthern Land Council approval was unlikely for that site.

A consultation meeting was held with Goŋ-Ḏäl, where many ideas were raised, but it was difficult to find a suitable one to match the project requirements. It was in a meeting with the CSM at Gapuwiyak that the idea for rebuilding the stage at the lake was proposed.

***Old lakeside stage in Gapuwiyak***

Three Local Authority meetings were consulted, and in early 2016 it was agreed that the installation of a permanent concrete stage at the community basketball courts was the preferred option, rather than at the lake edge.

A precast concrete stage was installed by a local contractor in early June 2016.

## 7.7 Ramingining

Multiple community consultations led to a presentation in October 2015 to the Ramingining Local Authority (LA) of several options. The LA members identified that new shade and seating at the oval was the preferred and most appropriate gift item. The YEEWs and local council staff then consulted on exact locations around the oval.

The Ramingining local RJCP provider was contracted to install two skillion roof shade structures and two tiered seating stands, with construction nearing completion in late June 2016.

# 8 In-House Displays (BEEBox)

## 8.1 Design and Development of the In-house Displays

The development and roll-out of a custom designed energy use interface—the Bushlight Energy Efficiency Box (BEEBox)—was a significant component of the project's trials, aiming to address the key barrier of a lack of real-time energy use feedback. The project scope included a target of installing 250 in-house displays, with the timing of installs set by the original funding agreement and project plan as:

- milestone 7, 30 September 2014: first 50 installed
- milestone 8, 31 December 2014: additional 50 installs
- milestone 9, 31 March 2015: additional 50 installs
- milestone 10, 30 June 2015: final 100 installs.

The communities participating in this project pay for household electricity using pre-payment meters (PPMs). While households need to regularly top up the credit in the meters by buying power tokens, they do not receive informational feedback on where and how that credit is consumed within the household.

In order to address the specific issue of lack of informational feedback, CAT developed the 'BEEBox' (Bushlight Energy Efficiency Box) technology.


*BEEBox demonstration display unit connected to an electric jug*

## 8.2 BEEBox Development

The BEEBox is an innovative technology developed to meet a specific need in Indigenous communities. Although there are numerous commercially available energy monitors that are used in urban areas, they are not suitable for use in the given context. Commonly available interfaces are designed to work with customers who receive a regular (quarterly) power bill and convey a range of information on portable screens, including real-time energy consumption in kWh, relative temperature and humidity, and other indices. They are usually navigated using drop-down menus and/or touch-screens. There are a range of identified barriers[50] to efficient energy consumption that are not addressed through conventional energy meters on the market.

Commercially available energy use interfaces do not meet the needs of many low-income Indigenous communities. Remote residents often have English as a second or later language, and other literacy and numeracy challenges. They have not had wide exposure to energy concepts and may not be familiar with the indices conveyed through commercial interfaces. Overcrowding and extreme climates also mean that many portable interfaces are not suitable. These challenges mean that conventional interfaces are of limited value in the context of remote Indigenous and other pre-payment meter households.

The precursor technologies to the BEEBox are the Bushlight EMU (Energy Management Unit) and the Urja Bandhu. All of these devices were developed by CAT Projects and CAT from its base in Alice Springs. The Bushlight EMU is a user interface and control that was rolled-out into more than 150 remote Indigenous communities through the successful Bushlight renewable energy program (2002–2012). In this case, it assisted residents of to manage their household energy budget generated by a stand-alone community photovoltaic power system. As well as indications of current consumption trends, it also included timers for certain discretionary appliances. The Urja Bandhu is the cost-effective user interface and controller that was developed for Bushlight India in around 2008. This project provided village electrification (solar photovoltaic) for several remote Indian villages, and the Urja Bandhu was an important tool for demand side management. The lessons learned from the development of these two devices fed into the subsequent development of the BEEBox. The BEEBox's first trial in communities occurred in the desert outstations of Utopia in 2013, followed by deployment in the Manymak Energy Efficiency Project.

## 8.3 What is a BEEBox?

The BEEBox was designed in response to the identified needs of residents of remote Indigenous communities. The design process brought together more than a decade of experience working in the remote Indigenous community context through the Bushlight Renewable Energy Program, as well as other large Indigenous energy efficiency projects. It was specifically developed to help manage energy consumption in remote households and to stand up to the rigours of extreme climates, and remote community living.

The BEEBox is a robust, visual user interface that conveys a range of energy use information to householders, along with a controller that is located in the household switchboard. It is Australian designed and manufactured. The device is intended to measure and communicate information on a household's overall energy consumption, not individual circuits. Using the concept of a tailored 'daily energy budget' for each household, the device displays the rate of current energy use and dollars spent for the day. A key difference between the BEEBox and other commercially available displays is that the BEEBox provides 'at a glance' information to users, using a simple 'traffic light' colour coding system and a 'dollars spent today' alarm clock-style display.

The BEEBox display is the consumers' primary interface. It is mounted on a wall or shelf in a central or high-traffic location within the house so that passers-by will trigger the motion sensor and the consumption

[50] Structural factors that lead to high energy consumption in Indigenous communities include thermally inefficient public housing stock, locations of extreme temperatures and increased cooling/heating requirements, high cost of energy-efficient goods and large proportion of fixed high energy use appliances (e.g. electric hot water systems).

information will light up. The 'daily power budget' green lights accumulate over the recording period (typically over a day) and give consumers an indication of whether they are on track to remain within their nominated household energy/cost budget. If the designated energy budget is exceeded, the red lights will come on. The 'money spent today' display segment provides an accumulated 'to-date' cost for the recording period. The 'power speedo' lights show the consumer their instantaneous power usage.

## 8.4 Technical Specifications

The technical specifications of the BEEBox controller are as follows:

- IP56 rated enclosure designed for easy installation in standard consumer switchboards
- communicates by radio with BEEBox display using free 915 GHz frequency spectrum
- programmable via easy-to-use dedicated software interface on the controller using standard USB cable
- programmable parameters include: location details, date and time, budget reset period (daily, weekly, monthly), budget setpoint (up to 2500 kWh in increments of 250Wh, either fixed annually or with monthly values), period reset time, two tariff levels with start/end times and instantaneous power threshold display values
- internal SD card stores a minimum of 12 months of 15-minute consumption and power quality data (voltage, current, watts, VAR, VA, PF, period cumulative kWh, total cumulative kWh, display status and radio signal strength) along with configured values
- internal battery ensures configuration data is held indefinitely
- robust design and construction of display and controller suitable for harsh environments.

The technical specifications of the BEEBox display include:

- can be either freestanding or wall-mounted
- for internal use only; uses standard 12V DC plug pack
- displays cumulative kWh budget, cost of consumption and instantaneous power usage for current period
- safety compliance and radio-emissions tested according to Australian standards
- incorporation of a motion sensor and timeout for the lights on the display.

## 8.5 Physical Installation Approach

The installation goal for the project was for the BEEBox to monitor the entire household consumption, with the controller installed outside the house as close to the meter as practical and the in-house display in a prominent internal location nominated by the householder.

For this project, the BEEBox controller was connected on the customer side of the power meter, with electrical connection directly onto the customer mains using a piercing connector.

## 8.6 Custom Programming for the Project

The thresholds for each level (green, yellow, red) are fully programmable, with nominal design intent being to set them relative to the consumer's nominated daily budget. In this way, maintaining consumption within the green zone results in the 'daily power budget' not being exceeded. Time in the orange zone warns of consumption potentially exceeding the nominated budget. And the red zone makes consumers aware of an energy intensive consumption pattern they potentially need to manage depending on duration. The 'power speedo' thresholds, nominated 'daily power budget' and tariffs for presentation of the 'money spent today' segment are all configurable at the time of installation and adjustable by a suitably trained technician.

The BEEBox budget and speedo components are fully programmable via the controller.

*YEEW assisting a contractor in Galiwin'ku to install a BEEBox*

## 8.7 Design of the Engagement Process and Budget Values

A BEEBox engagement plan was developed prior to the installation of BEEBoxes in Milingimbi and was based on the learnings from the roll-out of BEEBoxes in Utopia by Bushlight staff. It formed part of the larger community engagement plan document.

The BEEBox was intended to build on the provision of quality energy efficiency information for households by providing consumer feedback on energy use to further enable informed decision making. In preparing the plan, two parameters were recognised:

- BEEBox installation would be 'opt in' by households.
- To maximise benefit, 'sign up' for a BEEBox should occur once solid household engagement had already taken place; that is, when people have a solid foundation of energy efficiency information.

The suggested BEEBox house visits were:

- First BEEBox-related visit by YEEWs: discuss energy efficiency activities and introduce residents to the BEEBox to familiarise and gain an indication of interest, and arrange a follow up visit.
- Second BEEBox house visit: with LIEEP staff member, interpreter and YEEWs, sign up households that are interested in having a BEEBox. This visit explains the workings of the BEEBox, discusses the budget for the house and talks about the installation process. The resident would indicate where the BEEBox display would be installed in the house.
- Third BEEBox house visit is a follow-up visit to check that the unit is working OK, does the household need further training or do they want to change the budget.

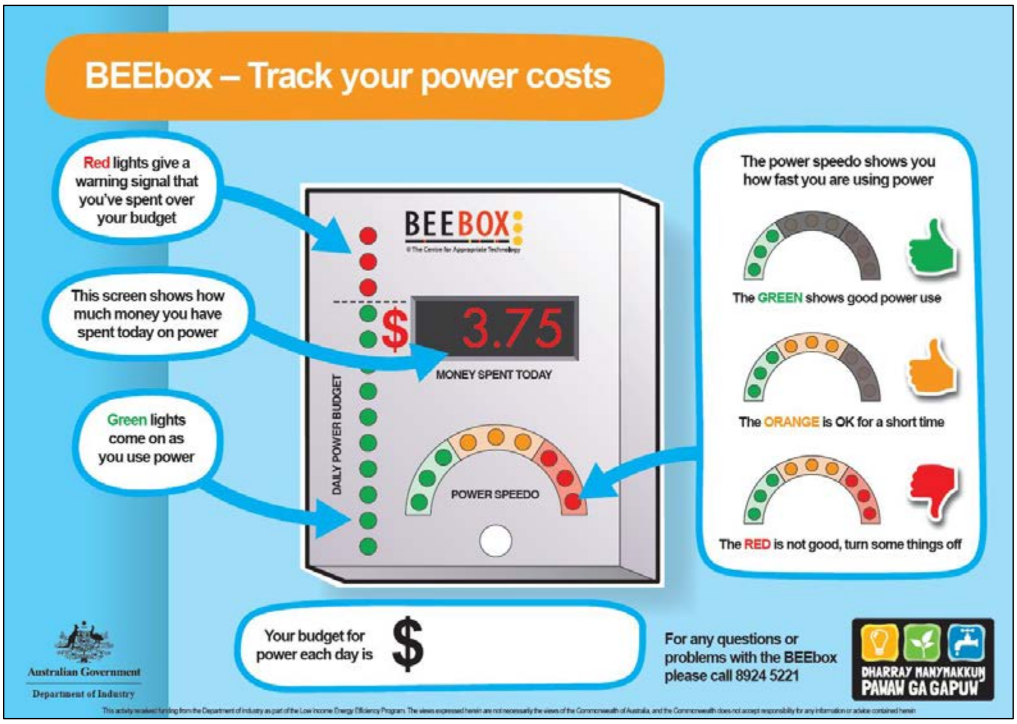
## 8.8 Setting the Budget

The BEEBox design includes a programmable budget and speedo thresholds, allowing for customisation of these to suit each household's relative consumption levels, regardless of whether they were high or low energy use homes. The data loggers that were installed in all homes at the commencement of the LIEEP project provided crucial baseline data that was able to be used to inform the choice of the budgets for BEEBox installs.

The approach to programming the BEEBox budget and speedo parameters evolved over the course of the project. For the first deployment in Milingimbi, the budget was set to a single annual figure representing the household's average daily energy consumption for the six months of March to August 2014. The option to set distinct monthly or seasonal budgets was not utilised.

Subsequent installations utilised a longer period of historical consumption, incorporating wet and dry season months to better represent overall annual consumption. They also utilised a budget figure representing the third quartile of consumption rather than the mean. This was settled on in recognition that daily energy consumption varied considerably day to day. A budget representing a mean would result in the household seeing the budget exceeded every second day, whereas the third quartile setting would result in households only seeing the budget exceeded on one day in every four on average, notwithstanding that the budget reset time was midnight meaning the householder would need to be observing the in-house component late in the day to notice the budget being exceeded.

*Figure 2: A poster of the BEEBox was displayed on participating residents' walls adjacent to the BEEBox*




## 8.9 BEEBox Training for the YEEWs

In Milingimbi and Galiwin'ku, the first two communities to have BEEBoxes installed, BEEBox training was delivered by the assigned project team community engagement officer and an additional CAT project officer who had previously worked on the Utopia BEEBox roll-out. The resources that had been used in Utopia—

posters, photos and budget graphs—were modified and utilised in the training. A working display model of the BEEBox was made that could be taken to the communities. An appliance, such as an electric jug, could be plugged in to show how the BEEBox display changed while power was being used.

It had been planned that the best approach for training the YEEWs on the use of the BEEBox would be to first install a unit in the houses of those workers who volunteered and use this as a learning environment prior to attempting household engagement. In the first two communities, this was not possible because of the delay in BEEBox manufacturing and the need to meet milestone targets for the project. In the subsequent four communities, the workers were the first to have a BEEBox installed, and they were in place for a few weeks before any further house hold visits were conducted. This gave the workers (those that had agreed to have one installed in their houses) an opportunity to observe the BEEBox display while they were using household appliances.

In these four communities, ARDS was engaged to deliver the training on BEEBoxes in Yolŋu Matha. This was done towards the end of the first four-week block of training about energy efficiency. Here is an extract from the report the ARDS trainer prepared after training delivery at Ramingining:

> *Today we went back through the meter box/BEEBox story and went into the budget as well as the installation process. I used the same butcher's paper I had used on the Friday but re-told the story and had everyone's attention. This was really successful. We went through the meter box and the BEEBox as we have previously:*
>
> *The meter box works like a basket that holds energy when credit is put in. It counts how much is left, and if any appliances ask for food, it gives it to them. This led into a short discussion about some appliances being humble, and others being very greedy. As the meter box counts, it counts backwards or downwards from whatever power card you put in (say, 2 x $20 cards = $40) back to $0. Then the Taggle [data logger] sends the information to [PWC] and they can see how much everyone is using.*
>
> *The BEEBox works like a friend to the meter box. They both count power, but the BEEBox brain counts forwards or upwards, and tells us how much has been used that day. The brain sends the story to the display in the same sort of way that the Taggle sends it to [PWC]. Then the display tells us three stories. One is the speedo—like a car—telling us how fast the power is being used. The next two are really the same kind of story, but told in two languages. Both tell us how much power has been used that day, and one tells us in money; the other tells us with lights.*
>
> *Then we had a break and came back to talk about the budget. We talked through the data from the Taggle and used an example of a house that used $40 in 4 days. We found the average and drew it on the pretend data and then explained that this was used to decide what that house's budget would be. We unpacked the words 'average' and 'target' and 'budget' on our new words list. Then we brought back the idea to the BEEBox and I explained that the point between the green and red lights on the display is where the budget number would sit. Everyone's would be different, and the $ display would also show the same amount when it got there.*
>
> *I drew up a new sheet using the aiming hunter [metaphor] and explained that different houses would be aiming at different points, and the lower they could get it, the more skilled they were at using power.*

*There was a bit of discussion after this, and it was clear that people were actively grappling with the new ideas. We would revisit the whole thing again on Wednesday.*

## 8.10 Explaining the BEEBox Budget

BEEBox budgets were discussed with households extensively throughout the training and house visit process. In the first two communities to receive the BEEBoxes, Milingimbi and Galiwin'ku, attempts were made to discuss setting a 'preferred budget' with the householder. The education and engagement with households was done by the YEEWs after they had received training by CAT officers using an interpreter and a working model of the BEEBox.

The YEEWs made a preliminary house visit to explain how the BEEBox worked and what it was for and to gauge interest in having one. They then returned to the houses that had indicated they wanted a BEEBox and took with them a recommended daily budget amount and a form to complete that would record the location of the display inside the house and a section to record the householder's preferred budget. In Milingimbi, the recommended budget figure was based on an 'average' consumption from Taggle data collected during April and September 2014. In Galiwin'ku and the other four communities, the recommended budget was set at the level of the third quartile based on data collected over a longer period, usually from April 2014 up to the date of pre-installation engagement in each community.

Further household engagement and YEEW training was undertaken in Milingimbi once household consumption data from the Taggle data loggers was arranged to show the use of electricity on a daily basis in relation to the recommended BEEBox budget. A project team member held discussions with the YEEWs in Milingimbi showing them the graphs on usage that had been generated and discussing some of the houses that had a high 'overspend' for their consumption. The analysis and presentation of the data was made available late in the project, close to the end of community engagement, so there was only a small window of opportunity to go back to some of the houses and do further engagement. A small number of these houses requested that their budget figure be changed and where possible this happened.

***Milingimbi YEEW setting a household budget with a participating resident***

## 8.11 Distribution of BEEBoxes

The allocation of BEEBoxes to communities was not specified in the project plan, apart from Ramingining initially being excluded from trialling them. In discussing the appropriate allocation approach, the importance of equity between communities was taken into account, but the team first needed to see what the take-up would be like in the first communities before it could gauge if they were going to be popular or not. It was not long after Milingimbi and Galiwin'ku YEEWs began the BEEBox household engagement that the project team realised that households were expressing strong interest in having an in-house display. As per the data from household visit forms, the majority of houses in Milingimbi and Galiwin'ku initially offered a BEEBox by the YEEWs wanted to have the technology installed (Table 13).

***Table 13: Interaction records related to offering a BEEBox***

| **Community** | **BEEBox offer and response** | | | |
|---|---|---|---|---|
| | **No** | **Not sure** | **Yes** | **Total** |
| Galiwin'ku | 2 | 4 | 76 | 82 |
| Milingimbi | 3 | 4 | 34 | 41 |

It was noted after allocation of BEEBoxes in Milingimbi and Galiwin'ku that the approach had been ad hoc and was possibly inequitable. For example, first in, first served, based on YEEWs' relationships with residents, with many households missing out because they didn't know about them earlier. Questions were raised regarding this approach and whether it would create perceptions of the project favouring some households over others or create tension between houses that did and didn't get one and confusion about the process.

In an attempt to resolve this problem, the project team asked the ARDS trainers to include a discussion with the YEEWs when doing the initial BEEBox training. This would give the four remaining communities an opportunity to tailor a distribution method that met their cultural requirements. Some ideas were put forward by the project team, including conducting a 'ballot' to choose which house to install a BEEBox. Each community decided on a method that involved two aspects. One method was to target houses that the YEEWs knew were struggling to purchase power cards. The second method was to take into account Gurrutu (kinship) relationships and obligations that the YEEWs had in the community. Here is how the ARDS trainer recorded a training session in Ramingining:

> *I got to the issue of BEEBox distribution, and discussion began immediately. We brought up the idea of the ballot, and Dorothy had raised the issue that she knew people who were always looking for money for power cards. We decided that it was better that the workers decide who needed it the most because of their financial situation, number of people in the house, or just didn't know how to use it well. We then discussed the issue of making sure we're not seen to be just giving the BEEBoxes to close family, or only giving them to people in one area more than another.*

## 8.12 YEEWs' Involvement in the Installation of the BEEBox

Whenever possible, the YEEWs accompanied the installation contractors when they went to a participating household to install the BEEBox. During this visit, and as the contractors set up, the YEEWs' task was to let the household know what work was being undertaken and what would be happening during the process of the installation. A checklist with photos was available for their reference. The YEEWs informed the household that the power supply would be turned off during the installation process and let the residents know about electrical safety issues, especially if children were present at the house while the contractors were working. The remaining time could then be used to explain more about energy efficiency if the household was interested. Once the BEEBox installation and testing was complete, they could then take the residents through the workings of the BEEBox by turning on some appliances (stove, air-conditioner etc.) and watching the changes on the in-house display. This provided an opportunity for demonstrating how the BEEBox worked. The YEEWs could then continue to ensure that the next household was prepared for installation.

## 8.13 Installation

The installation of the BEEBox in home display units was procured and project managed by the PWC senior project officer. Manufacturing and certification delays with the BEEBox meant that the first units arrived in Darwin in September 2014. A total of 250 BEEBoxes were initially allocated for installation (Table 14).

In September 2014, the first 50 BEEBoxes were shipped to PWC with the intent of installing 50 in Milingimbi, for which a Darwin-based electrical contractor was engaged. Due to a concern of low take up in other communities, plus a high level of interest from householders, another nine BEEBoxes were added to Milingimbi's allocation. By mid-November 2014, 59 BEEBoxes were installed in the community.

In October 2015, the second batch of 100 BEEBoxes was delivered from CAT.

The second tranche of 100 BEEBoxes installations was contracted in November 2014 in Galiwin'ku. A local Galiwin'ku-based electrician was successful in winning this contract. The first 50 BEEBoxes were installed in Galiwin'ku by late December 2014. The remaining installation in this contract was significantly delayed by cyclones Lam and Nathan, which struck the community in early 2015.

During this delay, anecdotal evidence coming from the Milingimbi community suggested that some BEEBoxes were being unplugged and the GPO (general power outlet) used for other purposes. Early on in the inception phase of the BEEBox roll-out, CAT Projects strongly suggested that the project team install a separate dedicated GPO just below ceiling level where it would be impractical to use for other appliances; however, budgetary constraints meant that this option was not pursued. For the second half of the Galiwin'ku roll-out, the contract was varied to include the installation of a dedicated GPO as was originally recommended. This was included in all subsequent contracts.

The remaining 100 BEEBoxes were delivered from CAT in early 2015. Another 30 BEEBoxes were installed in Galiwin'ku under the contract between May and August 2015, bringing Galiwin'ku's total to 80 BEEBoxes installed.

The installing contractors were required to program a number of parameters into the BEEBox controller units via a proprietary software program. This was managed by providing contractors with a data sheet pre-populated with the parameters for each lot number. Also captured in the data sheet were:

- pre-payment meter number and space for the contractor to record a reading
- BEEBox controller/display unit numbers
- compliance tick box section including:
    - asbestos identification
    - before and after photos taken
    - BEEBox display and controller programming and pairing complete
    - budget/info poster mounted to wall

- new GPO installed
- Certificate of Compliance (CoC) completed
- voltage check and connection check completed.

*Table 14: Allocated and actual BEEBox installations*

| Community | Initial allocation | Installed |
|---|---|---|
| Milingimbi | 50 | 59 |
| Galiwin'ku | 100 | 80[51] |
| Gunyangara | 10 | 10 |
| Yirrkala | 40 | 38 |
| Gapuwiyak | 50 | 39 |
| Ramingining | 0 | 26 |
| **Total** | **250** | **252** |

Delivery of the data sheets were part of the install contract, and payments were linked to successful delivery of the sheets.

The third tranche of BEEBox installation was awarded in February 2015 to a Gove-based contractor for installations in the communities of Yirrkala and Gunyangara. Under this contract, 48 BEEBoxes were installed in these two communities by November 2015 (38 in Yirrkala and 10 in Gunyangara).

In Early 2015, agreement was obtained to include Ramingining in the BEEBox roll-out. Given that a significant number of target houses had been destroyed or made uninhabitable in Galiwin'ku by the two cyclones in early 2015, the project team re-allocated the remainder of Galiwin'ku's BEEBox quota to Ramingining.

In April 2015, the project team identified the risk of having no spare BEEBox units in case of failures on install, as well as having allocated two BEEBox units as display models for training purposes. Not having readily accessible spare units posed the risk of milestone numbers not being met in the case of a single failed unit prior to install. Based on this risk, an additional 10 BEEBox units were purchased from CAT projects.

The final tranche of BEEBox installation for Gapuwiyak and Ramingining was awarded to a Darwin contractor in August 2015 and completed by November 2015. Thirty-nine BEEBoxes were installed in Gapuwiyak and 26 in Ramingining, which brought the total number of BEEBoxes installed to 252 out of a target of 250 (Table 14).

## 8.14 BEEBox Data Extraction

In April 2015, a BEEBox data extraction was undertaken in the community of Milingimbi. Data for 55 out of the total 59 houses was extracted and included 15-minute interval energy consumption data, on/off indication data and the signal strength being received from the in-house display.

Data was downloaded to a laptop via a USB cable into Excel format. A Darwin-based contractor completed this work along with the project team data officer. The energy consumption data was compared with the Taggle energy consumption data by grouping both the data sets into daily consumption resolution. Analysis of the two data sets showed that the energy consumption measured by the two devices was virtually identical.

[51] Eight BEEBoxes deployed in Galiwin'ku prior to Cyclone Lam were on houses vacated after the cyclone, with the BEEBoxes either damaged beyond repair or recovered and redeployed.

Data in the extract included a value representing the signal strength from the in-house component to the controller, and a summary value from 0-1 (where 0 means no record and 1 means record received with good strength). This data was interpreted such that if the value is > 0.2, the display unit was plugged in and communicated for that period. The iteration of data involved grouping and quantifying data records with > 0.2 BEEBox display status.

In anticipation of capturing additional data extracts, the project's database was modified to include storage of the BEEBox data; however, no additional extracts were completed.


***Visiting CAT employee programming a BEEBox with a Galiwin'ku YEEW***

# 9 Household Retrofits

## 9.1 Evolution of Design, Targets and Budgets

The installation of household energy efficiency upgrades or retrofits was a key trial within the Manymak Energy Efficiency Project. The funding agreement, established on 14 May 2013, initially allowed for a household retrofit budget of $2,981,000 towards retrofitting 550 participant households with energy saving devices for the five north east Arnhem Land communities of Yirrkala, Milingimbi, Galiwin'ku, Gapuwiyak and Gunyangara.

The retrofits approach was split into two distinct sections: major retrofits and minor retrofits.

Major retrofits were items with a cost greater than $1000 that required complex delivery and management were to be delivered using additional project and contract management support, whereas minor retrofits cost less than $1000 and generally required a less complex means of delivery were to be delivered directly by PWC.

As part of the milestone 2 submission, the project plan adjusted the total retrofits budget down to $2,901,000 to support increases to the BEEBox and Data logger budgets.

## 9.2 Renegotiating the Scope

Early in the project, a major risk was identified: that it may not be possible to achieve the retrofit target of 550 households across the five main communities (with Ramingining at that time not stated to receive retrofits as part of the project in its role as a control community). The total number of eligible houses in the five communities was identified as 550, of which a significant number were new and relatively efficient houses rolled out as part of national Indigenous housing programs (NPARIH and SIHIP).

The National Partnership Agreement on Remote Indigenous Housing (NPARIH), which now incorporates the Strategic Indigenous Housing and Infrastructure Program (SIHIP), was the largest housing program ever undertaken by the Australian and Northern Territory governments. The joint housing program aimed to deliver 934 new houses, 415 rebuilds of existing houses and 2500 refurbishments across 73 remote Indigenous communities and a number of community living areas (town camps) in the Northern Territory by 2013.[52]

The roll-out of NPARIH included construction of new houses across the project's six participating communities in the five years up to the commencement of the project's detailed energy efficiency retrofit scoping in 2014. Energy efficiency measures included in the new housing included heat pump or solar hot water systems, 900mm eaves over most walls and in particular on east or west-facing windows, compact fluorescent lamp (CFL) PAR38 security lights with a PhotoElectric (PE) detector, Bondor ceiling insulation, light-coloured roofing and magnetically ballasted fluorescent tube interior lighting.

Community housing stock had been split into the following categories as part of scoping and delivery of NPARIH:

- new – delivered through NPARIH/SIHIP (less than five years old)
- legacy – this housing stock included dwellings in original condition that were not assigned to receive refurbishments

[52] National Partnership Agreement on Remote Indigenous Housing, http://www.housing.nt.gov.au/remotehousing/strategic_Indigenous_housing_and_infrastructure_program

- refurbished – housing stock more than five years old that typically received new kitchens and wet areas and other priority repairs
- beyond economic repair housing (BER) – housing stock assessed as not viable to bring up to housing standards, though due to housing pressures some were still in use as dwellings.

Refer to Appendix A for additional details on the various housing types identified.

In order to meet the original project target within five communities, the project would need to install a retrofit to every single potential house, part of which would rely on tenants opting in for appliance retrofit items. Achieving 550 retrofits would therefore have relied on 100 per cent participation, while the project's overall participation target was only eighty per cent of households approached to participate.

Budgetary constraints were also seen to place further pressure on achieving the target of retrofits due to the relative expense of the preferred major retrofits, which were the items assessed as having the greatest potential impact on household energy efficiency and meeting the necessary robustness criteria for remote housing.

A more achievable target was agreed by the Australian Government: to reduce the retrofits target to 80 per cent of the original—440 of the 550 homes. It was planned that this would be achieved through a combination of major retrofits to the older housing stock along with opt-in appliances and fixture retrofits for new housing.

The timing of retrofit installations was also negotiated to reflect the long lead times required to implement major retrofit roll-outs in community (building on DHsg experience with similar works) and the impact of the wet season, which was predicted to prevent significant work during the peak rain months of January to April.

## 9.3 Retrofit Implementation Plan

In early 2014, the following approach to choosing appropriate retrofit technology was adopted as part of milestone 4, based on the approach detailed in the original trial design as well as results from the energy efficiency barrier survey evaluation:

- Focus on retrofitting well-proven major items such as solar hot water (SHW) and heat pump hot water systems, ceiling insulation and awnings.
- Target for these major retrofits will be between 100 and 200 households.
- Also provide a separate set of opt-in tenant-level retrofits such as light bulbs, thermostats and energy-efficient power boards.
    - The barrier surveys identified that 59.5 per cent of households had an air-conditioner, many without built-in thermostat, 95.2 per cent of households reported to have a TV, giving further support to the potential utility of standby switches/energy-efficient power boards[53].
- In order to ensure compliance with the project's risk and compliance plans, PWC on behalf of the consortium would engage additional project management support for the installation of major retrofits items.
- DHsg to approve assets, coordinate tenants and acceptance, test the 'landlord' retrofits, which then passes to DHsg for long-term control.
- Contingency allowance to be made available to support maintenance of the retrofits for the life of the project to reduce risk for DHsg and the consortium.
- Consideration of conducting a more detailed study on a selection of houses to answer thermal performance questions of importance to the project, subject to scoping the resources required.

[53] Refer to appendices for further barrier survey results

## 9.4 Shortlisting and Selection of Households

To progress the household retrofits element of the project, the project team and the NT Department of Housing used a variety of means to profile the housing stock, including[54]:

- analysis of PWC pre-payment meter data
- DHsg Condition Assessment Tool (CAT) surveys – condition reports on all major components of each dwelling
- survey / interview with households.

Because of the lead times involved, scoping of housing was implemented ahead of the establishment of the community engagement ambassador program.

The aforementioned SIHIP/NPARIH classifications were adopted by the project team for the purpose of identifying groups of housing stock. These categories were used in order to identify which groups of houses were or were not appropriate for a major or minor retrofit. The following methodology was applied to each category:

- New housing – in all new housing stock, it was established that there was little opportunity for installing major retrofit items, as they were designed to meet a five-star rating, with heat pump or solar hot water systems, energy-efficient lighting, passive solar design including wall and window eaves, light-coloured roofing and Bondor ceiling insulation. The focus would be on opt-in appliance retrofits to be offered through the ambassador program as it rolled out.
- Refurbished housing – this housing stock was deemed to be the most viable for further scoping for major retrofit items because the majority of these houses had electric hot water systems or solar hot water systems potentially running on booster only, no ceiling insulation and in many cases, unshaded windows. This was assessed from site visits, DHsg CAT surveys and the LIEEP 'Housing Energy Efficiency Discussion Paper' produced by the DHsg.
- Legacy housing – this was a small group of houses that were in original condition, being neither BER nor having received any refurbishments. This housing was included in major retrofit scoping.
- Beyond economic repair housing (BER) –not considered eligible for a major retrofit item.

## 9.5 Shortlisting of Retrofit Items

In late 2013, the project team worked closely with the DHsg architect and staff to begin the scoping process of housing types and potential retrofit items to be considered to form part of the project's retrofits program. Early discussions led to the production of a retrofits opportunity scoping list, which detailed a large range of the potential appropriate retrofit items that should be considered.

The following criteria were established by the DHsg contract architect and reviewed by the consortium members' project team:

- energy saving priority (high, medium, low)
- estimated kWh saving potential
- consultation required with residents (high, medium, low)
- compliance with funding agreement
- asset ownership (NTG/tenant)
- risks and benefits.

[54] These data sources are discussed in more detail in the Manymak power use project's Data Collection and Reporting Plan

DHsg and project team staff conducted visits to each of the communities to visit a sample of houses. The purpose was to review the many different housing styles in communities, which had evolved over decades of separate housing supply projects, with a focus on energy efficiency opportunities for each housing style.

As a result of these investigations, DHsg produced a retrofits discussion paper for the project that addressed the following:

- definition of parameters to assist in selecting houses and targeting efficient retrofits of fixtures, fitting and appliances
- review of existing requirements of DHsg
- identification of lessons learnt and feedback from recent projects
- definition of elements of housing suitable for retrofit
- clarification of types of retrofits – split between public housing property and tenant property.

The following comments and observations arose from this discussion paper:

- New and upgraded remote housing stock currently includes many energy-efficient (EE) components and design measures, such as light-coloured roofing, window awnings, roof insulation and efficient fluorescent tubes. The range of houses with existing EE measures should provide the project team with a statistically robust study base for modelling purposes across the study communities. This could allow the project to measure changes to energy usage for various subsets of house types.
- The various existing energy efficiency components could be assessed and monitored through the project for example, comparing the relative performance of existing hot water systems (HWS).
- The retrofit work scopes selected should inform decision making in regard to DHsg's design parameters and the selection of EE fixtures, fittings and equipment for use in remote public housing into the future.
- Generally, the higher priority items identified by DHsg include construction tasks e.g. design (layout, materials and product selection), structural certifications, site supervision of works and final approvals.
- There will be a significant management task in monitoring the maintenance and upkeep of existing EE items across the study communities.
- The introduction of fittings requiring specific consumables or new equipment will require local participation across all sectors of the community. For example, community stores will be asked to maintain a supply of energy-efficient bulbs and tubes and community maintenance staff or panel contractors need to be familiar with the installed equipment for ongoing upkeep.

The discussion paper proposed that the following items be offered for consideration in targeted study subsets involving construction work:

- Glazing treatment. Replace clear polycarbonate for translucent glazing for part of the window. This would build on a previous desktop study by RMIT on the energy efficiency benefits of translucent versus opaque glazing, particularly in louvers[55].
- Provide ceiling insulation and improve seals to habitable rooms where air conditioning is currently installed.
- Improve solar protection to exposed walls by:
    - replacing 'darker' paint colours with lighter tones
    - adding insulation (exterior or interior)
    - installing awnings

[55] Martel, A. and Horne, R., 2011. Thermal comfort modelling of Top End remote Indigenous housing in the Northern Territory. *MTRO (More Than a Roof Overhead) Working Paper*

    - installing wall screens
    - providing shade trees and ground cover.
- Cooking equipment. Select and evaluate various stoves, ovens and hot plates.
- Hot water systems. Trial alternative hot water systems to test assumptions of power use and water consumption.

Shade awnings were initially identified as a recommended retrofit item; however, they were later removed from the final retrofits to be offered as their energy efficiency utility did not justify the expense and potential risks, which included:

- high cost of building and certifying fixed awnings to cyclonic conditions
- shade sails typically have a very short life in community due to vandalism
- unless a house is air-conditioned, window awnings provide thermal comfort benefits but minimal energy-saving potential.

A strong consideration overall in the retrofit approach was the importance to community members of equity—that households would not be left out while others received a perceived significant benefit. A project team member from DHsg identified this in previous house refurbishment projects where some houses were upgraded and not others. This caused tension within the community and raised many questions of equity.

Community preference was for awnings that would provide outdoor shaded living areas, rather than just an awning. This could be achieved at similar cost to a retrofitted awning, but it would then increase the risk of equity issues due to the universal demand for the provision of more outdoor shade. The project would need to provide an outdoor shaded area for every house in a community if it provided any.

## 9.6 Solar Hot Water Versus Heat Pump Hot Water

Some debate was entered into by the project team and DHsg project officers as to whether solar or heat pump hot water systems were more appropriate for installation in the east Arnhem Land context. There was some anecdotal reporting of high rates of failure of heat pumps that were installed as part of the NPARIH/SIHIP programs; however, it was not possible to get accurate figures of actual failures. Additionally, the PWC contracted essential services officer (ESO) in Milingimbi noted that leaf litter collecting under solar hot water collectors has led to widespread roofing damage and that a more appropriate stone guard needed to be developed to mitigate damage from vandalism. In order to address these issues and others identified by the project team, CAT Projects was contracted to write a report that addressed the following scope:

- undertake an assessment of the relative economic costs and benefits of solar hot water systems (HWS) versus heat pumps for installation in east Arnhem Land communities
- redesign the solar HWS mounting frame to reduce trapping of leaf litter against the frame under the unit and gain compliance/approval for a new frame
- review and assess potential improvements to the solar HWS stone grille/guard and safety net
- review and determine an approved standard assessment practice for selecting either a 180 litre or 300 litre solar HWS, accounting for the generally non-standard nature of systems used in these locations (characterised by high occupancy rates and social contexts of hot water demand)
- establish an approved pipework and fittings schedule consistent with Territory Housing requirements for all new roof mount solar HWS installations (e.g. use of stainless steel and UV stable roof mount plumbing fittings with roof penetrations to be fitted with approved deck tight seal)
- develop specifications for potential installation of split heat pump systems
- specifications for installation that reduces the need for roof access for common maintenance tasks

- determine an approved specification for new mountings for heat pumps, including the use of preformed, poured reinforced slabs and approved waffle or propriety stand pads
- investigative report to confirm the selection process for either J Series or L Series solar HWS based on community water quality thresholds and assessment of purchase, installation and maintenance costs.

The report identified advantages and disadvantages of both systems:

Advantages of solar HWS over heat pump HWS:

- One primary consideration for the householder is that in the case of a power outage or insufficient pre-payment meter credit, hot water from a solar HWS will still be available when there is sufficient incoming solar energy.
- In the warmer months when hot water usage will generally be lower, a household may find the use of the electric one-shot booster is not required. Therefore, hot water provision for significant portions of the year may still be at no cost to the household.
- During periods of low or no occupancy, a solar HWS will not require additional pre-payment meter credit unlike a heat pump HWS, which will still use a small amount of energy and pre-payment credit while occupants are away, unless the heat pump HWS has been turned off.

Advantages of heat pump HWS over solar HWS:

- Heat pump systems are installed at ground level, making installation and maintenance simpler and avoiding the safety risks of installing and servicing roof-based appliances.
- A heat pump HWS provides larger quantities of hot water at a lower cost than a solar HWS due to the solar system using resistive electric heating for top-up heating.

From the finding of this report, CAT Projects recommended that for households averaging up to five occupants, a solar HWS should be installed because the cost crossover point between the two technologies was found to be six people. Therefore, for households averaging seven occupants or more, a heat pump HWS was recommended to be installed. For households averaging six occupants, or for those with highly variable occupancy, a decision was recommended to be made based on detailed hot water usage figures, additional benefits of the different technologies relevant to the particular household and product warranty periods. Additionally, CAT Projects recommended that the smaller 180L solar HWS only be used for shelters or small houses of one or two occupants.

With regards to the issue of leaf litter being caught under solar HWS collectors, the report recommended and designed a framing solution that provided an increased gap between the roof and the solar collectors.

The CAT Project addressed the stone guard aspect of the scope of the report and developed the recommendation to develop a proprietary stone guard that was based on a compromise between mesh size and gauge of wire that maintains the same level of collector efficiency currently afforded by the Solahart proprietary stone guard.

Based on the recommendation from the CAT Project's report, it became clear that the most efficient hot water delivery option for the project from a purely economic view was heat pump technology, given that the average number of householders in each house participating in the project was greater than seven. However, the report did not adequately address the anecdotal issue of premature failure of heat pumps in east Arnhem Land households; therefore, the approach decided on was to trial a mixture of both technologies, including an alternative heat pump technology.

## 9.7 Final List Of Retrofit Items

The final list of retrofits developed from the scoping approach described above was as follows.

Major retrofit items to be allocated in consultation with DHsg:

- Replacement of electric hot water units (including existing solar hot water units operating essentially as electric-only units) with a mix of:
  - Quantum 340L heat pump HWS
  - Solahart 302J solar HWS.

- Installation of R3.5 bulk ceiling insulation into houses with suitable ceiling spaces and only for houses with air-conditioning in place.

Minor retrofits to be offered on an opt-in basis through the ambassadors:

- stove timers
- LED/CFL PAR38 outdoor light bulb replacement
- Ecoswitch standby shutoff switch
- HeaterMate air-conditioner thermostat.

## 9.8 Scoping the Households

To ensure the most appropriate retrofit was chosen for each participating household, a comprehensive scoping process was undertaken. The first step of the scoping process was the production of a household retrofit site survey checklist to be used as a tool to provide a nomination of households suitable to receive priority retrofit items from the recommended retrofit list. Then in mid–2014, household scoping visits were undertaken by a DHsg asset management officer in 296 houses across Milingimbi, Galiwin'ku, Gapuwiyak, Yirrkala and Gunyangara. Ramingining was not included as it was not at this time assigned to receive retrofits.

These visits were conducted using the existing DHsg protocols for notifying residents of inspections of community housing, with the added context of it being related to an upcoming energy efficiency project. BER houses and new housing were not scoped, given that they were not suitable for a major retrofit item.

Once this scoping process was complete, the project team entered all data into a spreadsheet and produced a list of priority recommended retrofit items. This priority list was then used to produce quantity surveyor-supplied estimates and formed a first phase roll-out of major retrofits.

This initial plan would support the achievement of the milestone 6 retrofit requirements but implied that the remaining 300 retrofits required to meet the end of project target would need to be met through household engagement on opt-in minor items and potential additional household scoping for major items.

## 9.9 Implementing Major Retrofits

Early on in the project, it was identified that additional project management resources were required to support the project's major retrofit roll-out, taking into account resourcing, risk and compliance management requirements. After consideration of a number of options, it was agreed that DoI as the current delivery agent for DHsg infrastructure works in the region would be the appropriate project and contract management agent, but that the relationship would be established directly between PWC and DoI in order to avoid multiple agreements and in recognition that DHsg did not have a project funded position to manage the relationship.

Through a service level agreement between PWC and DoI, the DoI East Arnhem office was engaged to manage this work. The first tranche of work, which was project managed by DoI during 2014 and early 2015, was broken up into four separate packages for Milingimbi, Galiwin'ku, Gapuwiyak and the Nhulunbuy region (Yirrkala/Gunyangara), with the larger packages going through an open tender through the NT Government Tenders Online system and the smaller Nhulunbuy region package using existing panel contracts. All successful contractors were Northern Territory based. Table 15 details the major retrofit items installed in each community.

***Table 15: Tranche one, major retrofits delivered through DoI – actual***

| Community | Solar HWS | Heat pump HWS | Ceiling insulation (# of lots) | Cost (GST ex) |
|---|---|---|---|---|
| Milingimbi | 14 | 32 | 0 | $435,645.46 |
| Galiwin'ku | 10 | 52 | 0 | $439,833.62 |
| Yirrkala/Gunyangara | 21 | | 8 | $236,830.00 |
| Gapuwiyak | 34 | 0 | 7 | $262,584.55 |
| **Subtotal** | **51** | **80** | **16** | **$1,374,893.63** |
| Project management fee | | | | $188,009.00 |
| **Total** | | | **147** | **$1,562,902.60** |

Safety was a key consideration for all works undertaken as part of the Manymak Energy Efficiency Project. Contractors were required to provide evidence of safety management systems, as well as specific safe work method statements (SWMS) and/or job safety and environmental assessments (JSEAs) for specific work activities. Safety spot checks were periodically undertaken by the senior project officer, project director and the PWC safety officer in order to ensure that work was being completed in accordance with the above systems. No safety incidents were recorded as part of these works.


***Solar hot water system installed as part of the project***

In late 2014, having completed its milestone targets for the calendar year, the project team gained agreement from the consortium and the Australian Government to include the community of Ramingining in the retrofit program. At this time, it was agreed with DHsg that due to ongoing concerns with maintenance risk, no further installations of heat pump HWS would be undertaken. DHsg staff then undertook a second round of retrofit scoping in Ramingining as well as revisiting Gapuwiyak and Yirrkala, focussing on solar hot water and ceiling insulation.

The resultant identified list of additional major retrofits was then delivered through a second service level agreement with DoI. That process was delayed by reassessment of DoI's capacity in light of the additional workloads for DoI generated by the housing and infrastructure damage caused by the dual cyclones of early 2015. The second tranche of DoI work undertaken in 2015 is summarised in Table 16.

*Table 16: Second tranche of DoI work completed*

| Community | Solar HWS | Ceiling insulation (lots) | Cost (GST ex) |
|---|---|---|---|
| Ramingining | 35 | 12 | $414,088.19 |
| Yirrkala | 0 | 11 | $69,029.08 |
| Gapuwiyak | 18 | 9 | $230,227.27 |
| Project Management fees | | | $80,778.61 |
| **Total** | **53** | **32** | **$794,123.15** |

This tranche of works was again tendered and issued via panel contracts and was delivered by local NT contractors. A high level of focus on risk, safety and compliance management was applied to these works, and all installations were installed with zero safety incidents

*Ceiling insulation being installed in Yirrkala*

## 9.10 Major Retrofits Community Engagement Process

The community engagement process of the major retrofits program was initially planned to be undertaken as part of the ambassador program; however, in order to meet retrofit milestone commitments, four of the communities were programmed to have major retrofit appliances installed before the ambassador program had commenced. Milingimbi was the only community to have Yolŋu energy efficiency workers (YEEWs) in place and trained before this first round of retrofit installations. Given the absence of YEEWs to undertake this engagement process, the project team along with additional CAT engagement officers engaged with households that were to get retrofit items prior to installation. Households were approached with the assistance of an interpreter to let the householder know that an energy-efficient appliance was to be installed and what impact this would be likely to have on their household. The project was also introduced overall, and marketing and promotional material delivered.

For the second tranche of the major retrofit program roll-out, all communities had active YEEWs employed. The following community engagement procedure was planned and implemented:

- Two weeks prior to installation, YEEWs delivered a modified DHsg pro-forma letter to the households that they were to receive a retrofit item.
- Prior to installation, YEEWs engaged with each household on the retrofit item they were to receive, in language, and provided some education and an estimated time that a contractor would arrive to install the retrofit item.
- YEEWs then accompanied contractors when retrofit was being installed.
- YEEWs then completed a follow-up visit to answer any questions/concerns about the retrofit item and also explain some basic maintenance and running procedures.

## 9.11 Minor Retrofits

### *Stove timers*

Surveys and householder discussions indicated that the free-standing electric stoves provided by DHsg for remote Indigenous housing in Arnhem Land have a very short life expectancy[56]. Anecdotal advice from DHsg was that stove tops are expected to last less than 12–18 months. The reason for these failures is less clear; however, after speaking with a number of households, a common concern emerged that elements were frequently left on after use, particularly by visitors and children. This would lead to shortened life of the appliance as well as high energy use. Stove tops typically have a maximum power draw of 1.6kW per element, giving them the potential to consume 39.6 kWh per day for one element left on, which at the 2016 tariff amounts to a daily cost of $11.50.

The installation of a stove timer was put forward as a control for this issue, with strong anecdotal community support from project engagement discussions.

Stove timers had been previously trialled in Yolŋu households in a number of Arnhem Land communities, with all units having been subsequently disconnected. Unfortunately, very little corporate knowledge could be found as to why these timers were installed, who manufactured them or why they were eventually disconnected.

Initial market research showed that there was not currently an ‘off the shelf’ stove timer appropriate for installation available for purchase; therefore, the project team embarked on a design process to develop an in-house solution. There were a number of generations of timer developed, which are outlined below:

[56] Project barrier survey identified that 35 per cent of stoves were reported as not functioning.

The first generation of stove timers was designed by a PWC panel contractor, incorporating feedback from the project team. It was deployed in the community of Milingimbi, and several units failed as a result of ant infestation of the timer or contactor within the device.

The second generation of stove timer was designed by a PWC contracted electrical controls engineer. An illuminated green button that showed that the timer was on was added and the contactor capacity was upgraded. Sealed leads and connectors were also installed at manufacture so that the unit wouldn't need to be opened by the installing electricians. This was done in order to mitigate risk of the installer incorrectly wiring the unit or inadequately insect-proofing the enclosure after opening.

Stove timers were offered to households on an opt-in basis during the YEEWs' house visits. Units were then manufactured based on the number of opt-ins received, and three separate electrical contractors were engaged to install the units in Milingimbi, Galiwin'ku, Yirrkala and Gunyangara. The project team made the decision not to offer stove timers in the communities of Ramingining and Gapuwiyak as neither community had a locally based electrician that could provide prompt maintenance to the timers if required.


*First generation stove timer*


*Second generation stove timer*

**Stove timer lessons learned**

- The risks associated with designing and manufacturing a small-run appliance for the domestic environment, which is less controlled and defined in comparison to industrial environments, are significant, and design is best conducted with domestic environment specialists.
- Ensure that a new product is trialled in a community or environment where a qualified tradesperson is available and engaged to support and troubleshoot.
- Ants are a significant problem for new electrics in remote communities, and ant control should be built-in to the design and allowed for in maintenance and support planning.
- Low stocking rates and delivery delays in supply chains for niche products need to be allowed for.
- Avoid timing installation of new equipment immediately before periods of downtime and low resourcing availability, particularly the Christmas–New Year period.

## *Eco Switches*

Another tenant minor retrofit that was offered was the Ecoswitch, a domestic appliance that provides a simple means for householders to completely switch off multiple appliances with an easily accessible single master switch. They are particularly useful as a means to turn off appliances that consume significant standby power when the power outlet switch (GPO) is inaccessible.

Only a small number of households were considered likely to be appropriate to install an Ecoswitch because the entertainment area where televisions and stereos are located in the housing stock generally had a mid-wall GPO, making switching appliances off at the wall a simple process. By the end of the project, 12 households received an Ecoswitch, the majority of which were trials in the homes of YEEWs.

### Heater Mates (Coolbros)

Thermostatic control of tenant-installed box air-conditioners was identified in the retrofit scoping process as a potential priority tenant-level item. Some box-type air-conditioners do not have built-in thermal regulation and have the potential to be left running at full power. Having received a sample of the Heater Mate plug-in thermostat, the project team decided to trial the use of this device in the projects.

Heater Mates are only appropriate to install on air-conditioners that do not already have an inbuilt programmable thermostat; therefore, only a subset of households with an air-conditioner would benefit. Sixteen Heater Mates were installed in total through the project.

### LED / CFL Par38 Floodlights

The majority of houses that participated in the Manymak Energy Efficiency Project had security floodlights fitted for outdoor lighting. All new housing stock already had efficient CFL lamps installed, and the project team decided that the slightly lower energy draw of equivalent newer technology LED PAR38s didn't warrant retrofitting them.

*LED PAR38 security light installed in Ramingining*

Therefore, only houses that had halogen PAR38 security lights were deemed eligible to receive this retrofit item. Scoping of households revealed that fewer than 20 houses across the six participating communities were eligible. This is attributed to the fact that local community stores were found to be stocking only CFL bulbs. In total, 13 PAR38s were installed through the project.

## 9.12 Summary of Retrofit Installations

A total of 498 retrofits were installed in participating communities, including 201 major retrofits and 297 minor retrofits. Table 17 below summarises the number of minor and major retrofits installed in each community.

*Table 17: Summary of retrofit installations*

| Community | SHWS | HPHWS | Stove timer | Heater-mate | Eco-switch | Batts | PAR-38 | Total retrofits |
|---|---|---|---|---|---|---|---|---|
| Galiwin'ku | 10 | 52 | 74 | 10 | | | | 146 |
| Gapuwiyak | 34 | | | | | 16 | 7 | 57 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Gunyangara | 8 | | 19 | 3 | 9 | 3 | | 42 |
| Milingimbi | 14 | 32 | 76 | 3 | 3 | | | 128 |
| Ramingining | 35 | | | | | 12 | 6 | 53 |
| Yirrkala | 13 | 3 | 40 | | | 16 | | 72 |
| **Total** | **114** | **87** | **209** | **16** | **12** | **47** | **13** | **498** |

## 9.13 Impact of Cyclones Lam and Nathan

Cyclone Lam passed almost directly over Galiwin'ku on 19 February 2015 In early 2015, in the midst of the project, three of the six communities participating in the project were badly affected by cyclones Lam and Nathan. While, thankfully, people were kept safe, the cyclones caused significant damage to housingrequiring a long period of repair and rebuilding. Galiwin'ku was hit particularly hard, with an estimated 20 per cent of houses beyond repair.

In Milingimbi and Galiwin'ku, project activities were well advanced pre-cyclone. The project had not yet commenced in Ramingining when the cyclones hit.

*Figure 3: Screen shot from Bureau of Meteorology showing the path of Cyclone Lam over east Arnhem Land*


Broadly, the impacts of the two cyclones on the major retrofits program were:

- Milingimbi: three to four weeks of shutdown, minimal damage.
- Galiwin'ku: at least three weeks of shutdown of the LIEEP work crew, 63 houses condemned (declared as unliveable) out of 216 potential participants in that community (10 per cent of total project scope), dislocation of 300 to 600 residents as a result into other accommodation. The ability to engage with the remaining houses was uncertain.
- Yirrkala and Gunyangara: minimal effect.
- Gapuwiyak: some damage, but minimal effect on progress.
- Ramingining: some damage, but no impact on the retrofits program.

# 10 Project Governance

The original funding bid and resultant funding agreement defined the project consortium with IES Pty Ltd as the lead agent.

The formation of a consortium was a requirement for LIEEP project funding, seen as an effective way to bring together diverse skills, experience and capacities from a range of stakeholder organisations. Formalising the consortium and its governance framework was a major part of the project.

## 10.1 Consortium Agreement

A key requirement of the funding agreement was for Indigenous Essential Services (IES) to establish an associated agreement with the consortium partners to confirm their roles and responsibilities outlined in the funding agreement.

A consortium agreement was drafted based upon the model used successfully by the Alice Solar City consortium project (part of the Australian Government's Solar Cities trial 2008–2013) of which PWC was a consortium member, and by the Alice Water Smart project (2011–2013), which PWC led.

The consortium agreement broadly covered:

- consortium establishment, relationships, objectives
- relationship to the funding agreement
- consortium governance arrangements
- managing consortium funds and resources
- protecting the consortium and allocating risk
- changing or terminating the relationship
- resolving conflicts and differences of opinion
- schedule of roles and contributions of each consortium member.

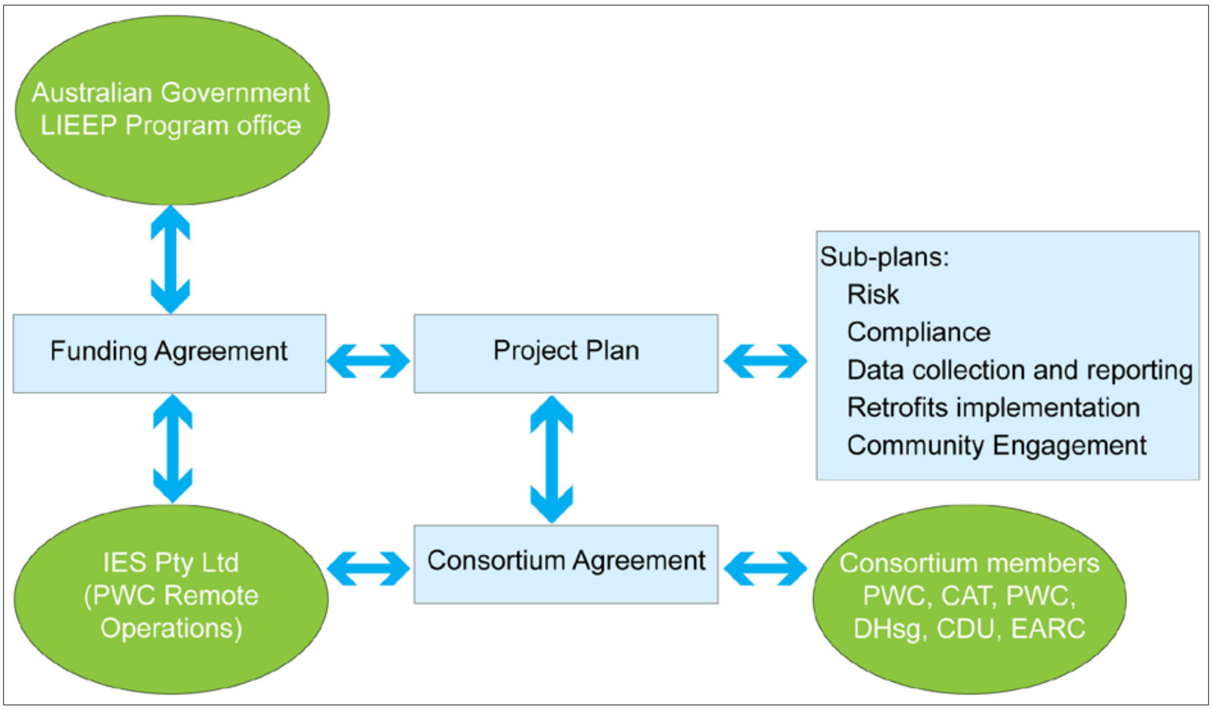
The consortium governance arrangements were that the project plan document that formed part of the funding agreement would also be referenced by and form part of the consortium agreement. Changes to the project plan would then be able to be agreed to by the Consortium Management Committee and then approved by the LIEEP program office without requiring formal execution of a variation to the consortium agreement. Figure 4 below provides a structure of governance and agreement and visualisation of the relationships between the parties and the documents.

The draft consortium agreement was circulated in September 2013 to all six consortium members. Due to the complexity of obtaining agreement from all six members, and particularly due to issues with the clauses around risk and indemnity, the agreement was not agreed and formally executed by all six parties until May 2014. It was executed with the original working title of the project 'Manymak (Good) Power Use!'.

No compelling requirement to change the consortium agreement arose during the project term, with the project plan instead being the focus of capturing changes to operational requirements.

The consortium agreement allowed for formation of a Consortium Management Committee, which consisted of two nominated representatives from each consortium member with a quorum of at least one representative from each organisation. This committee met at least quarterly, with hosting and chairing of meetings rotated between consortium members and secretariat provided by the project team.

*Figure 4: Project governance*




## 10.2 Stakeholder Governance

The original trial design allowed for formation of an additional Stakeholder Advisory Board, whose aim was to ensure additional input and guidance from key parties. Potential parties were approached in regards to forming a formal board; however, a board was not formed.

The community and stakeholder engagement at the commencement of the project identified that key stakeholders were based within the communities and that arranging and governing meetings between six to eight communities, ensuring appropriate representation, would be logistically difficult. The approach taken was instead to engage regularly with stakeholders in each community in person as part of periodic visits to the communities by project team members.

## 10.3 Project Team and Structure

IES Pty Ltd outsources service delivery, including staff employment, to its parent company, PWC, through the Remote Operations business unit. The project delivery was therefore led by PWC employees.

The original trial design included the hosting of a dedicated project team by PWC at its Ben Hammond Complex (BHC) in Darwin, with associated overheads provided as an in-kind contribution. The project would then be delivered in community through the ambassador program, employing, training and mentoring people from within each community to deliver the trial activities.

The choice of Darwin for the project team rather than within an east Arnhem Land community was based on:

- PWC not having existing office facilities in east Arnhem
- relative ease of recruiting to Darwin as opposed to the regional centres
- proximity to the Remote Operations Demand Management team of which the project was a part, and who were to provide significant input into design and operation

- direct access to PWC facilities and corporate support staff and services in Darwin
- travel cost implications lessened due to ability to access regular scheduled air flights from Darwin to most of the communities (no scheduled services from Nhulunbuy to the communities).

The project was established and managed for its duration by a project team based at BHC, with the initial team members consisting of four positions shown in Figure 8, along with in-kind support roles illustrated in Table 18.

*Table 18: Original project team structure*

| Organisation | Role | Allocation to project | Role description |
|---|---|---|---|
| PWC/IES | Project director | 100 per cent FTE 3 years | Oversight of all activities, management of project team, relationship with Australian Government, financial management, stakeholder management |
| PWC/IES | Senior project officer | 100 per cent FTE 3 years | Program planning for the project, general project support, project/contract management support for IES deliverables, coordinate in-kind reporting process |
| CAT | Community engagement officer | 100 per cent FTE 2.5 years | Liaise with stakeholders in communities, design education materials, train and mentor ambassadors |
| CDU | Research officer | 50 per cent FTE 3 years | Research and evaluation design |

*Table 19: Original in-kind support roles*

| Organisation | Role (or position) title | Role description |
|---|---|---|
| PWC/IES | General manager, Remote Operations | High-level representation of organisation on consortium |
| PWC/IES | Manager, Water and Energy Demand Management | Oversight of project for lead proponent, coordination of in-kind resources from IES |
| CAT | Manager, Bushlight / CEO | High-level representation of organisation on consortium |
| CAT | Manager, Community Engagement | Manage CAT activities |
| DHsg | Director, Remote Programs Delivery | High-level representation of organisation on consortium |
| DHsg | Regional DHsg representative | Coordinate DHsg's role in the project, specifically the housing retrofits and in-kind reporting, represent DHsg at the project team level |
| EARC | Director, Infrastructure/Technical Services | High-level representation of organisation on consortium |
| EARC | EARC representative | Coordinate EARC's role in, and be point of contact for, the project, including in-kind reporting |
| CDU | Director, RIEL and CRE | High-level representation of organisation on consortium |
| CDU | Business manager, RIEL | Business relationship management |
| CDU | Senior research fellow, RIEL | Oversight of research officer, evaluation and data collection and reporting design |

After further scoping and development of the project plan, and in order to meet operational requirements, the project team, directly funded by the project, was expanded to include the additional roles in Table 20, with the CDU researcher position changing to supporting a team rather than one position. Figure 5 provides a visualisation of the reporting structure.

The project director and senior project officer positions were filled by the original recruits for the life of the project. The original community engagement officer and research officers commenced in June 2013 and left their roles (and moved away from Darwin) at the end of June 2014. The community engagement position was then filled with two subsequent people for the remainder of the project. The second senior community engagement officer position was filled in March 2014 and remained with one individual for the remainder of the project; likewise, for the third position, which commenced in April 2015 and concluded in February 2016.

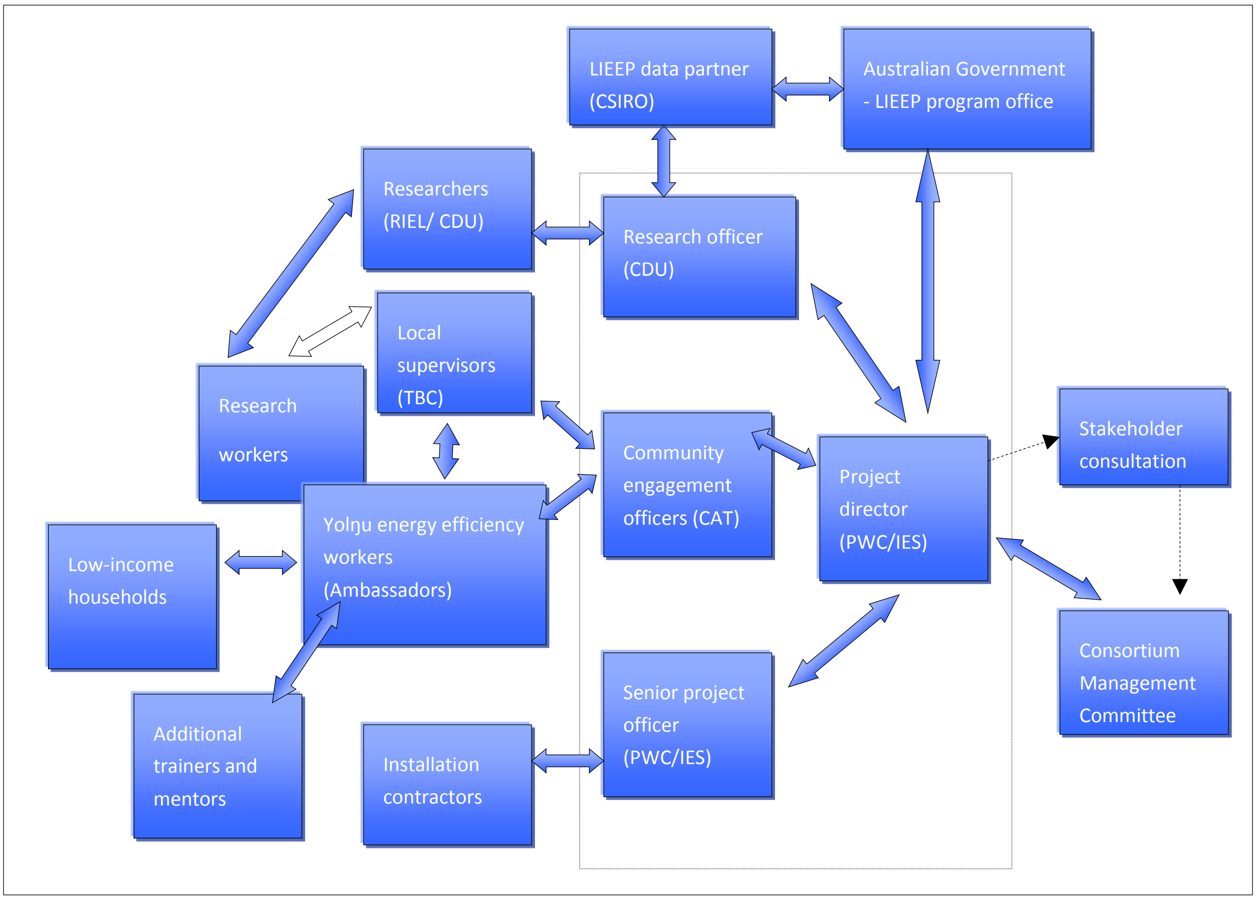
The research officer position was filled in August 2014 with a new lead researcher subcontracted from a different department within CDU, who arranged for the research budget to incorporate allowance for support researchers including the addition of a lead co-researcher based in community.

The ambassador program recruitment and staffing policy is outlined in a separate section of this report.

***Table 20: Additional project team positions added***

| Organisation | Role (*or position)* title | Allocation | Role Description |
|---|---|---|---|
| CAT | Manager, Community Engagement | Ad-hoc | Manage CAT team, support education, ambassador and survey development (fee for service) |
| CAT | Second (senior) community engagement officer | 100 per cent FTE 2 years | Liaise with stakeholders in communities, design education materials, train and mentor ambassadors and overall community engagement coordination |
| CAT | Third community engagement officer | 100 per cent FTE 1.5 years | Liaise with stakeholders in communities, design education materials, train and mentor ambassadors – two communities |
| CDU | Data entry and analysis officer (part time) | Casual, nominally 0.6 FTE | Based at BHC: data collection, storage and transfer, quantitative analysis and evaluation, contribute to reporting |
| CDU | Lead researcher | 0.4 FTE | Based at CDU campus: research coordination and qualitative/ social research approach |
| CDU | Yolŋu Co-researcher | Casual nominally 0.1 FTE | Co-design of research |
| CDU | Additional research team | Casual | Additional support staff within agreed research budget |

*Figure 5: Project organisational structure*




## 10.4 Financial Management and Procurement

Project funds were received by IES Pty Ltd and (as negotiated with the Australian Government) deposited into the single bank account maintained for IES. Financials were managed within the PWC financial system as part of the overall IES financial reporting as a separate business unit. There were no cash in-kind contributions from consortium members to be managed by IES as part of the project.

Additional income added to the project budget during operation included interest earned and income from the sale of small-scale technology certificates (STCs). A process for estimating the interest earned on LIEEP funding in the IES bank account was agreed with the program office and was credited monthly. Agreement was also reached with the program office that income generated from sale of STCs generated by the project's retrofit activities (installation of eligible solar hot water and heat pump hot water units) would be credited as income and incorporated into the project budget.

Expenditure of LIEEP funds was managed in the context of the PWC procurement arrangements. At the commencement of the project, PWC was part of the Northern Territory Government's procurement system. On 1 July 2014, PWC, as a government-owned corporation, launched a new procurement framework outside the procurement direction set by the Northern Territory Government but retaining many of the key features and continuing to utilise the all-of-government tendering system for larger contracts.

The key principles underlying the procurement requirements were: value for money; ethical and fair treatment; probity, accountability and transparency; promotion of PWC's objectives. Procurement actions were guided by a tiered approach, with small-value purchases being able to proceed with a single quote, larger purchases requiring three quotes and values above $100 000 requiring an open tender process.

Within this framework, the consortium agreement was interpreted as representing a pre-selection of suppliers for goods and services, with the agreed project plan providing the contractual basis for issuing purchase orders to and receiving invoices from individual consortium members for performing their roles in the activity. Consortium members, therefore, did not generally receive up-front allocations of project funds to self-manage but rather invoiced PWC for goods and services provided.

Service level agreements were also put in place for the transfer of funds between PWC and the NT Department of Infrastructure.

Expenditure of the LIEEP funding therefore fell into four categories: IES internal direct project costs, monies invoiced by consortium members as part of the project Plan, SLA transfer, and mainstream PWC procurement contracts.

## 10.5 Travel Arrangements

Due to the significant amount of travel estimated for the original trial design, travel was established as a distinct activity line in the project budget. The bulk of travel for the project team and consortium member staff was arranged and managed by PWC through direct purchases and through its travel requisition system, 'TREQS', with consortium members covering some costs as in-kind and being provided with purchase orders to charge additional project-related travel costs against as agreed to from time to time.

The travel activity did not capture all project-associated travel costs, with contractor travel (e.g. retrofit and BEEBox installation by Darwin or Gove-based contractors) typically incorporated into their costs and charged against the associated activity in the budget.

Travel consisted largely of project team trips from Darwin to the six project communities, with the community engagement officers spending more than 50 per cent of their time in community during the peak operational periods.

A significant increase in the travel budget was negotiated during the project to meet the needs of the expansion of project team from one to three community engagement officers and the high degree of field work required, along with the travel needs of the revised qualitative research approach.

# 11 Data Loggers

Central to the success of the Manymak Energy Efficiency Project was the ability to collect detailed data on electricity consumption in participating households in order to support the project evaluation. The pre-payment token meters used for remote households provided limited consumption data and rely on irregular manual reads. To provide more accurate data, the project scope included installation of additional logging equipment to all participating households.

A blanket approach was taken towards the installation of data loggers. Unlike the BEEBox where installation was optional, data loggers were installed to record power usage for all eligible houses in the six communities as part of PWC's metering arrangements.

## 11.1 Technology Used

The parameters used to select an appropriate data logging technology for the project were based on:

- delivering the most convenient, beneficial, reliable and cost-effective solution
- measuring household energy usage in intervals of nominally 30 minutes, with a minimum functional life of three years
- making the gathered data for each community available to remote operations in a quality assured versatile format, in a timely manner
- existing pre-payment meter must not be disturbed.

An open procurement process was undertaken by PWC, and a combination of a Landis+Gyr EM1000 pulse meter coupled with a Taggle pulse transmitter and central receiver was selected as the most appropriate solution, with the following key benefits:

- very cost-effective solution
- Taggle technology is produced by an Australian company that is focussed on wireless communication
- Taggle transmission range allows for a single receiver installation per community
- the Taggle business model allows for separation of the metering, communication and data storage solutions
- provides a low-energy solution for wireless smart water metering and a capacity to support up to 10 000 Taggles per community (allowing for expansion of the system to support water smart metering cost-effectively)
- the technology was already in use by PWC in Alice Springs, Darwin, and Ali Curung for water smart metering and had proven to be reliable and robust in field trials.


***EM1000 and Taggle unit installed behind a typical meter board***

## 11.2 Community Engagement

Community communication for the roll-out of the technology in late 2013 and early 2014 included:

- project team community engagement officers spending at least three days in each community, at least a week before installs began
- engaging with key stakeholders, including Department of the Prime Minister and Cabinet staff, regional council staff, community elders and the broader community
- using interpreters where possible (this always proved useful and effective)

- complementing discussions with the use of posters and the community public announcement systems where functioning.

Some key lessons learned from this work were:

- don’t rush engagement
- approach stakeholders individually—sitting down with people in the community is far more effective than presenting at meetings
- spending adequate time on engagement makes projects run more smoothly
- the project work is a fairly low priority for community members when considered alongside health, education and financial considerations.

## 11.3 Installation

The roll-out of 620 data loggers was completed during the wet season over five weeks, between February and March 2014, giving the program almost two full years of power use data. Existing PWC panel contractors were engaged to install 620 data logger receivers across six communities. These households were identified during the scoping phase of the project in early 2013 as potential participants in the project.

During the course of the project, an additional 13 data loggers were added to households that became eligible to participate in the project. All households were located within the six LIEEP target communities and were assets maintained by the DHsg. All households that had a data logger installed received power via a PWC pre-payment card meter.

Safety of contractors and residents were a priority throughout the planning and installation process. The senior project officer performed on-site spot checks periodically to ensure that all work was being undertaken safely and effectively.

During the life of the Manymak Energy Efficiency Project, nine of the 620 Taggle units were found to be faulty and were replaced. All of these faults were attributed to battery faults. Additional faults were identified but not resolved, including the many Taggles installed on cyclone damaged and decommissioned housing in Galiwin’ku.

***Contractors installing data loggers***

## 11.4 Additional Installs

In response to the loss of housing stock in Galiwin'ku from damage sustained during cyclones Lam and Nathan, 42 new demountable temporary accommodation units, called 'pods', were commissioned by the Northern Territory Government. After ownership of the assets was clarified, the project team contracted the installation of additional Taggle data loggers on 30 of these demountables, which was completed in December 2015. Below is a summary of data loggers installed by community:

*Table 20: Summary of data loggers installed in each community*

| Community | Number of data loggers installed |
|---|---:|
| Galiwin'ku | 216 |
| Gapuwiyak | 102 |
| Gunyangara | 29 |
| Milingimbi | 115 |
| Ramingining | 85 |
| Yirrkala | 86 |
| Galiwin'ku transitional housing | 30 |
| **Total** | **663** |
| Target | 620 |

## 11.5 Data Logging and Handling

To generate a Watt-hour pulse for the Taggle unit to accumulate and transmit, an EM1000 meter was installed behind each meter board. This was installed on the 'upstream' supply side of the existing meter to maintain power supply to the pulse meter in the event of disconnection events, with the additional benefit that no additional power costs would be incurred by customers. The existing prepaid meters in place at participants' houses remained and functioned as normal.

The operation of the resulting data collection and transmission system is explained below:

The Taggle unit counts the pulses received from the EM1000 pulse-meter, and the accumulated pulse counts are then sent periodically through proprietary radio technology, with one central receiver device and antenna installed in each community. Data is sent from the Taggle unit to the receiver approximately every 30 minutes, with the four most recent accumulated readings sent, providing some backup if transmissions are unsuccessful. The Taggles are not synchronised, with transmission starting from when they are activated by a magnetic swipe process.

The receiver accumulates data from all Taggles in its range and sends this data via the Telstra 3G network to Taggle. The receiver is able to store around 200 days of data should the 3G connection be unsuccessful.

Taggle Systems process and quality check the data before sending a daily data file to PWC's server. The project's custom database application then uploads this data into the database to be accessed, quality checked and analysed by the project team.

The energy consumption data from the participant houses is organised in the database in several views, such as total and average consumption in kWh as daily, weekly and monthly energy consumption view. This included allowance for storage of a manually corrected dataset to compensate for significant data problems caused by receiver downtime, which resulted in several days of readings being represented by one reading.

This data formed a key reference for analysis of the impact of various household education interactions and energy efficiency focussed retrofits taking place.

## 11.6 Legacy Arrangements

The consortium planned to leave the technology in place after the end of the project to enable potential for extension of the research of the project, with removal planned to coincide with other planned meter replacement work.

# 12 Data Management and Project Database

The collection of comprehensive data to support evaluation was a key requirement of the LIEEP program. A project-specific database application to store the quantitative data was a specific milestone deliverable under the funding agreement.

It was originally envisaged as a redeployment of the database application used for the Alice Solar City project[57] which was seen as being likely to meet the needs of the project and was nominally available as an in-kind contribution from PWC, which had access to its intellectual property as a consortium partner for the Alice Solar City project. To meet data collection and reporting requirements, it was also originally envisaged that the database would be hosted and managed by CDU as part of its role.

During development of the project plan, the decision was made to not use the Alice Solar City design and for PWC to host the database.

Several factors contributed to this arrangement, including:

- The database application was seen as an operational tool to support day-to-day operations, not just as an evaluation tool, thereby aligning it more closely with overall operation (while still needing to maintain compliance with privacy and research ethics requirements).
- PWC had significant internal capacity to design and deliver a custom application within its operating environment and in general preferred to manage this component directly rather than through a consortium member.
- A review of the Alice Solar City application technology highlighted that the full source code had not been obtained from the third party developer and host, and it was developed on ageing application environment infrastructure not suitable for redeployment within the PWC environment.
- Incorporation of operational needs into the application also meant PWC wanted it directly accessible by the project team based within PWC facilities.

As part of plans to evaluate the entire LIEEP program, the LIEEP program office and its evaluation partner, CSIRO, provided a single LIEEP data schema, which was a fixed framework and format for all LIEEP projects to provide their data. The project database needed to store data in a way that could easily map onto this single schema.

The procurement for the project's data logger component resulted in selection of Taggle as the data provider. This meant that a solution able to deal with their particular energy data format was required. PWC was already developing such an application in-house for the separate Living Water Smart project, which was also using

[57] Alice Solar City was a whole-of-community renewable energy and energy efficiency project that ran in the Northern Territory town of Alice Springs from 2008 to 2013. It was delivered by a consortium that included PWC. It received funding through the Australian Government's Solar Cities program, on which many features of the LIEEP program were based.

Taggle technology for water metering. Agreement was obtained to use this application as the basis of the project database as an in-kind contribution from PWC.

A new instance of this pre-existing application was deployed on the same hosting system, and it was extended to incorporate the full LIEEP schema. This was further expanded to meet the operational needs of the project, in particular tracking of the ambassador program staff and their interactions with households.

The application was available in a production environment from October 2014 onwards, with access to the database limited to the project team and PWC system administration staff. The bulk of data entry and maintenance was handled by the CDU data officer. Some basic reporting and graphing capacity was built in to the application, but the bulk of operational reporting was met through the use of automated import and refresh of data directly into Microsoft Excel spreadsheets that the project team could access on demand.

Total expenditure on development, hosting and maintenance was just under the original budget of $162 000 at the conclusion of the project.

# 13 Data Collection, Research and Evaluation Methodology

## 13.1 Framework

The project commenced on the basis of an initial data collection and reporting plan approved by the program office.

Based on the project aims and the LIEEP objectives, the research team, in consultation with project team, developed the research and evaluation framework outlined in the table below as part of a review process commencing after June 2014.

*Table 21: Overview evaluation framework for Manymak project objectives*

**Objective 1**: Clarify barriers to the efficient use of energy by low-income Indigenous households in participating communities

| Objective theme | Outcomes (measures of success) |
|---|---|
| Barriers to efficient energy Use | Barriers (and solutions) to efficient use of energy identified and clarified |
| Pre-payment meters | Understanding of how pre-payment meters impact on energy use and energy efficiency in Yolŋu households |

**Objective 2**: Develop and trial best-practice engagement and technology approaches to address identified barriers to energy efficiency

| Objective theme | Outcomes (measures of success) |
|---|---|
| Best-practice engagement | Best-practice engagement approaches developed to address the identified barriers:<br>• recruitment and employment<br>• education of Yolŋu energy efficiency workers (YEEWs)<br>• education of Yolŋu households<br>• education resources<br>• Indigenous engagement |
| Best-practice technologies | Best-practice technology approaches developed to address the identified barriers: |

| Objective theme | Outcomes (measures of success) |
|---|---|
| | • household retrofit program<br>• in-household display installations (BEEBox) |
| Incentive scheme | Incentive scheme developed and deployed to facilitate best-practice community engagement |

**Objective 3**: Evaluate measurable household energy efficiency improvement in participating households

| Objective theme | Outcomes (measures of success) |
|---|---|
| Evaluation | Measurable household energy efficiency improvements in participating households, including Yolŋu perspectives |

**Objective 4:** Present a best-practice model for achieving improved energy efficiency with low-income remote Indigenous communities

| Objective theme | Outcomes (measures of success) |
|---|---|
| Best-practice model developed | Best practice models for energy efficiency education, energy efficiency employment, and best practice technologies and retrofits |
| Best-practice model presented | Model is accessible and useful for future energy efficiency programs |

**Additional objectives and co-benefits emerging throughout the project**

| Objective theme | Outcomes (measures of success) |
|---|---|
| Improving energy efficiency of the broader community | More efficient appliances/devices available from ALPA stores<br>More efficient house designs for future builds<br>Non- project residents (e.g. government housing) achieve improvements in energy efficiency<br>Improvements in efficiency of public assets and infrastructure in communities (e.g. street lights and public buildings) |
| Community co-benefits | Employment and local capacity benefits<br>Improvements in community health (e.g. thermal comfort, diabetes, asthma, mould, take-away food consumption)<br>Improvements in community psychological aspects (e.g. confidence, pride, self-efficacy)<br>Improvements in community governance (e.g. less crime)<br>Improvements in environmental outcomes (e.g. less air pollution) |

# 14 Quantitative Data Methodology

## 14.1 Measurement of Household Power Consumption

Prepaid meters were already installed in each participating household with the meters not requiring traditional meter readings in order to bill customers. The meters are read approximately annually for audit purposes, and the quality of the data thus obtained was assessed as unsuitable for use in the project. The project design incorporated installation of data loggers to address this gap.

As detailed elsewhere in this report, installation of the Taggle data loggers began in February 2014 and was completed in March 2014. Of the 663 Taggle data loggers installed, the majority (more than 600) of the installations took place in the first quarter (Feb–Mar) in the 2014 calendar year. Only a few were installed in 2015, and 30 Taggles were installed towards the end of 2015.

From installation until January 2016, 30-minute reading data was collected directly into the project database from almost all 633 households. To date, 98 Taggles were identified with some problems or were completely broken. Following cyclones Nathan and Lam in early 2015, property damage to 30 houses in Galiwin'ku meant that many individuals had to be relocated to temporary housing, which also skewed the data for this community.

Nine faulty Taggles were replaced during the project (battery faults), 22 Taggles are still marked as faulty and can be replaced. However, of the 22 faulty Taggles, eight were installed at houses with major retrofits.

On several occasions, because of problems with the central retriever, interval data was not collected for periods lasting from a few hours to a few days. Once communication was re-established, a cumulative reading could be obtained, providing the overall consumption for the intervening period. But the 30-minute interval data was lost, with data often representing accumulation over several days. These data points were manually adjusted to daily totals.

In total, data was excluded from 69 households of the total 663 data loggers installed due to various reasons discussed above. The data from the 30 data loggers installed towards the end of the project on Galiwin'ku transitional housing is limited to a few months and not included in the main comparative quantitative analysis.

Energy data for February to April was added to the database and to the analysis after initial drafting of this report, with the result that addendum results utilising the additional data are included in this document.

## 14.2 Energy Data Monitoring and Quantifying Energy Savings Approach

Generally, there are three main methods for establishing an energy baseline for measuring energy savings. One: regression analysis, two: modelling/simulation, and three: short-term metering.[58] Baselines should be matched to the specific features of each energy efficiency opportunity or impact being investigated.

The initial step in developing an energy baseline for a facility is to define the boundary across which the energy is consumed. For instance, in a community the baseline could be established for the entire community or a group of similar households or around an equipment or appliance. Ideally, a whole facility baseline should include energy data for a complete one year to account for the external climate and seasonal factors.

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[58] Energy Savings Measurement Guide 2013, Department of Resources, Energy and Tourism, Version 2.0, http://eex.gov.au/files/2014/06/ESMG.pdf.

However, the equipment baselines are highly dependent on each item and may have to account for other factors for that equipment.

According to the International Performance and Verification Protocol (IPMV), there are four guiding options to identify and quantify energy savings in energy efficiency programs.[59]

1. Retrofit isolation: key parameter measurement approach is based on engineering calculation of baseline and reporting period energy which has an application of measuring impact of a particular retrofit.
2. Retrofit isolation: All parameter measurement approach is based on short-term or continuous measurements of baseline and reporting period energy, and/or engineering computations using measurements of proxies of energy use, which has an application of optimising the load of variable power-drawing equipment.
3. Whole facility: involves analysis of whole-facility baseline and reporting period meter data using comparison and regression analysis, which has its application for measuring impact of multifaceted energy management program affecting many systems in a facility.
4. Calibrated simulation: involves energy use simulation, calibrated with hourly or monthly utility meter data, which has applications for multifaceted energy management program affecting many systems in a facility but where no meter existed in the baseline period.

The energy data for the project to establish baselines and measure savings was gathered through individual house data logging, along with appliance sub-metering for a small number of houses in the Ramingining study. The approach for the baseline generation and energy saving measurements from retrofits is in line with the whole facility category of the IPMVP framework, where the whole house energy consumption is utilised to establish the baseline and measure savings of the retrofits.

The saturation approach of the project's targets and implementation complicates a rigorous approach to analysis of the energy impact of the trials, and, in essence, the analysis proceeds on the basis of a non-experimental design. Findings are subject to selection biases inherent in the allocation of the trials.

The main approach employed for measuring energy consumption impacts from the project's trials emerged iteratively after initial analysis revealed the most significant correlations between key variables, and the trials with the most significant energy impacts.

The selected process involves comparing the relative change in energy consumption of houses receiving the trial (impact group) to that for a set of houses with an identical house category that did not receive the trial (or another significant trial) during the period of desired energy data then comparing the change in the difference between average consumptions for each group for a suitable period before and after the treatment event. This is commonly referred to as a Before-After Control-Impact (BACI) analysis.

No formal theory-based evaluation is attempted, which would provide a basis for linking the quantitative energy data outcomes to the separately collected qualitative interviews described below.

[59] Efficiency Valuation Organization 2012, Concepts and Options for Determining Energy and Water Savings Volume 1, www.evo-world.org.

## 14.3 Store Survey

The store surveys were part of the original trial design and were a performance measure of the project.

The survey was conducted at three local stores across Galiwin'ku, Nhulunbuy and Yirrkala in October 2013. Nhulunbuy is not one of the six communities targeted in this project. However, the store was surveyed because residents of nearby Yirrkala reported in the household barrier surveys that they sourced appliances and power cards from the Nhulunbuy store as well as the Yirrkala store.

The survey consisted of two parts: first, a questionnaire was conducted with store managers to determine purchasing patterns and availability of power cards. The questionnaire consisted of nine closed and open-ended questions covering why certain appliances are stocked, what appliances are stocked and power card sale issues. The questionnaire was administered by the CAT community engagement officer, who noted down the responses. Second, an inventory of appliances in stock was undertaken to determine the prevalence of energy-efficient appliances in stores.

## 14.4 Barrier Survey

A barrier survey was designed to collect demographic information, barriers to energy efficiency, knowledge of energy efficiency, power card usage and attitudes on energy efficiency. Local reference groups (LRGs) in the communities were contacted and sent a copy of the survey. A team of CAT/Bushlight and IES staff attended LRG meetings to present the project and to seek approval for the barrier survey. The survey was approved by the Local Authorities in both communities, then by the Australian Government. With all approvals in place, the surveys were conducted by CAT Bushlight staff in 23 households in Galiwin'ku and 19 households in Yirrkala over a two-week period in October 2013. Interpreters from the Aboriginal Interpreter Service (AIS) were engaged to accompany CAT staff conducting the surveys.

Potential participants were introduced to the survey and then asked if they wanted to take part. All invited households agreed to participate and signed a consent form. Surveys were conducted as an interview with members of households for an average of 45 minutes. All surveys were completed. Participants were reimbursed for their participation with a $20 power card gift at the conclusion of the survey. Survey responses were analysed and grouped according to a five point Likert scale, dichotomous choice or grouped into categories.

## 14.5 Housing Scoping and Condition Assessment Data

The Department of Housing provided listings of the housing that it managed, including the lot number and status identified as part of the comprehensive SIHIP/NPARIH housing upgrade programs—new housing built through the programs, housing that was refurbished, legacy stock that was not refurbished, and housing identified as beyond repair and scheduled for replacement or removal.

DHsg also conducts periodic assessments of the condition of housing that it manages through an onsite inspection by its staff. The Department of Housing supplied a data extract of a subset of this data of relevance to the project where data was available. Data supplied included number of rooms, wall and roof construction, type capacity and condition of hot water system and other fixed electrical appliances. The completeness of the data and its age was subject to the number and breadth of surveys that had been historically completed.

Additional data on house construction and fixed appliances was obtained through the project-specific scoping process conducted by DHsg technical officers as detailed in the retrofits section. The scoping data collection sheets included information on external building materials and wall construction, house design type, building orientation, number of air-conditioners, condition of electric oven and stove, type and condition of existing hot water system and roof characteristics.

Most of the scoping data was entered into the project database's dwelling table and 'existing water heating' table. However, houses identified as 'beyond economic repair' were not scoped, given their likelihood of being demolished and then reconstructed.

This data was supplemented where insufficient by data obtained from data collected by YEEWs through the appliance surveys.

## 14.6 Data Collection By YEEWs

The YEEWs utilised several different forms to collect data from participants. The primary form was a house visit form intended to be completed as part of every visit to a house in the community. The form recorded information including house location, date, name of primary occupant contacted and the topic of the household visit.

The Australian Government required all project participants to complete a LIEEP privacy notice in order to ensure that data could be transferred to the government in line with the funding agreement data supply requirements. A project-specific privacy notice was completed for households that chose to participate. The process that was undertaken to adapt the privacy notice to the needs of the Yolŋu audience is described in the community engagement section of this report.

Typically, as part of the same visit as the privacy notice signing, an appliance survey was then conducted with the participating householder which involved working through a visual checklist of potential appliances and recording the number and condition (working/broken) of appliances present in the home as reported by the householder. These forms were emailed or physically transferred to the project team in Darwin and were input into the project database.


***YEEWs in Galiwin'ku filling in forms after a house visit***

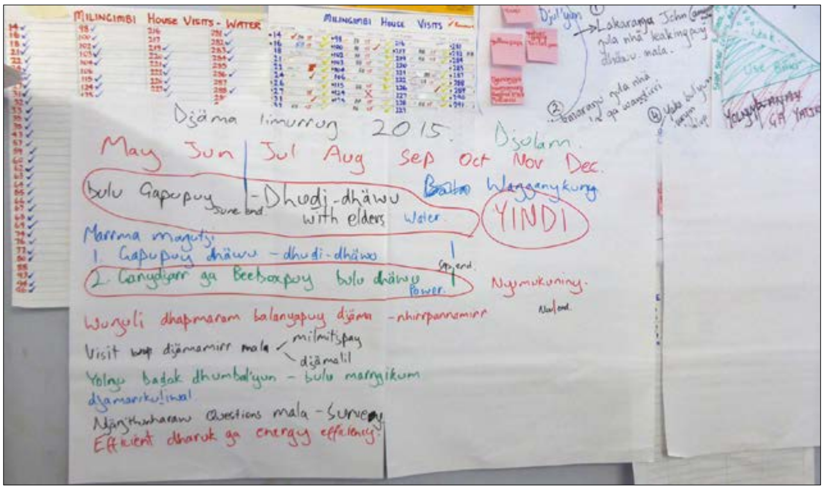
## 14.7 Knowledge, Attitude and Behaviour (KAB) Survey

The KAB survey was implemented in Milingimbi only to identify householder knowledge and attitudes towards energy consumption and energy usage behaviours at the commencement of the project, as well as to assess changes in knowledge, attitudes and behaviours as a result of the project. The KAB survey was designed to be delivered in Milingimbi by the project's Yolŋu energy efficiency workers at the start of the project and towards the end of the project.

To assess perceptions of existing challenges and practices around energy use, respondents were asked to indicate how often the power cards are depleted, how long the power cards last, the delay until the next power card is purchased, and the money that is spent on each power card. To ascertain knowledge and attitudes towards energy consumption, respondents were asked to indicate which practices tend to accelerate the consumption of energy and deplete the power cards.

To assess whether practices, knowledge or attitudes towards energy consumption changed during this project, respondents participating in the survey towards the end of the project were explicitly asked to indicate whether they believed the project helped their household.

The survey was developed by CAT Project team staff in consultation with the CDU researcher, and training for the YEEWs in conducting and filling out the survey was delivered by the project team staff. The surveys were then conducted by the YEEWs initially with and then without supervision by project team staff.




***Wall notes recorded during a training session in Yolŋu Matha***

# 15 Qualitative Data Methodology

## 15.1 Evolution of Research and Evaluation Design

After commencement of engagement in Milingimbi and trial of the KAB approach and a change of lead researcher, CDU researchers recommended that a new qualitative, participatory, interactive approach suited to the distinctive circumstances of east Arnhem Land and delivered in Yolŋu languages would generate a clearer insight into identifying the barriers to more efficient use of energy and water by Yolŋu households and would support effective evaluation of the project's trials.

## 15.2 Approach One: Before and After Ethnographies

The first qualitative approach was to conduct one-week ethnography before the project commenced and one-week ethnography towards the end of the project. In line with this approach, the first ethnography was conducted in Milingimbi.

The ethnography was conducted 10-14 November 2014 by the principal researcher along with a CDU staff member (lecturer in Yolŋu studies) fluent in Yolŋu with established relationships in Milingimbi. The intentions and aims of the ethnography were to:

- introduce the principal researcher to Yolŋu and Milingimbi
- get to know the YEEWs
- exchange knowledge
- capture and evaluate changes and learnings at the individual, household and community level
- gain insight into:
    - knowledge, beliefs, values and behaviours regarding power and water
    - barriers and enablers
    - costs/impacts of current power and water usage and benefits of using less power/water or using both in different ways
    - gathering stories that would explain and give meaning and truth to life and events for the community and for stakeholders.

The data was collected via participant observation, unstructured group discussions with YEEWs, and individual interviews with relevant Yolŋu community elders and non-Indigenous community members:

- five sessions with YEEWs
- three interviews with relevant Yolŋu community elders
- three interviews with relevant non-Indigenous community members
- participant observations

During this process, group discussions were conducted predominantly in Yolŋu Matha. The conversations were interpreted by the Yolŋu studies lecturer and in discussions by a Yolŋu interpreter. During the group discussions, the principal researcher and the Yolŋu studies lecturer took field notes. The interviews were recorded, transcribed and analysed.

A feedback report regarding the education of the YEEWs was then delivered to the project team. This report detailed what worked, what was missing, what did not work and recommendations.

## 15.3 Data Collection: Interviews, Discussion Group and Participant Observation

In line with the culturally responsive research methodology used, the qualitative data collection approach needed to be adapted in response to feedback from Yolŋu and from the project team, to changes in the project implementation, and to requirements of the project. The qualitative data collection was developed and implemented in close collaboration with the project team, especially the community engagement officers in each community. The collaboration consisted of:

- the project director, the community engagement manager and the principal researcher discussing the research in weekly research and evaluation meetings
- one or two researchers participating in the weekly project team meetings
- the project and research teams discussing the research and evaluation in three several-day workshops
- direct correspondence with the community engagement officers via phone or email.

The approach that evolved was developed and conducted jointly with the CDU research team and the Yolŋu communities using Yolŋu co-researchers.

In a two-day workshop in February 2015, the CDU research team, including an experienced Yolŋu researcher, introduced a Yolŋu co-researcher proposal to the project team as a new approach to meeting the evaluation needs of the project. The approach was approved by the project team, consortium and the Department of Industry and Science and the lead Yolŋu co-researcher was then employed and the approach was implemented in the remaining communities.

## 15.4 Approach Two: Yolŋu Co-Researcher Approach

This approach consisted of the lead Yolŋu co-researcher working together with the non-Indigenous principal researcher to design culturally appropriate research and evaluation.

In the qualitative component of the research and evaluation, they collected subjective perceptions, interpretations (beliefs, thoughts, responses etc.), actions/interactions and relevant artefacts (maps, pictures, photos, documents). This data was collected via facilitated workshops/discussion groups, participant observation and interviews.

## 15.5 Participants

Participants were selected who, based on theoretical assumptions, on the energy efficiency literature and the experiences of the project team, were most likely to provide relevant data. To take into account the varied perspectives, data was theoretically sampled from:

- Yolŋu households
- Yolŋu energy efficiency workers (YEEWs)
- Yolŋu co-researchers
- non-Indigenous people living in communities, working with Yolŋu, or providing services to Yolŋu
- project team members.

Within the above groups, a combination of kinship, purposeful, systematic and fortuitous sampling was used. The Yolŋu households, YEEWs, Yolŋu co-researchers and non-Indigenous people living in communities, working with Yolŋu, or providing services to Yolŋu were sampled across all six participating communities.

Sample participants' backgrounds as diverse as possible and who could provide comprehensive and varied insights into the Yolŋu power and water use and the value of this project were drawn from each of the above groups. Sampling was adjusted based on the findings (e.g., Yolŋu mentioning that children were not taught power and water as part of the school curriculum led to interviewing a school principal and teachers).

## 15.6 Recruitment of Local Yolŋu Co-Researchers

The recruitment of Yolŋu co-researchers was conducted by the lead Yolŋu co-researcher in each community. The process was led by the Yolŋu co-researcher's kinship relationships in the community.

The leading Yolŋu co-researcher and the non-Indigenous co-researcher worked in the communities together, identifying suitable Yolŋu co-researchers in each community. They then trained them to conduct the pre-project interviews and later the evaluation interviews.

The first interviews were done together. After the lead Yolŋu co-researcher and the principal researcher left the Yolŋu community, co-researchers continued conducting interviews in their respective communities independently. Interviews took place in local Yolŋu languages spoken in that particular community. The interviews were recorded on video. Video recordings were then interpreted by a Yolŋu interpreter and fully transcribed. The transcriptions were analysed and documented by Yolŋu and non-Indigenous researchers.

## 15.7 Data Collection In Communities

Local Yolŋu co-researchers conducted two sets of interviews. Data was collected both at the start of the project and towards the end of the project using different types of interviews, discussion groups and observations.

### *Pre-Project Interviews*

The first set of interviews was held with households and YEEWs before the project commenced in that community. The aim was to gain an understanding of the power and water stories and how to use power and water wisely by identifying barriers, facilitators and opportunities and how Yolŋu actually use power and water. The pre-project data was collected via unstructured narrative interviews with Yolŋu households and co-researchers in four of the six participating communities (Milingimbi, Yirrkala, Gapuwiyak and Ramingining) between November 2014 and June 2015.

For the pre-project interviews, the lead Yolŋu co-researcher and the principal researcher went to each community for up to one week. During this fieldwork, three local Yolŋu co-researchers were identified, recruited and educated about how to conduct the interviews (including discussing the plain English language information sheet and consent form). The education involved discussions and practice interviews. After the lead Yolŋu co-researcher was satisfied with the quality of the interviews and the local Yolŋu co-researchers were confident, interviews with households were conducted in the particular Yolŋu languages spoken in the community. Yolŋu households were sampled by the lead Yolŋu co-researcher and the local Yolŋu co-researchers based on their kinship relations.

*Table 22: Overview of pre-project data collection*

| Community | Field trip (days) | Yolŋu co-researchers | Discussion groups | Interviews | | |
|---|---|---|---|---|---|---|
| | | | | Co-researchers | Households | YEEWs |
| Gapuwiyak | 5 | 2 | | 2 | 8 | 1 |
| Yirrkala | 4, 5 | 3 | | 3 | 11 | |
| Gunyangara | | 3 | | 1 | 1 | |
| Ramingining | 5 | 3 | | 3 | 10 | |
| Milingimbi | 5 | | 4 | | | |
| Lead Yolŋu researchers | | | | 2 | | |
| **Total** | **24** | **11** | **4** | **11** | **30** | **1** |

Participants could choose the place and time of the interview. Interviews were conducted mainly in their house, on the verandah, under trees and at the beach but also in public spaces and in the project office at different times of day. Depending on their choice, households were reimbursed for their participation with a $20 power card or with food to a value of $20.

## *Evaluation Interviews*

The second interviews were conducted with households and YEEWs at the end of the project to evaluate impacts. During fieldwork, the principal co-researcher interviewed non-Indigenous community members in English to understand their perspectives. Findings from each community were fed back to the project team and YEEWs. Local Yolŋu co-researchers in one community tracked the use of power and water over several weeks in a small number of households to gain an understanding of how Yolŋu use power and water on a day-to-day basis. This was part of a thermal comfort and tracking study.

Evaluation data was collected using semi-structured interviews in all six participating communities towards the end of the project, between September 2015 and January 2016. For the evaluation interviews, an interview guide was designed to ensure the areas of interest to the project team, consortium and Department of Industry and Science were covered. The discussion points were based on the revised project Research and Evaluation Framework and developed together with the lead Yolŋu co-researchers. Two versions were designed to capture the different experiences of households and YEEWs, as summarised in the table below. Discussion points were written in English, accompanied by pictures.

*Table 23: Overview of discussion points covered in evaluation interviews*

| Households | YEEWs |
|---|---|
| **Participation**<br>yes, no, stopped – why? | **Work status**<br>working, stopped working – why? |
| **Visits by YEEWs**<br>number, content, format, education resources, learnings | **Employment**<br>motivation, recruitment, information sessions, hours, team approach, supervisors<br>engagement with project team |
| **BEEBox**<br>reasons, explanations, how it works, does it help, usage | **Education**<br>delivery, content, format, resources, length, input, learnings |
| **Power cards** | **Household visits** |

| Households | YEEWs |
|---|---|
| how working, how long they last, strategies for obtaining new cards | approach, content, changes observed |
| **Retrofits**<br>reason, explanations, how it works, usage | **Outcomes**<br>knowledge, skills |
| **Changes power knowledge and usage**<br>cooling, heating, storing food and cooking, washing and drying clothes, TV and stereos, PC and mobiles, lights | **Changes power knowledge and usage**<br>cooling, heating, storing food and cooking, washing and drying clothes, TV and stereos, PC and mobiles, lights |
| **Changes in water knowledge and usage**<br>inside, outside, how used and changes | **Changes in water knowledge and usage**<br>inside, outside, how used and changes |
| **House design**<br>features of house; concerns, needs and wants | **House design**<br>features of house; concerns, needs and wants |
| Each of these areas were explored in terms of:<br>• What worked well?<br>• What was hard?<br>• What could be done better? | |

For the evaluation interviews, the lead Yolŋu co-researcher and the principal researcher returned to each community for up to a week. During this fieldwork, in the two communities in which no pre-project interviews had been conducted, local Yolŋu co-researchers were identified and recruited. In one community (Yirrkala) a new local Yolŋu co-researcher was identified and recruited due to unavailability of the previous co-researchers. For the evaluation interviews, a local YEEW was recruited to team up with the local Yolŋu co-researchers.

For the evaluation interviews, Yolŋu households and YEEW participants were selected and recruited by the lead Yolŋu co-researcher, the local Yolŋu co-researchers and YEEWs. Care was taken that a diverse sample was recruited. Table 13 details the sampling criteria for household and YEEWs.

*Table 24: Sampling criteria evaluation interviews*

| Households | YEEWs |
|---|---|
| over 18 years, different ages | |
| female and male | |
| elders, traditional owners, leaders | |
| Principal tenant and householders | Still working and no longer working |
| Yolŋu who participated in the project, who stopped participating and<br>non-participants<br>Different kin groups | Supervisors, senior workers and team members |

The majority of interviews were conducted by the lead Yolŋu co-researcher and/or local Yolŋu co-researchers and a YEEW in the local Yolŋu languages. Some of the YEEWs were non-Indigenous people living in the communities and were interviewed by the principal researcher in English. While the vast majority of interviews were conducted with one householder, some interviews were conducted with couples. Discussion groups were conducted to accommodate some YEEWs preferring to be interviewed as a group. The number of YEEWs participating in the discussion groups ranged from three to six and was fluid. The discussion group in

Milingimbi was conducted over several sessions, whereas the discussion groups in Gapuwiyak and Yirrkala were single sessions.

The interviews and discussion groups were recorded using video cameras. The majority of participants chose to be video recorded, but some participants chose to be only voice recorded. The interviews were interpreted by a trained Yolŋu interpreter of the highest qualification level with kin in each of the participating communities and fluent in the various languages spoken in the different communities. The interpreter either wrote down the interpretations or recorded the interpretations. The interpretations were fully transcribed by a professional transcription service by a team of Indigenous transcriptionists.

To complement the Yolŋu perspective, in-depth narrative interviews were conducted with non-Indigenous community members living and/or working in communities. These participants were sampled based on relevance and availability. They included electricians, plumbers, ALPA store managers, local council service managers, school principals and teachers, doctors and nurses, rangers and cultural consultants. The in-depth narrative interviews with non-Indigenous people were conducted by the principal researcher in English, face-to-face in the communities at a venue selected by the participants, or by telephone. As with the pre-interviews, the households were reimbursed with a $20 power card. The YEEWs who participated in the interviews were reimbursed for their participation by either getting two hours pay (YEEWs who were still working) or by receiving $20 (YEEWs who already had stopped working).

Table 25 provides an overview of the evaluation data collection with households, YEEWs and non-Indigenous community members living and/or working in the communities.

*Table 25: Overview of evaluation data collection*

| **Overview qualitative data collection — post-project** | | | | | | |
|---|---|---|---|---|---|---|
| | | | | **Post-project interviews** | | |
| **Community** | **Fieldwork (days)** | **Co-researchers** | **Discussion groups YEEWs** | **Households** | **YEEWs** | **Balanda** |
| Gapuwiyak | 3 | 2 | 2 | 8 | 5 | 3 |
| Yirrkala | 7 | 1 + YEEW | 1 | 10 | 1 | 6 |
| Gunyangara | 5 | 2 | | 10 | 1 | |
| Ramingining | 5, 3 | 1 + YEEW | 1 | 11 | 5 | 6 |
| Milingimbi | 7 | 1 + YEEW | | 11 | 9 | 6 |
| Galiwin'ku | 5 | 1 + YEEW | 1 | 11 | 5 | 3 |
| YEEW forum | 3 | 2 | 1 | n/a | n/a | n/a |
| **Total** | **38** | **14** | **6** | **61** | **26** | **24** |

## *Participant Observation*

Participant observation was conducted by the principal researcher and the lead Yolŋu co-researcher during 14 fieldwork visits across all six participating communities between November 2013 and November 2015.

Participant observation included activities and observations such as community layout, housing design, power and water usage inside and outside the house throughout day and night, hunting, cooking, interactions among Yolŋu and between Yolŋu and non-Indigenous communities, electrical appliances offered in community stories, and clinic and hospital visits. Informal conversations occurred throughout the participant observation, and observations were recorded in the form of field notes.

## 15.8 Data Collection with the Project Team

Data collection from the project team and consortium was initially envisaged as an online survey early in the project. After the change in lead researcher, the new approach was for the perspectives of the project team only to be collected at two time points: midway through the project and at the end of the project. The mid-project interviews were conducted in September 2014 to capture the experiences and interpretations throughout the first 18 months of the project. Five team members from PWC and from the CAT/Bushlight participated in these mid-project interviews.

The second set of interviews were planned to be implemented at the end of the project following completion of community-based activities to assess the effectiveness of the project from the perspective of the project team (February 2016). Three of the eight project team members shared their experiences and perspectives. In addition, four Yolŋu and non-Indigenous employees of the Aboriginal Resource Development Service (ARDS) who provided training were interviewed regarding the education sessions and the YEEW Forum in Gulkula.

The mid-project interviews in September 2014 covered the roles, activities, experiences and interpretations about what worked, what was challenging, how the challenges were addressed, what did not work and how the project could be done better in future. The evaluation interviews covered the same content areas between September 2014 and February 2015. The topics covered in the project interviews included:

- working as part of the consortium team
- engagement with communities
- employment of YEEWs
- education of YEEWs
- working together with the YEEW teams
- BEEBox and retrofits
- YEEW Gulkula Forum
- the exit strategy
- messages and channels
- research and evaluation.

The interviews with the project team members were recorded with a voice recorder and fully transcribed.

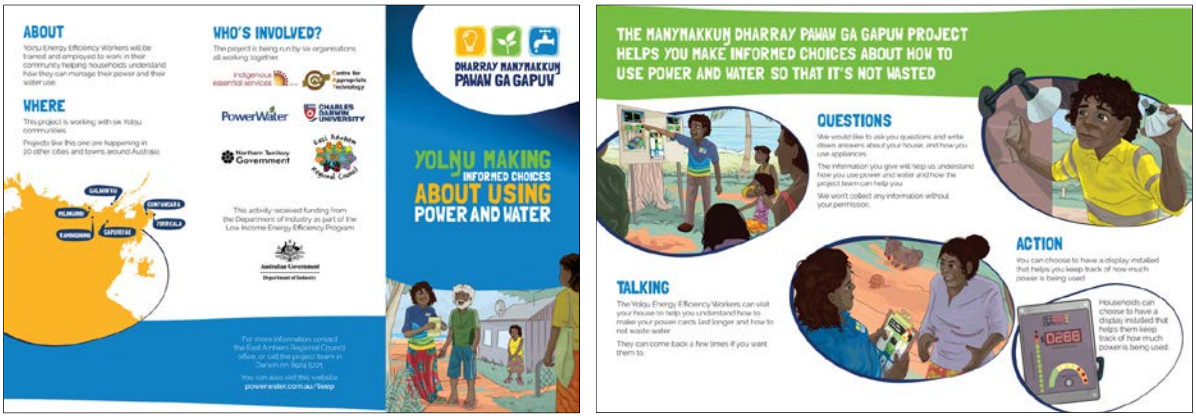
## 15.9 Qualitative Data Analysis: Thematic, Narrative and Content

The pre-project interviews were analysed using a combination of thematic analysis and narrative analysis to allow the salient themes to emerge from the interview data and to order the themes sequentially.[60] The evaluation interviews were analysed using a combination of content analysis and thematic analysis to ensure that both the evaluation topics that were of interest to the project team and consortium and evaluation topics that were of interest to the Yolŋu would be captured.[61] The analysis framework for the content analysis reflected the discussion points used in the interviews. Themes that emerged beyond the framework were added to the framework. Themes that covered topics that emerged in the start of the project interview were added at the start of the project interview analysis. The analysis also contained constant comparison between the pre-interview and evaluation interviews. That is, data in the evaluation interviews that was relevant to the themes emerging in the analysis of the pre-interviews, was integrated into the pre-interview analysis.

[60] Flick, 2014; Riessman, 2008; Silverman, 2013
[61] Ibid.

To enhance the rigour of the data analysis and to manage the data analysis within the tight timeframe of the project, researcher triangulation was used. The lead Yolŋu co-researchers, some local senior Yolŋu co-researchers and Yolŋu interpreter were interviewed to capture their oral analysis. The start of the project interviews, evaluation interviews and project team member interviews were analysed by three different researchers: the non-Indigenous principal researcher and two other non-Indigenous researchers. All three non-Indigenous researchers are also non-Australians. Throughout the analysis, the researchers discussed their respective analysis to identify common themes and to clarify themes. At the end, the analysis was checked by Yolŋu interpreter.

The interview transcripts were analysed using the qualitative analysis software packages Atlas and Nvivo to further strengthen consistency and speed of the qualitative analysis.[62] The interviews were analysed within and across participant groups (i.e. Yolŋu households, YEEW, non-Indigenous community members, project team) and communities (i.e. Gunyangara, Yirrkala, Galiwin'ku, Milingimbi, Gapuwiyak and Ramingining).




*The brochure was used by the YEEWs when introducing the project to householders*

[62] Di Gregorio and Davidson, 2008; Dowling, 2008; Flick, 2014

# 16 Thermal Comfort and Tracking Study

A thermal comfort and tracking study was conducted from August to December 2015 with six Yolŋu households in Ramingining. The purpose of this study was to investigate the thermal comfort variables in hot and humid climates, to collect detailed information on energy consumption of key appliances, and to investigate the barriers to and enablers of efficient use of power and water.

According to the International Standard ISO 7730, thermal comfort is defined as:

> *'that condition of mind which expresses satisfaction with the thermal environment.' Thus 'thermal comfort' describes a person's psychological state of mind and is often referred to in terms of how one feels - generally in relation to air temperature. However, thermal comfort is more complex and needs to take into account a range of environmental and personal factors.*[63]

Thermal comfort is an important theme within LIEEP and a poorly understood feature of remote Indigenous housing:

> *There is a lack of knowledge regarding energy consumption patterns in Indigenous households, particularly around thermal comfort, which is a major driver of energy consumption.*[64]

## 16.1 Methodology and Methods

The research was to be conducted through a mixed methods design utilising quantitative and qualitative research. The principal researcher and the lead Yolŋu co-researcher designed the research implementation with the local Yolŋu co-researchers and the Yolŋu energy efficiency workers in Ramingining to ensure a culturally appropriate and meaningful approach. A specific plain English language information sheet and consent form was developed.

## 16.2 Sample

Ramingining was selected because, as the last community engaged by the project, it would enable a 'before and after' project comparison. The participants were six Yolŋu households selected to provide a cross-section of house designs and ages, and patterns of power usage.

A pool of suitable potential participants was identified together with the local Yolŋu co-researchers and YEEWs based on data collected to that date. After being trained by the lead Yolŋu co-researcher and the principal researcher, shortlisted participants were approached by the local Yolŋu co-researchers. They were informed about the study using the attached plain English statement, the project brochure and consent form, and then invited to participate.

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[63] World Green Building Council, Wellbeing and Productivity in Offies, Research Note-Thermal Comfort; see also ASHRAE (American Society of Heating, Refrigeration, and Air-Conditioning Engineers) https://www.ashrae.org/standards-research--technology/standards--guidelines.

[64] See https://www.powerwater.com.au/__data/assets/pdf_file/0008/104579/lieep_newsletter_sept_2015.pdf. M.D. Ambrose and M. Syme, *House Energy Efficiency Inspections Project*, Report to the Department of Industry, Innovation and Science, December 2015

## 16.3 Quantitative Measures

The quantitative component metered water and energy consumption through hot water systems and stoves, and aimed to measure six thermal comfort variables, energy consumption and hot water consumption. The designed approach was to install a Taggle prototype temperature and humidity logger and a backup temperature and humidity wall-mounted Hobo logger in each of the participating tracking study houses. The indoor radiant temperature and indoor air-velocity measurement was to be measured through a complete Hobo weather station in at least one house as a reference. In addition, period readings for air-velocity and radiant temperature to be taken through a Kestrel hand held device by the co-researcher during the time of thermal comfort perception interview. The interview was designed to capture the level of clothing and metabolic activity. Table 26 details the thermal comfort, energy and hot water consumption variables measured.

Due to logistic delays and concerns from the project team and co-researchers, a complete weather station could not be installed within any of the participating houses. Hence, measurement of important thermal comfort parameters was relied on through handheld device readings through the co-researcher.

All participating houses had hot water system energy and water consumption Taggle, temperature and humidity Taggle and Hobo logger installed. The stove energy consumption Taggle was installed in five participating households. All participating houses had the Taggle, power and meter sensor, and hot water flow meter installed. The installation of these devices was organised by the project team and coordinated by the Ramingining Yolŋu co-researchers with some support from the assigned CAT community engagement officer.

Data was collected from the Taggle loggers from the beginning of September 2015 through to April 2016 when the equipment was removed.

A brief thermal comfort questionnaire was developed and interpreted into Yolŋu Matha by lead Yolŋu lead-co-researcher and the project Yolŋu interpreter. The lead Yolŋu co-researcher and principal researcher conducted fieldwork August 2016 in Ramingining to train the Ramingining Yolŋu co-researchers using the questionnaire.

*Table 26: Thermal comfort, and energy and hot water consumption variables and measurement*

| Variable | Measurement |
|---|---|
| Indoor temperature and relative humidity | Taggle combination device mounted on wall |
| Indoor air velocity and indoor radiant temperature | Kestrel mobile handheld device via co-researcher |
| Hot water system and stove energy consumption | Dedicated KWh pulse meter with Taggle |
| Household hot water consumption | Hot water flow meter with Taggle |
| Perceptions of<br>- temperature<br>- humidity<br>- air velocity | Survey |
| Clothing (type, amount) | Survey |
| Perceived metabolic rate | Survey |

## 16.4 Qualitative Measures

At completion of the thermal comfort questionnaire, local Yolŋu co-researchers asked the participating Yolŋu to share their power and water stories in semi-structured interviews. Interviews were based on discussion points designed together with the lead Yolŋu co-researcher, the Yolŋu interpreter, and the local Yolŋu co-researchers and YEEWs. Participating households were reimbursed with a $20 power card per day they participated in the study. Semi-structured interviews aimed to explore:

- what Yolŋu think and feel about power and water
- what appliances Yolŋu use and how they use them during the dry season
- how Yolŋu use power and water
- how much power and water Yolŋu use
- what temperatures, humidity and breeze inside the house Yolŋu feel most comfortable with
- what works well and what is difficult for Yolŋu in regards to power and water usage
- what would help Yolŋu with power and water.

The qualitative interviews were recorded on video then interpreted by the Yolŋu interpreter and subsequently transcribed in full.

## 16.5 Quantitative Data Collected

Complete data from all the 35 data points from the tracking study houses was not obtained due to failures in the prototype loggers and possible installation failures during retrofit installations. As detailed in the table below, data was lost from three HWS power Taggles after the installation of a new solar HWS disabled the logger. In addition, data was completely lost from two water flow measurement Taggles from two HWS.

The available data was utilised for calculating the heat index inside these houses, also known as apparent temperature. Furthermore, the available data was utilised to present the actual energy use percentage from different HWS and the electric stove.

*Table 27: Overview data collection thermal comfort and tracking study*

| Tracking parameters | Number of data points | Complete data | Partial data | No data | Comments |
|---|---|---|---|---|---|
| Houses | 6 | | | | |
| Power Taggle | 6 | 6 | | | |
| HWS power Taggle | 6 | 3 | 3 | | Data lost after retrofit |
| HWS water Taggle | 6 | 4 | | 2 | 2 tag prototypes never worked |
| Stove power Taggle | 5 | 5 | | | |
| Temp./humidity Taggle | 6 | 6 | | | |
| Temp./humidity logger | 6 | | | | Data extraction awaiting device demounting |

## 16.6 Ethics

In line with the requirements of research in Australia, this project was conducted under research ethics approval granted by the CDU Human Research Ethics Committee (HREC) under the number H13087.

Ethics with Indigenous peoples needs to be very well informed by the particular cultural and ethnical social structure to which they belong.[65] Accordingly, to conduct the research in a way that respects and values Indigenous people, facilitates equal collaborations and fulfils the requirements of governments for ethical conduct in research.[66] Leading and local Yolŋu co-researchers (some of whom are elders) were consulted by researchers experienced in working with Yolŋu and other Indigenous communities, and the CDU Human Ethics Committee throughout the project.

Specific plain English information sheets and consent forms were designed for Yolŋu households, YEEWs, project team members and Yolŋu households participating in the thermal comfort and tracking study. When the Yolŋu co-researcher approached potential participants, they discussed the information sheet (which included the project brochure) and sought consent using the consent form.

The evolution in methodology described above necessitated several variations to the ethics approval. The expiry date of the current ethics approval for this project is 22 July 2018.


DHARRAY MANYMAKKUŊ PAWAW GA GAPUW

Newsletter
August 2014

**The Manymak Energy Efficiency Project is delivering energy and water efficiency services in East Arnhem.**

Read on to find out what we've been up to.

**Project celebration event**

Project progress was successfully celebrated in Milingimbi on 1 July 2014. Yolngu Energy Efficiency Workers, government representatives, project partners and community members were out in force to celebrate work having commenced in earnest.

*Above: Yolngu Workers with their certificates, alongside Government representatives and project team members at the Milingimbi launch event*

Building on our learnings from Milingimbi, work will start in Galiwin'ku, Yirrkala, Gunyangara, Gapuwiyak, and Ramingining over the coming 12 months.

**Yolŋu Energy Efficiency Workers on the job**

Work in Milingimbi is well underway. Project partner East Arnhem Regional Council (EARC) has employed 15 Yolngu Energy Efficiency Workers, who have been trained to carry out household engagement and deliver education about power, where it comes from, and how residents can save power in their homes through informed decision making.

This Yolngu to Yolngu engagement will continue over coming months with mentoring and support from project team members and EARC staff.

*Above: Milingimbi Yolngu Energy Efficiency Workers training in preparation for taking energy efficiency messages to local households*

**Developing training materials**

Image based education materials underpin our approach to household engagement.

Using power in a good way

Australian Government
Department of Industry

LOOKING AFTER OUR POWER AND OUR WATER

*This activity received funding from the Department of Industry as part of the Low Income Energy Efficiency Program*

***Project newsletters were regularly produced and distributed to the communities and project stakeholders***

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[65] Morgan, 2014, personal communication

[66] NHMRC, 2003

# SECTION 3 DISCUSSION AND EVALUATION

## 17 Overview

This section presents a discussion of the results of the project structured into four sections, addressing the project's objectives as well as the overall LIEEP objectives. The four components of the discussion include:

1. Barriers to efficient energy use in low-income indigenous households
2. Community engagement approach - evaluation and recommendations
3. Technology trials - evaluation and recommendations
4. Project impact on total community power consumption.

Each of these components includes a summary of key findings and explanation of how they relate to the aims of the project. They also point out the limitations to the project approach and improvements that could be made in future trials. The discussion of these points lead into recommendations, which are summarised in the recommendations section of this report. Ultimately, the findings and recommendations discussed in this section of the report represent a useful model for future programs seeking to address energy efficiency in remote Indigenous communities.

The discussion includes a presentation of key qualitative and quantitative findings, with selected figures and quotes from interviews included as an evidence base throughout. Given the large volume of data involved, additional details of the quantitative data analysis, qualitative findings, barrier surveys, KAB surveys and cost-benefit analysis are provided in the appendices.

## 18 Barriers to Efficient Energy Use in Low-Income Indigenous Households

A primary goal of the project and of LIEEP was to identify and further clarify barriers to energy efficiency.

In addition to the barrier survey that formed part of the initial project design, the identification of barriers was also informed by a number of consultations, data collection and analyses in addition to the barrier survey. These include the ARDS community consultation in early 2014, field observations and feedback from YEEWs collected by project team members, trainer/facilitator reflection reports, the thermal comfort study, and the formal qualitative research trips and co-researcher interviews.

The following discussion starts with an overview of the barriers that informed the project design prior to commencement. It then discusses learnings through the project operation grouped by theme: built environment, appliances and technology, and then social and behavioural factors.

The project design and ongoing operation responded to emerging barriers and associated opportunities where practical within time and resource constraints. Other learnings and barriers for energy consumption and behaviours emerged only at the end of the project once quantitative and qualitative data collection was completed and detailed analysis was possible.

For example, the measurement of household power consumption using the Taggle data loggers installed by the project enabled relating household consumption to total community consumption, climate, house design features, house occupancy rates, and the number and type of key appliances including hot water systems and air-conditioners. Important learnings from this analysis could not be taken into account during the project but represent opportunities for future programs and policy.

## 18.1 Barriers Addressed in Project Design

The original project design addressed four specific barriers to low-income household energy efficiency in line with the LIEEP guidelines: information failure, capital constraints, remoteness/accessibility, and split incentives.

The project design sought to overcome information failure barriers to energy efficiency by designing an energy efficiency education package for low-income Indigenous households in the participating communities and delivering it through local people. The package was to be developed collaboratively with community residents to ensure it was culturally appropriate and consistent with previously demonstrated Indigenous engagement practices.

Information failure was also a perceived barrier for the project consortium members and stakeholders, largely due to lack of information on household energy consumption patterns, pre-payment meter disconnection patterns, and the efficiency of different house construction and energy appliance choices.

Capital constraints were also identified as a barrier. Household income sources were not identified in detail but are likely to rely significantly on income support payments. This, combined with the high cost of purchasing new, higher efficiency, appliances in community stores represents a barrier to the uptake of more efficient appliances.

The sheer remoteness of Indigenous communities in East Arnhem Shire is a major barrier to energy efficiency. Accessibility-related issues include the high cost of travel, lack of access to energy-efficient appliances and fixtures, limited exposure to mass media relating to energy efficiency measures, limited internet connectivity (and therefore restricted access to additional information sources) and a shortage of skilled labour.

Information relevant to how low-income Indigenous households in remote areas actually use energy is scant. In part, this is a consequence of their exclusion from the Australian Bureau of Statistics Energy Use and Conservation Survey conducted in March 2011.

The project's energy efficiency retrofits also addressed potential split incentives for energy efficiency faced by the Department of Housing as the landlord and Yolŋu residents as tenants, where the landlord may not prioritise the additional cost of high efficiency appliances or the provision of efficient building structures, as the benefit from the additional cost flows to the tenant in low power costs. However, the NT Government, of which DHsg is a part, subsidises the costs of power provision and so has a stake in improved efficiency outcomes. The project's retrofit trials provided an opportunity to provide information on the relative efficiency benefits of investment choices to support decision making, as well as to assess the benefits of accelerated replacement of ageing hot water appliances that operate at a lower level of efficiency.

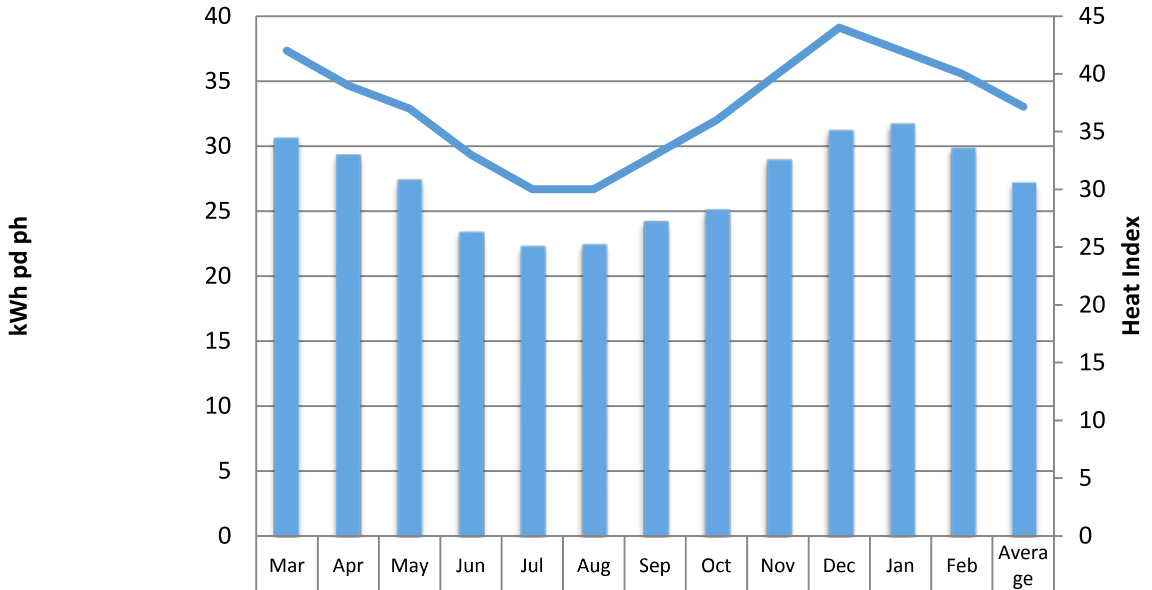
## 18.2 Climate and Environmental Factors

The project data shows that household energy consumption correlates closely with changing thermal comfort conditions, being higher during the hotter months (the wet season) than during the comparatively cooler months (the dry season). This is presented in Figure 6 below for March 2014 to February 2015.

The use of the heat index or apparent temperature is important for the hot tropical conditions of east Arnhem Land, given that the apparent temperature is consistently higher than the nominal maximum air temperature.

Of importance is that the average maximum apparent temperature is above 30 degrees all year, while typical norms of human comfort are in the range of 22 to 28 degrees' apparent temperature.

***Figure 6: Participant household average energy consumption 2014–15 compared to heat index (apparent temperature)***



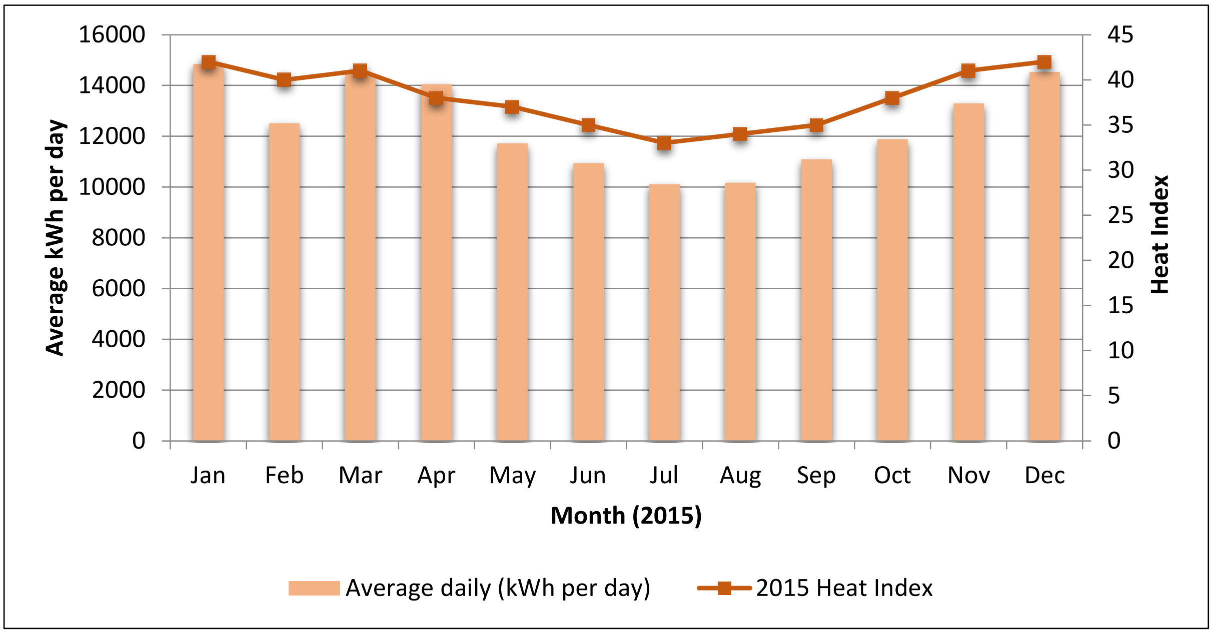

| | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Jan | Feb | Average |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2014-15 kWh pd ph | 30.7 | 29.4 | 27.4 | 23.4 | 22.3 | 22.5 | 24.2 | 25.1 | 29.0 | 31.3 | 31.7 | 29.9 | 27.2 |
| 2014-15 Heat Index | 42 | 39 | 37 | 33 | 30 | 30 | 33 | 36 | 40 | 44 | 42 | 40 | 37 |

The correlation between participant energy consumption and climate is also consistent with the whole-of-community trend for 2015 Figure 7.

The decrease in household consumption and the wider community power use in February 2015 is a result of Cyclone Lam and the consequential power outages in affected communities.

The seasonal trend reflects the impact of increasing use of air-conditioners and ceiling fans as well as an increased load on refrigeration appliances in the wet season. This would be offset by an assumed reduction in demand for hot water showers due to the increasing heat and a potential small reduction in lighting in the wet season due to slightly shorter nights.

*Figure 7: Whole-of-community average daily power use 2015 compared to the heat index (apparent temperature)*




## 18.3 Impact of House Type

The impact of house type that were involved in this project:

1. new houses, with a standard design and that generally did not receive major retrofits through the LIEEP project
2. older houses (mostly refurbished), with a range of design styles, most of which received major retrofits through the LIEEP project.

Households in the participating communities were found to use, on average, 26.8 kWh per day, with average consumption for new houses lower than that of legacy and refurbished houses. However, the new housing also has a smaller number of bedrooms on average, and on a per-bedroom basis, the new housing has higher than average consumption (Table 28).

*Table 28: Housing types, average number of bedrooms and power use*

| House Type | Lots | Average number of bedrooms | kWh / day | kWh/ day/ bedroom |
|---|---|---|---|---|
| New | 226 | 2.5 | 22.22 | 8.9 |
| Concrete block | 109 | 3.2 | 30.42 | 9.5 |
| Fibro cladding | 87 | 3.6 | 27.8 | 7.7 |
| Metal | 19 | 4.2 | 36.19 | 8.6 |
| Timber framed | 64 | 3.8 | 33.16 | 8.7 |
| **Total** | **505** | **3.1** | **26.86** | **8.8** |

The thermal comfort monitoring conducted in six houses in Ramingining from July 2015 to January 2016 produced conflicting findings on the comparative thermal comfort of lightweight versus concrete housing. In any case, both the house categories average indoor conditions were found to lie outside typical thermal comfort zones, thereby requiring the provision of additional air movement (ceiling fans) and/or air conditioning to achieve nominal thermal comfort.

In short, the house construction style, construction materials and age was not found to be a clear or significant determinant of energy consumption, with the other factors explored below being more important.

What is clear from the evidence of this project is that future housing program managers need to assume that air-conditioning will be installed and used by residents, and therefore the building envelope should be designed accordingly.

Attention should also be paid to the way that remote Indigenous residents use their homes in the tropics. From the qualitative data and community feedback collected, it was clear that residents valued outdoor living spaces and facilities but usually in ad hoc settings (i.e.- without infrastructure, using trees, open fires and such). To facilitate better energy efficiency outcomes, future housing programs should take this into account and provide outdoor living and cooking areas. This would help reduce the cost of mechanical cooling and electric cooking as well as easing the impact of crowding.

The issue of housing supply and design came up repeatedly during engagement with Yolŋu people through this project. Undersupply of housing in the remote east Arnhem Land communities is of prime concern to Yolŋu, who live with the daily challenges of overcrowding. They also expressed a strong desire to have greater carriage and ownership over housing design and build processes. This is not a new finding, and it is a challenge that many policy makers and built-environment professionals are aware of. The challenge is how to bring residents and policy-makers together on the issue of suitable, safe, efficient and affordable housing in remote regions.

### *Impact of Transitional Housing*

A key finding linking the impacts of house design and supply of appliances is the initial findings from energy data obtained from the Galiwin'ku transitional housing, post-cyclone. Temporary accommodation in the form of transportable 'dongas' was provided while a build of permanent housing was commenced. These dongas were installed in pairs, or 'pods', with a shaded breezeway between but limited shading to other walls and limited useful ventilation (windows). They were provided to residents with up to six functioning box-type air-conditioners per pod and an electric hot water system.

The following table provides a comparison of energy consumption data for the permanent housing in each community in comparison to the transitional housing for the two wet season months December 2015 and January 2016 for which data was available for the transitional housing. The transitional housing shows a considerably higher level of energy consumption overall and per capita, with per-capita consumption 60 per cent higher than permanent houses.

The average consumption for the transitional housing also fits well with the linear relationship established between air-conditioners and energy use for the case of six air-conditioners, as discussed subsequently. This suggests that the increase in energy consumption is predominantly a result of full use of the additional air-conditioners provided with the temporary housing.

This supports the energy efficiency benefits of the approach taken with other community housing design, including provision of eaves and wall shading, useful cross-flow ventilation, ceiling fans to all rooms and not providing air-conditioners by default. It also supports the need for future investigation into practical air-conditioner controls for residents. Evidence also suggests that maintaining the temporary accommodation past the immediate transitional need period should be accompanied by improvements to the passive elements and/or appliances in order to address the higher energy costs of the dongas.

Table 29: Comparison of energy consumption for permanent and transitional houses

| | Dec 2015 kWh per day, per house | Jan 2016 kWh per day, per house | Average | Average occupancy | Per capita kWh per day |
|---|---|---|---|---|---|
| Permanent housing (all six communities) | 31.4 | 32.7 | 32.1 | 9.1 | 3.5 |
| Transitional Galiwin'ku | 52.3 | 68.0 | 60.2 | 10.8 | 5.6 |

## 18.4 Impact of Appliances – Overview

The participants in the project are community housing tenants, with DHsg managing the housing stock in this region. DHsg is responsible for provision and maintenance of the fixed appliances in homes, including hot water systems, ceiling fans, light fittings, and an electric cooktop and oven within each household. These appliances are the most common appliances reported by participants.

Householders are responsible for the provision of other discretionary appliances, such as air-conditioners, televisions, washing machines, refrigerators and replacement light bulbs and tubes.

The monitoring of individual appliance consumption was only conducted for a small number of houses through the tracking study but provides some support for the following discussion for each major appliance type.

## 18.5 Fixed Appliances – Hot Water, Lighting and Stoves

### *Hot Water Systems*

The DHsg is responsible for supply and maintenance of the hot water system (HWS) in each house. The type of hot water system installed depends predominantly on the age and category of house. New houses are usually supplied with heat pump-type hot water systems, while refurbished houses are supplied with a mix of solar and electric hot water systems, as explained in the retrofits section of this report.

An analysis of the household energy consumption in comparison to the pre-existing hot water type was conducted prior to the project's retrofit trials. Consistent with expectations, the average energy consumption in the houses that had an electric HWS was highest (35.81 kWh per day). However, contrary to expectations, the average energy consumption in houses with solar hot water systems (29.40 kWh per day) was higher than houses with the heat pump hot water system (20.26 kWh per day).

Controlling for occupancy (but no other factors), the energy consumption of houses with heat pumps was still lowest; however, pre-existing solar hot water system households were found to be using more energy on average than those with electric hot water systems.

The Ramingining study of a small sample of six houses showed that hot water accounted for around 12 per cent of average consumption and that the houses with aged solar hot water systems used considerably more power for water heating than those with a new heat pump hot water—0.6kWh per person per day for the old solar hot water compared to less than 0.2kWh for the heat pump houses. The energy consumption of the hot water system showed no correlation with the measured water consumption through the hot water unit, nor with the reported occupancy.

The actual age, operational efficiency and impact of maintenance issues was not measured for pre-existing hot water systems overall. However, the results from the retrofit trials that replaced old solar hot water units with new units (discussed below) combined with the findings from the Ramingining study support the conclusion that the condition of older existing appliances stock was a key driver of higher energy consumption, and therefore maintenance and/or replacement is an important enabler of reduced energy consumption.

### *Lighting and Lighting Controls*

The majority of lighting fitted in housing was found to be relatively efficient fluorescent tube or compact fluorescent lamp technology. This included the majority of external lighting including 'PAR38' security floodlight lamps.

Data on lighting controls for internal lighting was not collected; however, anecdotally, some housing had a significant number of lights controlled per switch, limiting the ability for tenants to control the level of lighting.

Outdoor lighting controls were not systematically examined but anecdotally were found to be variable. Some housing had motion sensors fitted to external lighting, with or without overrides. Some newer housing had switches allowing external lighting to be optionally controlled with ambient light sensors. The level of residents' understanding of these lighting controls was not established but was identified through discussion with the YEEWs as a potential source of confusion. Preparation of additional specific data collection and household education to address this gap was considered, but it was not able to be integrated into the project operation prior to its conclusion.

Findings from the interviews and observation was that outdoor lighting was left running at night in many houses. This is a common occurrence in many Indigenous communities and the behaviour is in response to cultural beliefs and safety concerns. It was observed to often result in those lights subsequently remaining on during the day.[67]

### *Stoves*

Stove controls and the potential for stovetops and ovens to be left running were identified by householders during the barrier survey and general consultation in community as a barrier to energy efficiency. This led to the inclusion of stove timers in the project's energy efficiency retrofit trials.

The energy consumption of the small sample of stoves from the Ramingining study (that did not receive stove timers) found that the stoves accounted for around 2.5kWh per day or around 10 per cent of average participant energy consumption.

The findings from the analysis of impact of stove timers presented below indicates that this consumption is higher in many houses and that stoves being left running unnecessarily is a significant consumer of energy.

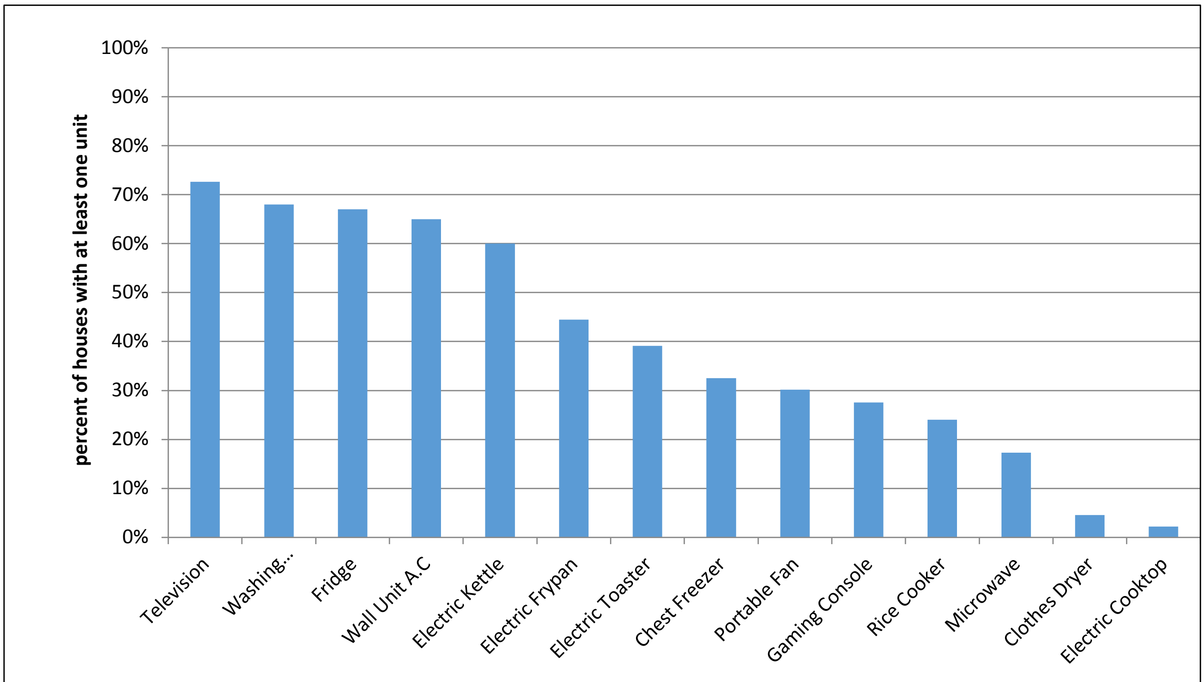
[67] This was the focus of a set of YEEW household visits in Milingimbi towards the end of their employment

## 18.6 Discretionary Appliances: Air-Conditioners, Televisions and Whitegoods

### *Results of Appliance Surveys*

The project collected data on the number and type of appliances installed in houses through surveys conducted by the YEEWs. The results for discretionary appliances are displayed in Figure 8, which shows the percentage of houses with one or more of each appliance type. Overall, the reported ownership of common appliances was found to be low. These results did not align well with the results from the much smaller barrier survey, and no other quantitative data set was obtained to confirm the findings from the YEEW appliance surveys. However, the findings from the appliance surveys for the known installed appliance types (fans, lighting and hot water systems provided by DHsg) provide some confidence in the discretionary appliance findings.

*Figure 8: Reported occurrence of tenant-supplied appliances*




Combining this information with the Taggle data allows us to attempt to identify which appliances have a potential influence on energy consumption while controlling for the multiple other influences on total household energy consumption.

### *Availability of Efficient Appliances*

A store survey was conducted to gain a better understanding of the availability of energy and water-efficient appliances to residents of east Arnhem Land communities and to determine how stores select appliances to stock.

The survey revealed that the stores stock products based on price, availability and consumer demand. One of the main limiting factors identified by stores in stocking energy-efficient appliances in general is the limited range of affordable energy-efficient appliances available from the wholesale suppliers. The items being stocked are selected in reflection of the low income of community customers. Energy efficiency was not generally a priority consideration when selecting stock for the community stores unless through a specific purchase request.

The high incidence of CFL floodlight lamps identified during the project's retrofit scoping was linked to these being the only option available in the local stores.

The YEEWs were not tasked with gathering information from households on the age or efficiency rating of appliances in place. However, second-hand (or third-hand or more) appliances were commonly observed in use throughout all communities. The household barrier surveys in Galiwin'ku and Yirrkala suggested that residents source appliances from several locations, including second-hand appliances being bought from the Yirrkala banana farm or gathered directly from the tip in Yirrkala. The general low levels of ownership of common household appliances supports the likelihood of re-use of all available appliances.

It is clear that older domestic appliances in circulation are generally less efficient than newer appliances, both due to improvements in efficiency as a result of regulation and technical improvements (e.g. more effective insulation in refrigerators) as well as the impacts of wear and tear and inadequate maintenance. However, access to any functioning appliance is a higher priority than its efficiency, and so efforts to improve energy efficiency through the supply of new appliances will generally result in an increase in overall consumption as the replaced units are found new homes.

As an example, the household barrier surveys suggest that a government initiative in 2013 that supplied digital TVs to households may have contributed to an increase in energy use in participating communities. Some houses that did not previously have a TV were supplied one, and other houses reported watching more TV as more stations became available.

Repair and refurbishment of existing appliances to improve their efficiency is made all the more difficult in remote communities owing to difficulties accessing replacement parts and skilled labour. It is important to note that there are skilled tradespeople and technicians based in remote communities, but they are usually occupied with a full workload from period contracts.

Given the results discussed above, a recommendation of this report is that future programs should allocate specific resources to work with local community stores to source and stock affordable energy-efficient appliances. In this case, the key performance indicators for the project did not include a focus on the supply side of appliances in communities. As such, the project team did not allocate resources to tackle this considerable issue. Future program designers should consider this at the planning stage.

### *Air-conditioners*

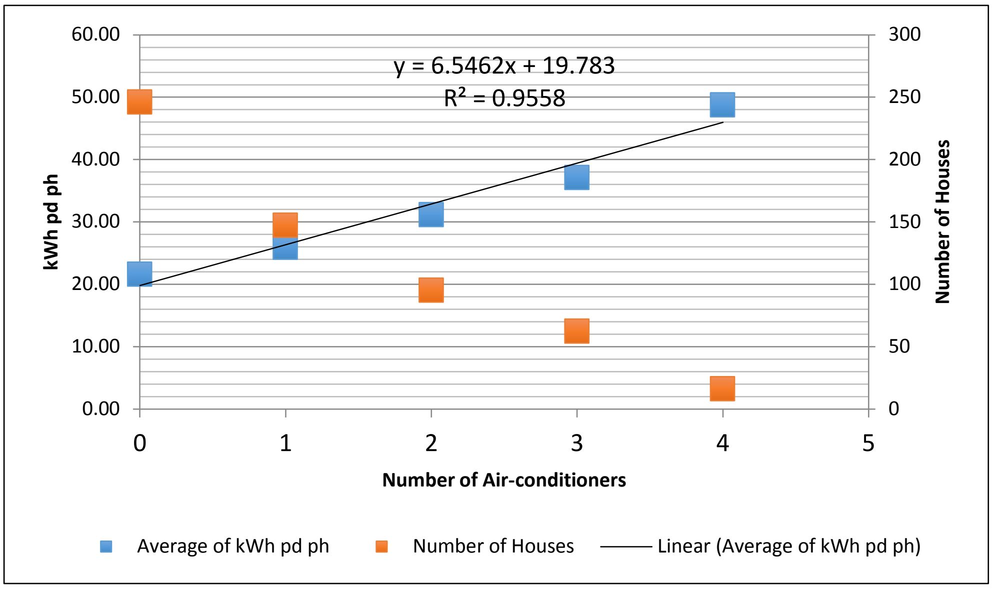
Air-conditioners are high energy-consuming appliances and have a considerable potential to increase household energy consumption in the hot, tropical east Arnhem Land region. The appliance survey data regarding the number and type of air-conditioners used in participating communities shows that the average number of air-conditioners was just over one unit per house. Exploring in more detail, the majority (57 per cent) of houses have at least one air-conditioner (average of two), while 43 per cent did not report having one. While most of the units identified by the tenants were box-type air-conditioners (95 per cent), a very small proportion have split-system air-conditioners (5 per cent).

Additional factors relating to air-conditioner energy use are the energy efficiency rating of the unit, the maintenance and general condition, and the available controls. The project did not gather information on the models or included controls, on the energy ratings of units in houses nor details of their maintenance other than 'working or broken'.

As expected, a strong positive correlation exists between energy consumption and the number of air-conditioners, with analysis showing that each additional unit adds around 6.5kWh per day of energy consumption (Figure 9). From this it can be assumed that air-conditioning accounts for around 24 per cent of average household consumption for the participating houses.

This represents 2372 kWh per annum. For a typical 0.7kW power rated box air-conditioner, this represents 3389 hours of run time at full load, which could be interpreted as 18 hours per day run time at full load for half of the year. This suggests that air-conditioners are being left running continuously with limited or no thermostatic control during the wet season. It should be noted that this is for an average of one air-conditioner per house with an average of nine occupants.

*Figure 9: Correlation between type and number of air-conditioners and average daily kWh*




Participant observation indicates that Yolŋu understanding of the ability to use a temperature set point with an air-conditioner is varied. Specific temperature set points can be selected with split system air-conditioners, which have a thermostat. Box air-conditioners are sometimes provided with a thermostat set point, but generally with a two or three-setting gradient of cooling power and fan speed.

The use of air-conditioning, particularly around extended run times, therefore represents a significant potential barrier (and opportunity) for energy efficiency.

The project's trial of the Heater Mate product to provide thermostat-based control for the more basic box-type air-conditioners is discussed elsewhere in this report.

## 18.7 Social and Cultural Factors Influencing Efficient Energy Use

There are a diverse range of human factors that influence or act as barriers to efficient energy use in households in the participating communities. Many of these are unique to remote Indigenous communities.

### *Social and Cultural Factors*

- Social issues of overcrowding and family dynamics resulting in difficulty in ensuring that all tenants and particularly visitors and youth are factoring price into their consumption-related behaviours.

- Social tensions from Yolŋu of multiple clans residing in housing provided to them in a community placed within the traditional lands of one clan (a barrier for delivery of household engagement as well as feeding in to other energy-related barriers).
- General impact of high occupancy and low per-person energy consumption.
- Yolŋu perspectives of the role of power and water in their lives, culture and future aspirations.
- Retention of inefficient appliances due to cost of repair or capital cost of purchase of more efficient replacement appliance, and/or lack of information on the relative cost-benefits (this relates to both Department of Housing and residents).
- Householder misconceptions and lack of understanding of energy concepts and drivers of energy consumption.
- Perceptions that non-Indigenous households (staff housing) and facilities (government and commercial buildings) use much more energy and are not subject to the same costs results in lack of motivation for Yolŋu to save energy (and water).
- Lights being left on for safety or cultural reasons.

Given the strong links between reliable and affordable access to energy and positive health and social outcomes, it would be counterproductive to pursue a blanket 'use less' message in this project. This unique context meant that the technology and community engagement approach needed to be nuanced and targeted to meet both the needs of the project and the needs of the participating communities.

### *Family Structure, Mobility and Household Management*

Many families in the participating communities do not conform to the Australian mainstream concept of a fixed nuclear family unit. In many Indigenous communities throughout Australia, an extended family system is common and can include quite distant relatives from surrounding communities. In the participating communities, it was common to observe a more complex mix of extended family and/or several generations of family members residing in one household, usually with numerous resident children. Householders also reported welcoming extended family from neighbouring communities, who may stay as house guests for extended periods, particularly in relation to cultural events in the community. Entire families relocating houses to make space for visitors was reported on at least one occasion.

The high number of residents in homes drives up total household consumption, but high occupancy also drives down *per capita* consumption. The high cost incurred may not be shared equally among household residents. A high proportion of children and young people living in homes can mean that the burden of electricity costs falls disproportionately onto a small number of income-earning adults. Indigenous communities have a relatively young population in general, and in the participating communities, this is also the case, with the average age across the six communities being 25 (refer Appendix A).

The vast majority of households in remote Indigenous communities are in receipt of some form of Commonwealth income support payment. They are firmly in the category of 'low income', with the mean individual income per week averaging $270 compared to the national average of $577. They are understood to spend a greater proportion of their income on essential services when compared to higher-income households[68]. People in receipt of income support payments also spend more time at home during the day, which drives up relative energy spend[69]. The average cost of a food basket in remote stores in 2013 was 49 per

[68] See KPMG and Brotherhood of St Laurence Report, http://library.bsl.org.au/jspui/handle/1/6014

[69] Urmee, T., Thoos, S. and Killick, W. 2012. Energy efficiency status of community housing in Australia. *Renewable and Sustainable Energy Reviews*, vol.16, pp 1916-1925

cent more expensive than in Darwin and 1 per cent more expensive than district centre stores[70]. This high cost of all goods and services in remote communities compounds the issue of low income and high energy spends for Indigenous households.

### *Impact of House Size and Occupancy on Energy Consumption*

The project generated findings linking power consumption to occupancy rates. Data shows that, on average, across the participating communities, about nine people live in each household[71]. The average number of occupants is based on maximum number of occupants reported per household in the various household visits conducted during the LIEEP energy and water use education. The reported number of occupants in each household is likely to be conservative. Yolŋu are mindful that their tenancy contracts permit only a certain number of tenants and typically under-report tenancy numbers for this reason. This interpretation is supported by the barrier survey results, which found an average of 10 per house and by comparison to the official population figures.

The qualitative interview data also suggests that the average number of occupants is likely to be much higher during ceremonies (especially funeral ceremonies) and commonly for prolonged periods of time (several weeks). Analysis of the reported mobile phone charger numbers combined with Census demographics (refer Appendix A) and the assumption that only adults maintain a mobile phone also supports the average of nine occupants.

Energy consumption was found to start at around 14kWh per day for a house with a single occupant and increase linearly with increasing household occupancy (Figure 10).

Houses with more bedrooms were found to consume more energy on average, and, not surprisingly, these larger houses are found to contain a larger number of energy-consuming appliances. Generally, then, higher appliance ownership leads to higher energy consumption, with more bedrooms providing spaces for more appliances to be installed.

Analysis of occupancy against the number of bedrooms within each home shows only a small increasing correlation, suggesting that family groups of similar size are occupying houses regardless of the number of bedrooms. This has implications for the supply of smaller housing in terms of crowding.

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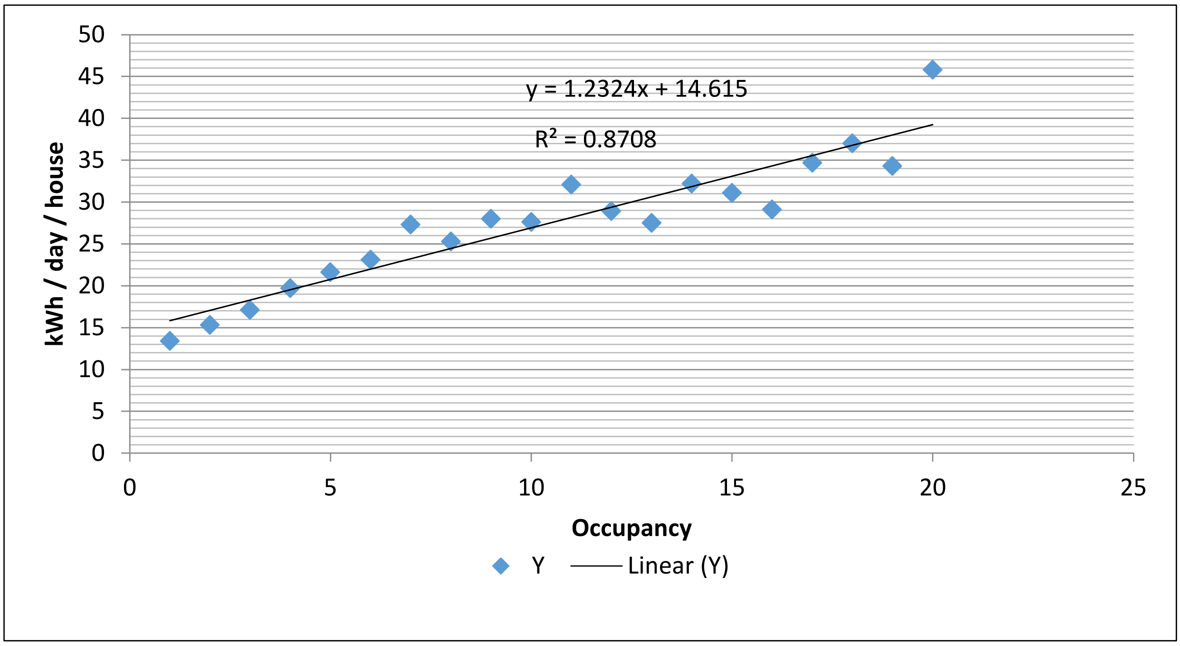
[70] NTCOSS Cost of Living Report, 2014
[71] refer to Methodology section and Appendix A for further details.

*Figure 10: Correlation between energy consumption and house occupancy*




The effects of high occupancy were a recurring theme throughout the project and an issue of prime concern for residents. However, the occupancy graph shows that because of the effectively fixed consumption overhead per house, increasing the housing stock to reduce crowding will result in an overall increase in energy consumption at the community level. This will place an additional cost burden both on householders and on the utility provider, a clear policy consideration for estimating costs associated with the future supply of additional housing to address overcrowding.

## *Literacy, Numeracy and Language*

Literacy, numeracy and language challenges present obstacles to the transfer of mainstream energy efficiency education programs into remote Indigenous settings. Their clans' Yolŋu Matha dialect is the first language of most of the Indigenous residents of east Arnhem Land, with English perhaps a second, third or subsequent language. This has clear implications for residents' ability to engage with energy efficiency education materials and directed a large proportion of the community engagement work for this project. Compounding this challenge is the low level of educational attainment for many remote residents and resultant literacy and numeracy challenges. Energy efficiency education materials also need to be targeted and culturally appropriate, which presents challenges for agencies used to working with mainstream audiences.

## *Perception of Inequity in Targeting Only Indigenous Households*

Household energy consumption represents only a small portion of total consumption in the participating communities. Quantitative data analysis of comparisons between participating household power consumption[72] and overall power production/consumption shows that, on average, the participating

[72] Gunyangara and Yirrkala are not included in the analysis because of unavailability of monthly kWh data, as these communities are under power purchase agreement with the mining company Rio Tinto.

households account for approximately 30 per cent of the total power consumption in their respective community.

Other consumers in the community include residential housing for government and other employees, as well as non-residential facilities, such as schools, shops, council offices, health clinics, art centres, and the water and power supply systems. The project did not gather data to determine in detail the composition of the other 70 per cent of power consumption, nor to specifically compare Yolŋu housing power consumption to other residential consumption in communities.

The percentage of total consumption represented by the project's target households means that impacts on total community consumption as a result of the trials will be comparatively small, assuming the trials only influence participant consumption (this is analysed in detail later in this discussion).

The low total percentage finding also adds significance to the barrier identified early in the project that an initiative focused solely on Yolŋu housing within the community can lead to a sense of inequity and therefore potential resistance to participation, with Yolŋu observing the consumption of power in non-Yolŋu housing being higher and potentially more profligate than their own, especially on a per-capita basis.

## 18.8 Yolŋu Perspectives on Barriers

The evaluation interviews for this project sought the views of residents on their perception of barriers to efficient household energy use. Table 29 summarises the barriers and enablers for efficient use across the six communities from the perspective of the Indigenous residents of those communities—primarily the principal tenants of Indigenous households. Many of these are reflected in the barriers identified by the project.

It is noticeable from these results that Yolŋu take a broad view of energy efficiency issues, seeing them in the wider context of pervasive overcrowding, poverty and social disadvantage in remote Indigenous communities. Quotes taken from the individual interviews provide perspective on the findings. For example:

> *As for the future, I am still concerned for some of us who are still in the Centrelink payments. Well before when we were not paying for the electricity, we had some money left, we bought groceries and we still had money left, now the power, it costs money and both, it goes to the power and it goes to the food. We spend money on both of these things. It's too hard for us to budget, do the budgeting. And because all of my family in this household is all on Centrelink money, there's no way we can budget our money because there's also no employment, we don't work and there's no work available.*

*Table 29: Yolŋu perceptions of key barriers to and enablers of efficient energy use*

| **Yolŋu perceptions of barriers to energy efficiency** |
|---|
| There have always been problems of communication and cultural misunderstanding between non-Indigenous people and Yolŋu, and non-Indigenous people often introduce changes without engaging, asking or explaining. |
| Non-Indigenous people do not understand Yolŋu Rom (Law) and the significance of kinship relationships. Therefore, there is a perception that it is ignored in relation to power and water education. |
| Confusion and misunderstandings surround the source, the infrastructure and the process of providing power and water, and associated devices (e.g., meter box, power card system). |
| Overcrowding makes using power and water efficiently and paying for power difficult. |
| Children use a lot of power and can be difficult to manage in overcrowded households. |
| Principal tenants and employed Yolŋu bear most of the burden of paying for the power cards. |

| Yolŋu perceptions of barriers to energy efficiency |
|---|
| Household repairs are not done in timely manner. |
| Limited Yolŋu involvement in the design, building and maintenance of housing reducing their relevance to residents' needs. |
| Historically, Yolŋu perceive that they were better off before non-Indigenous ways of living were introduced. |
| Fire and water were free for Yolŋu and now they need to pay for Balanda-provided power and water. |
| Perceptions of oppression and inequality create mistrust and resistance. |
| Yolŋu retain a deep connection to country and remember historical ways of living before power was introduced. |
| Fire and water were historically key elements for survival and therefore are respected through Yolŋu law or 'Rom' (and education should build on this). |
| Yolŋu kinship system governs the process of engagement. |
| Limited Yolŋu involvement in the process of building and maintaining housing and infrastructure (which affects suitability, employment outcomes and respect for the assets). |

The most emphasised barriers to effective use of power and water that emerged from the interviews across all six communities were associated with misunderstandings about how power and water are supplied to and managed within remote Indigenous communities in east Arnhem Land and how that relates to existing Yolŋu Rom[73] including that for the use and management of fire and water.

> *Because we are confused because of so many stories that are given to us. And if we stick to our foundation and to our own beliefs and help build foundation after foundation to keep it strong together and help each other through that tow of water and which direction it come from, we'll come to a solution or agreement.*

> *Yeah, I know that there's lot of things to cover, water wisely, electricity wisely, but to my thinking, it has to start with whoever knows or the knowledge that is given to the people which can be passed down, talk to kids about the importance of power and water, why it's important, and how people before used to use it, because they connected to it somehow for the knowledge of survival, and how we can survive it and respect what is happening.*

Interviews with Yolŋu identified and clarified many enablers that represent strength and resources that, properly harnessed, could help Yolŋu to use power and water more efficiently. Some Yolŋu households have managed to develop systems to share costs fairly and call other people into account for using power and water wisely. As is arguably also the case in many urban communities, there remains considerable confusion among Yolŋu regarding where power and water comes from, how power and water works, and how the meter box and the power card, in particular the emergency credit, actually work.

> *It will take a while to adapt to it. It is good that we are taking this step to take upon the knowledge in order to pass it down to the next generation. If we know, understand it, it will be easier for them. When they are still at school they will learn the system as they are growing. Then they will have the knowledge of how to look after power and water wisely.*

> *Yolŋu is Yolŋu forever, until we die. So what we can do is to strengthen our power and to help each other to be able to lead each other both ways. You Balanda, you teach us, we teach you so we can have balance. Blood. But we can stand to talk and stand and then in our own foundation, I know.*

[73] *Rom* refers to the Yolŋu concept of law, kinship, story, songlines, arts, everyday habits, discipline and legal system.

*But therefore, today I talk strongly on that because I said the policy makers and whoever, the government, will hear our story. And it has to come from our heart, but that's deep and true story. They need to hear from us, you know, whether we understand that power and water or no, you know. That's all.*

Yolŋu expressed concerns about being left without power and find it difficult and stressful to pay for it. This is particularly the case for principal tenants and for money-earning household members because other householders and frequent visitors commonly rely on these people to pay for power. Due to high occupancy rates, including visiting family, negotiating how to use power and agreeing on who is paying in the household for power often leads to conflict. Power disconnections affect the immediate security and safety, health and comfort of Yolŋu, in particular the disabled and sick, who often depend on medical devices and are less able to move outside if fans and air-conditioners are not working. Moreover, medication storage, food storage and thus diet, sleep quality, hygiene and washing of clothes are all affected by extended power disconnections.

However, the analysis shows that Yolŋu prefer the pre-payment meter approach over the mainstream credit billing system. In comparison to family in Darwin who receive quarterly power bills, frequent purchase of power cards is preferred over substantial bills. This finding is supported by other research on pre-payment meters in Indigenous communities in Central Australia[74]. Yolŋu explained that they have adapted to the power card system by using their kinship system, using fires outdoors for cooking as necessary, and by developing alternative strategies to ensure that they have power cards when needed.

## 18.9 Pre-payment Meters and Disconnection Context

In Australian households, electricity is typically paid for after consumption following receipt of a bill from the power utility that provides the electricity. However, in some circumstances, pre-payment of electricity occurs. Electricity pre-payment operates via the use of pre-payment meters that are located on or near the household meter. Pre-payment meter technology generally displays a range of information, including tariff information and how much credit is remaining[75].

Use of pre-payment meters is fairly limited in mainstream urban Australia. However, these meters are deployed almost exclusively in Indigenous communities. Pre-payment meters are currently in use in the Northern Territory, Western Australia, South Australia, Queensland and Tasmania and are most common in remote, off-grid areas.

Pre-payment meters have been used in the Northern Territory since the mid-1990s. Northern Territory residential electricity customers can choose to be supplied through a pre-payment meter instead of a standard credit meter. In practice the majority of residential customers in remote Indigenous communities and in town camps within urban areas have pre-payment metering installed. In 2008 there were around 8500 pre-payment meters in use, which represented 15 per cent of the total residential customer base of around 55,000[76].

In the Northern Territory, electricity pre-payment currently occurs via magnetic card meters; however, this is changing with the roll-out of new meter technology commencing in late 2015. Power is purchased in the form

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[74] McKenzie, 2013. *Pre-payment Meters and Energy Efficiency in Indigenous Households*, Centre for Appropriate Technology, www.icat.org.au

[75] TasCOSS, 2006. *Pre-payment Meters in Tasmania: Consumer views and issues,* Tasmanian Council of Social Services. http://tascoss.org.au

[76] TACG (The Allen Consulting Group), 2009. *Pre-payment meter systems in Western Australia: Cost benefit analysis and regulatory impact assessment,* http://www.erawa.com.au

of single-use cardboard cards with a magnetic strip, which are sold at local supermarkets or service providers in Indigenous communities. Card values vary between $5 and $50, and the card is inserted into the meter and credit applied to the meter. Electricity can then be used up to the value of that card. If the credit runs out, the meter discontinues supply, which is often referred to as self-disconnection.[77]

Supply is reconnected by purchasing a new card. There is usually a small amount ($8) of 'emergency credit' available to be applied by pressing a button on the meter, and power is not disconnected overnight when power card vendors are closed (the 'no-disconnect' period). Once a new card is purchased, the amount of emergency and overnight credit that has been used is deducted. Meters normally display information about the value of credit available but little additional information.

The social service sector has long raised concerns over equity issues surrounding the use of pre-payment meters.[78] Despite this, little focus has been made on this issue in an Indigenous setting.[79] In those houses with pre-payment meters, self-disconnection is a major problem because households may disconnect many times per week or month, and utilities and support agencies have had no way of tracking these occurrences.

For customers with credit meter billing, disconnections due to non-payment are prevented or reduced through a variety of hardship programs and safety net payments, many of which are currently unavailable to pre-payment meter customers. Other equity issues include limited access to credit when stores are closed or over weekends, difficulty accessing concession programs and an absence of consumer information, including detailed billing figures[80]. Lack of information on current, historical or comparative energy consumption negatively impacts on a household's ability to track and manage energy consumption.

## 18.1 Pre-payment Meter Disconnection Findings

The project's power data loggers collected interval data that allows for identification of disconnection periods in the form of half-hour periods of zero power consumption. This is complicated by periods of zero consumption also being attributable to power system outages (the data loggers are battery powered and so do not differentiate between no system power and no customer load), the meter being damaged and awaiting repair, and to the house being vacated.

Looking at data for March 2014 to February 2016, periods of disconnection were found to be grouped into a large number of disconnections lasting less than one day, combined with a smaller number of disconnections lasting three or more days that account for 40 per cent of total disconnect time, as summarised in Table 30.

[77] Brutscher, P. 2011. *Self-disconnection Among Pre-Payment Customers- A Behavioural Analysis,* Electricity Policy Research Group Working Paper 1207. http://www.econ.cam.au.uk

[78] McLean, K. 2005. *Why APAYG is not the best option for people living on low incomes,* Tasmanian Council of Social Services - www.tascoss.org.au; also, O'Sullivan, K., Howden-Chapman, P. and Fougere, G. 2010. 'Making the connection: the relationship between fuel poverty, electricity disconnection and pre-payment metering, *Energy Policy,* vol 39, pp 733-741

[79] Office of Clean energy, 2008. *Data Analysis of Prepaid Meter User Survey in Remote Aboriginal Communities,* Strategic Edge Consulting, Subiaco, Western Australia; McKenzie, 2013. *Pre-payment Meters and Energy Efficiency in Indigenous Households*, Centre for Appropriate Technology, www.icat.org.au

[80] Ehrhardt-Martinez, K., Donnelly, K. and Laitner, J. 2012. Advanced Metering Initiatives and Residential Feedback Programs: a meta-review for household electricity saving opportunities, *American Council for an Energy Efficiency Economy,* www.aceee.org; also, Sharam, A, 2003. *Second Class Customers: pre-payment meters, the fuel-poor and discrimination,* Energy Action Group. www.home.vicnet.net.au

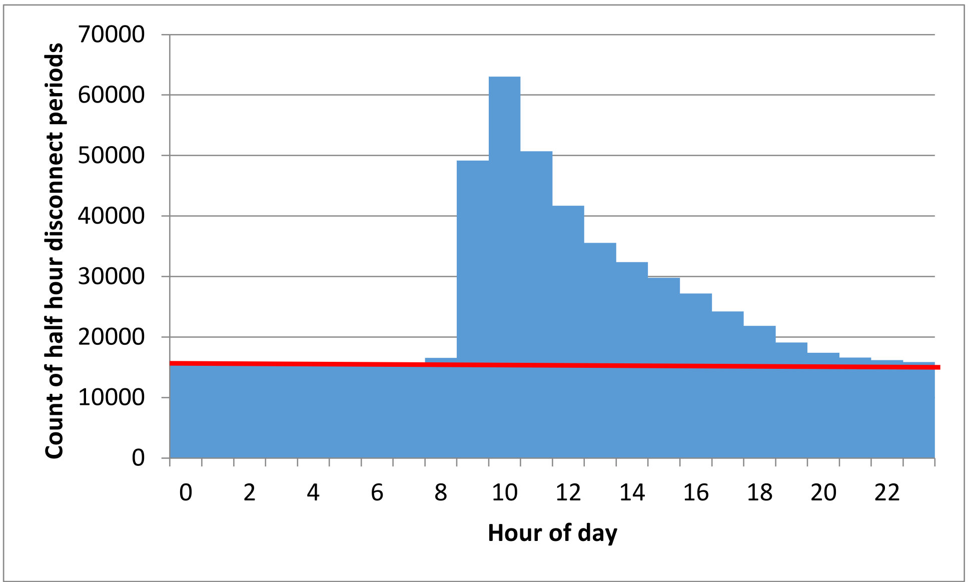
*Table 30: Lengths of disconnection events*

| Days spanned | Number of occurrences | % of total disconnect time | Average length |
|---|---|---|---|
| 0 | 48537 | 59.1% | 3.61 hours |
| 1 to 2 | 23 | 0.4% | 2.41 days |
| 3 or more | 741 | 40.5% | 6.8 days |
| **total** | **49301** | **100.0%** | **6.02 hours** |

The disconnections lasting less than a day for March 2014 to February 2015 (before the project was fully active) amount to an average of just under 40 minutes per day per house, or 2.7 per cent of the time, with some seasonal variation.

A view of all zero power readings in terms of time of day highlights the strong correlation of short-term disconnections, with the 9am end of no-disconnect period, as shown in Figure 11

*Figure 11: Disconnections by time of day (2 years of data, 5 communities)*




Households then are likely to have used emergency credit (which at $8 amounts to one day of typical use) to get through to the no-disconnect period. A $20 power card will last an average household around three days, which would equate to around two disconnections per week—7.5 hours at average length. This would equate to around an hour of disconnection per house per day, which is higher than the 40 minutes average. The data shows that a proportion of houses are regularly applying credit to avoid disconnection, but suggests that in the main the disconnect is the signal that prompts action to seek out and apply additional credit.

Additional discussion on the project impact on disconnections is presented in Section 21.3.

## 18.1 Maintenance of Housing And Appliances

A key contributor to good energy efficiency outcomes is appropriate maintenance of the home and the appliances within it. The results and learnings from this project highlight the importance of timely maintenance. In many cases, proper maintenance is more important than the efficiency features of the home or appliance itself because improper use and poor appliance condition lead to excessive energy consumption. Examples include leaking hot water systems and broken fridge seals. Maintenance problems can also lead to reduced consumption in the case of broken electrical hot water heaters and stoves (35 per cent of houses reported their stove at least partially broken in the barrier survey).

Because the houses participating in the project are community housing, responsibility for maintenance falls to the Department of Housing. Apart from periodic inspections by DHsg staff, the responsibility for reporting maintenance issues falls on the residents. Not all residents understand the system or are not comfortable to or motivated to report.[81] The project team identified early on that reporting processes for residents to advise that maintenance issues need to be addressed was important. The aim was to prevent YEEWs being seen as fixers for all housing problems, and this was mostly addressed by directing residents towards appropriate contacts within the Department of Housing, or having Yolŋu staff assist with required paperwork. As noted by YEEWs during the evaluation:

> *Also, we did a lot of helping the community by helping to fill out the forms, or how to go about reporting maintenance or damages. We used to give them, the main tenants, paper that they used to fill in, we helped them fill it in as well as helping people who don't know how to read and write, to do with the maintenance work and then we had to ring the Territory Housing and report the maintenance problem.*

Issues around maintenance of fixed appliances, such as hot water systems and stoves, were also important. In some cases, existing solar hot water systems were damaged and found to be operating only through the electric booster, thus consuming as much or more than conventional electric hot water systems. These findings informed the retrofit program, and one of the recommendations of this report is that decisions about retrofits need to be made with maintenance in mind; minimising maintenance failures is as important as the inherent efficiency of the appliances themselves.

For emerging technologies, such as solar heat pumps, it is also important that local tradespeople in remote areas are adequately trained and skilled in their troubleshooting and maintenance. Ideally, local Indigenous community labour should be used to install, maintain and repair retrofit devices and appliances. The sourcing and use of local labour is a key recommendation of this report. In this project, there was an initial perception that heat pumps were prone to breakdown and not suitable for this context, largely as a response to contractor perceptions of the technology and a lack of training provided to the industry. Training was subsequently delivered, and these concerns were then largely allayed. This reinforces the need to include consultation and upskilling of local industry in decisions around installation of new appliance technology.

## 18.2 Summary of Barriers Identified

**Housing stock and technology factors**

- limitations around the efficiency of fixed appliances supplied with government housing, particularly on older housing stock
- type and condition of hot water system
- lack of controls on some appliances, particularly for older housing stock
- number of air-conditioners and available control systems

[81] Christie, Michael 2010 Milingimbi Water: A report to the Power and Water Corporation from the Yolŋu Consultancy Initiative, Charles Darwin University, Darwin, Uniprint NT

- house size and housing supply
- thermal efficiency, passive solar design and general impact of older housing stock
- limited availability of efficient appliances available for tenant purchase.

**Social and cultural factors**

- social issues of overcrowding and family dynamics resulting in difficulty ensuring all tenants and particularly visitors and youth are factoring price into their consumption-related behaviours
- general impact of high occupancy and low per-person energy consumption
- Yolŋu perspectives of the role of power and water in their lives, culture and future aspirations
- retention of inefficient appliances due to cost of repair or capital cost of purchase of more efficient replacement appliance, and/or lack of information on the relative cost-benefits (this relates to both Department of Housing and residents)
- householder misconceptions and lack of understanding of energy concepts and drivers of energy consumption
- perceptions that non-Indigenous households (staff housing) and facilities (government and commercial buildings) use much more energy and are not subject to the same costs results in lack of motivation for Yolŋu to save energy (and water)
- lights being left on for safety or cultural reasons
- stoves, air-conditioners and other appliances being left running for potentially little or no energy service value.

**Other factors**

- remoteness of settlements increasing costs and limiting access to information
- pre-payment meter system
- climate – long wet season with thermal comfort levels continuously exceeded
- factors identified during original program design: information failure, capital constraints and split incentives.

In exploring the barriers that remote Indigenous communities face in achieving energy efficiency, the project uncovered several factors that are in fact barriers to *increased* consumption in these communities. The general finding of the project is that residents of remote Indigenous communities usually consume far less energy per person than people living in urban areas. The reasons for this include:

- low per-person income levels
- low levels of appliance ownership
- the pre-payment meter system acting as a limiter on demand
- lack of housing and smaller housing acting as a brake on demand through high occupancy and less appliances per person and/or less use of appliances, resulting in improving per-person efficiency in a narrow sense.

# 19 Evaluation of Community Engagement Approach and Recommendations

This section evaluates the community engagement approaches trialled through the project, discussing the key trials separately, from quantitative and qualitative perspectives. This addresses the second and third original objectives of the project: to develop and trial best-practice engagement and technology approaches to tackle identified barriers to effective energy and water use, and to monitor and evaluate measureable household energy efficiency improvements in participating households.

A key impact of the community engagement and education process is a better informed participant group. Householders' improved understanding of energy efficiency concepts came through strongly in evaluation interview results:

> *I switch off the washing machine switch, the television and the stove. When I go out, for example, for a funeral elsewhere, I turn the fridge and the washing machine off. If I'm at home all the time, everything is turned on because I am in the house. But I turn the stove off.*

> *Since I was told that day from the educators, I keep an eye on everything. If there's water running, I turn it off. I turn the tap off. If there's a fan going without a soul in the room, I turn it off. Also, if I get a $10 worth of power card, I turn the three air-conditioners off so that power will last us longer. Power will last us longer, until the next day until we get more power card. We use the air cons for a little while and then I tell them to turn it off. I tell the people if we all go outside, we have to turn everything off and make sure you use the chargers at night only and not during the day. That way, by communicating in one household, we are looking after the power and water.*

> *I get power card and it lasts me about a few days, maybe a week-and-a-half, before it runs out of power card. That is because I am doing what I – what information I've learned from the educators about power and water. And yes, my power lasts for two weeks, at the most. So we have been switching some of the power points off, turning off air-conditioners, fans. Even though when we go out, we turn everything off: the fan, the stove, the rest of the power points before we go out of the house*

> *This project has really helped me to use power wisely, not like before when everything was used anytime, any hour and now we have to be aware how much we are using on the washing machine and the stove, and not to use it so much. Not to use the stove or those devices all the time, use them as less as possible. The less we use them, then we'll still have some money left that we can hold onto for power cards and food as well.*

> *Yes, yes, I only use the air con only at night. Before I used to use the air con all the time, both day and night. I only use it during the night time now because nowadays I sit in the fresh air.*

What is clear from the trials and evidence gathered throughout this project is that there are several principles that should be employed to guide future community engagement projects in this sector. These are detailed further throughout the discussion section, but may be summarised in the following points:

- A tailored approach is required. Urban, non-Indigenous approaches will not work in this context.

- Indigenous staff and participants need to be central to the project design and delivery from the outset. Ideally, this would occur at the grant-writing stage, or at least prior to the contract being finalised.
- Engage a project partner with skilled and experienced staff—both Indigenous and non-Indigenous.
- Ensure that genuine community engagement is at the core of resource planning and decision making from the outset. Adequate resources are required to undertake community engagement that is purposeful.
- Understand how people in the community learn best and from whom; a peer-to-peer model is ideal.
- Concepts must be related to participants' existing worldview and build upon their existing knowledge and understanding.
- In this cross-cultural context, all assumptions must be questioned.

## 19.1 Indigenous Employment Approach

The success of the employment of Indigenous people was a key outcome of this project and will help ensure the continuity and spread of the energy efficiency message. Participant YEEWs noted:

> *It's Yolŋu delivering education to Yolŋu... you bring back to your people, to your family, to your community and if there are skills here at home, Yolŋu is the best person to deliver training to Yolŋu.*
>
> *That was really very good… idea to pick Yolŋu people to deliver the information… because the Balanda comes around and gives the information once, but we, as Yolŋu, we have more than one visit to a household or anybody we see on the street that we haven't seen, spoken to; we'll tell them about it. We, as Yolŋu people, make sure that everyone is covered by the story, by the information. We know that we don't stop there once we listen to a message. We keep on relaying the message and keep on talking about it.*
>
> *When I come back home, I still talk to the people about this and that and about the education; about how to look after power and water wisely. The education or the story doesn't end there. It is also during our off hours that we still educate the people within our own household.*
>
> *I do explain to my family, but it just makes me aware and this project has inspired me so I have to start talking to my family, try to explain to them and try to talk about it amongst ourselves, talk to them about it...*

In total, across all six communities, 92 Yolŋu energy efficiency workers (YEEWs), senior workers and supervisors were recruited and employed throughout the project period, along with two non-Indigenous supervisors and two non-Indigenous support staff. The total number of YEEWs recruited and employed at the start of the project was 67. The remaining 23 YEEWs were recruited, employed and trained throughout the project as additional roles or replacements for the 26 YEEWs who stopped working.

The higher number of Yolŋu recruited and employed indicates that Yolŋu are willing and available to take up suitable employment opportunities, and that the recruitment and employment strategies were effective. Across the communities, more male (n = 52) than female (n = 39) YEEWs were engaged. The flexible work arrangements helped participants meet their cultural obligations *and* project milestones. The YEEWs pointed out:

> *Here at Galiwin'ku, we had a big team. There was a lot of people in the team. If there was a funeral on, we would support each other and work out who would attend the funeral and who would not because of the work. Then another group would go the next day, just to pay respects to the person. Then just for a day or something and then go back to work the next day.*
>
> *We organised the team to do group teamwork within the community.*

The project was rolled out progressively across the participating communities to allow the project team to trial and refine the approach. The length of employment available in the final communities was limited by the project's December 2015 cut-off date for all trials. As a result, the YEEWs' length of employment varied considerably from around 22 months in the first community (Milingimbi) to about six months in the final community (Ramininging).

> *But what this project did was really helpful and useful. It helped us a lot. This project really helped us and the people of community. It went for a year and it's finished up December… We did our best and a lot of people know about the information. We have covered most of the people. The people know what we had been delivering - what information and messages we have been delivering to them.*

***YEEW project team at Gapuwiyak with ARDS trainer***

The number of hours the YEEWs worked in each community and the number of household visits also varied substantially due to differences in length of engagement, community size and number of YEEWs employed. In total, YEEWs worked nearly 25 000 hours across all communities, equating to about 6250 four-hour days[82]. The total hours worked ranged from 937 hours in Gunyangara to 6380 hours in Milingimbi.

The retentation rate of the YEEWs was high. A total of 80 of the 91 YEEWs completed at least 15 days of training at the commencement of their employment, to qualify for inclusion in the project's target for 'ambassadors trained'. This equates to 88 per cent of Yolŋu completing the training. In total, 26 YEEWs stopped working for the project prior to completion, resulting in a 71 per cent retention rate of YEEWs. This is

[82] The YEEWs were employed for a nominal four hours per day.

anecdotally a high retention rate for Yolŋu employees, and having this number of ambassadors trained across the six communities is a major achievement of this project.

Reasons for YEEWs ceasing work on the project varied and included difficulties in accessing reliable childcare, direct impact of cyclones on YEEWs' homes and individuals finding full-time work. The vast majority of the reasons cited for stopping involvement were beyond the control of the project, and therefore provide further weight to the assertion that the employment model was a good fit for the target employees.

> *Halfway doing the job, I left the job because of personal reasons. I had to do another work, but I did leave some notice stating that I really was interested and wanted to come back to that work, whatever happens.*

The teamwork in the project helped achieve the high retention, as pointed out during the evaluation:

> *When I started as an educator, I kept going. I did not pull out. I kept on going. I never found any difficulty in that area, working as an educator. Because whatever we found difficult, especially the educators ourselves, we came together and shared whatever difficulty we were facing. We did teamwork in helping and encouraging people who did not attend work during the day. We did not find anything hard. We found it really good. Because the sharing of the knowledge of the BEEBox and the meter box was a really good part of the job.*

The qualitative data indicates that the high retention rate is due to a combination of stategies. The YEEWs were actively encouraged to lead the implementation of the LIEEP project in their communities, to work as a team and work part time. Furthermore, YEEWs were supported by the project team, and for the most part, education was conducted in Yolŋu Matha by experienced bilingual trainers. The employment model helped the staff work within the cultural protocols while meeting project needs, as illustrated by the YEEW comment:

> *We've got an equal number of sexes in our YEEW group; there's five blokes and five women, but as we do our rounds to each household, we make sure there's always a lady and a bloke that goes to each house and deliver the message to the house owner. The other reason to approach a house to interview a person, it has to be a bloke, a man and a lady because we have the strong tie with the cultural issues about respect, about poison relationships, avoidance relationships that are so strong in our cultural background, that's why it's important… Also it is better to have a female and a male as well as the age brackets... they both have knowledge in some areas. The old person as a worker can help with the old knowledge of how it was used before, how fire and water was used before, and the young generation in that group as a worker can talk about the new system for the power and water that is being used today.*

YEEWs were motivated because they perceived the job as meaningful, the project was accepted by the community and met community needs, and Yolŋu were educating Yolŋu in their language. During evaluation interviews, the YEEWs commented:

> *I want to learn more and be trained so that I can carry on passing that message across to my people in the future.*

> *That's why we took this project so we can look after our people and give them an education, teach them, in our communities now. Because in the first place PWC used to come, they used to come because of the reason, water, but they never used to turn around and give a clear explanation of the water, what had to be done and financial-wise the cost of it, we didn't even*

*know. We were not aware of it. This project has really helped us so we can pass on the story to the people… on how to live and look after water.*

*[YEEWs] want to work, they want to stick onto this. They like this project, they want to stick in this project. They want to continue with their work on education…Now we understand that they're really all educators now.*

Enablers of the success of the employment approach included:

- the employment pay rates were selected to ensure that they were competitive with the existing payments through the CDEP, RJCP and CDP systems
- the employment of groups allowed for flexibility and meeting cultural commitments and family obligations
- short days and flexible hours
- design of training was specific to the project
- regular contact and support from the project team community engagement officers.

Towards the end of the YEEW employment period, the project also supported 13 of the 91 YEEWs (14 per cent) to study a Certificate I or II in Business Administration, a training opportunity that was initiated by and arranged by EARC. This training was seen as further building their confidence. Having a certificate to prove the skills to future employers is likely to increase their employment opportunities. Four YEEWs completed the certificate, and three YEEWs were part way through completion.

Recognising and arranging important add-on activities, such as school and other organisation presentations, added value to the project in the community where these were completed. These co-benefits were recognised by the YEEWs during the project evaluation:

*We [YEEWS] have gained that knowledge so we can give it out, we can share it out to all the people, even for the small kids that are still growing up so that the story will be passed down. Even those kids at school, they don't know about this story. Yolŋu schoolkids in every grade, they don't even know the story. That's why we have to cover the community such as the schools so the kids can hear this story too. They can pass it to another child or another adult who they can talk with others, the rest as well… It's also for the whole Yolŋu people to, you know, gain knowledge, acquire skills and support their kin.*

Throughout the Indigenous employment trials undertaken in this project, a number of factors emerged that could be considered a model applicable to other employment programs operating in remote communities. The combined use of these approaches resulted in employment and engagement outcomes that were critical to the overall success of this project. A recommended model for employment in this context should include the following:

- A recognition of the competing time and cultural obligations of residents of remote communities, including family commitments and time away for ceremonial purposes. These factors mean that part-time or casual employment is much more appropriate and likely to be successful than full-time employment.
- Employ an adequate number of part-time or casual staff to cover the required workload.
- The pool of staff should respect cultural protocols by including representatives of different genders, ages and clan groups. Selection of staff should be undertaken with the assistance of a local cultural advisor to help meet these needs.

- If employment agencies or third-party contractors are being used to manage the employment process, it is important that these factors be clearly specified into contracts.
- Workplace induction is important, especially for people who may be undertaking paid work for the first time. It should be conducted in local language to meet the needs of the employees.
- Indigenous staff should be empowered to lead the project implementation approach, with support from adequately skilled and experienced non-Indigenous staff.
- Employment outcomes are likely to be more successful if Indigenous staff perceive the project to be of real value to their community. Having local staff lead the deployment of the project can help achieve this objective.
- Appropriate resourcing needs to be provided. This can be a significant challenge in remote community settings, but it is critical. Enabling resources include uniforms, vehicles, office space and administrative support.

## 19.2 Training of the YEEWs

Previous sections of this report detail the evolution of the different methods trialled to train Indigenous staff in energy efficiency concepts and household visits. Through the trials across the six participating communities, it quickly became clear that proper training of Indigenous staff was critical for the energy efficiency message to reach households.

> *The training, to me, was really good because I was learning as well. Before I did the project or became an educator, I wasn't aware. I didn't even know about power and water. I didn't take notice of power and water before, until I did the project and join in as the educator. Then it started to open my mind and I could see – it started to paint a picture what power and water was all about.*

> *The training really opened up our minds because to be honest, we never even knew. All we knew is that there is a light, but we don't know where it comes from, how it is made, how it is transported and then we have a light. Never, ever heard about the history of electricity or the power.*

Staff needed to be confident in the concepts, the 'whole story', before being able to train their peers. In order to achieve this, training was conducted in local language by skilled trainers. The YEEWs pointed out:

> *In the training we did get a lot of help, which was really useful because the trainers were Balanda, white people that spoke our languages that came. They talked to us in language… How they went about the training, teaching us, was really clear because we did understand the way they had the training done to make us understand how to go about relaying the same information that we gained and deliver it to.*

> *Where I did really learn about the project is when the person, a Balanda - white person - who can talk in Gupapuyngu language was talking to us in Gupapuyngu language, explaining to us. That's where I really understood what it was all about and about the project.*

One of the key principles supporting community engagement in the project is 'two-way learning'. Two-way learning is a principle that has been embedded in the framework of knowledge relationships between Yolŋu people and others for more than a decade.[83] For the project's education approach, this meant that training respected cultural foundations of power and water, and much time was spent by trainers on these foundational ideas[84].

The training included visits to power and water facilities in community, which was appreciated. Visiting the power station and having the power station explained to them enabled the YEEWs to make connection between, for example, the diesel barge and the power station. The YEEW feedback suggests that the training would be more effective if it involved more activity-based learning[85].

Formal training was complemented by opportunities for YEEWs to share their learnings with other YEEWs:

> *It's really good when other people [YEEWs from other communities] come in and share their experiences. That's really good to share, support each other in the sharing. People really good at… sharing their experiences, for example, at Gapuwiyak, Ramingining, Milingimbi and Yirrkala and Gunyangara. In a way, we're supporting and helping each other once we are sharing these stories. People like at Lake Evella, Milingimbi, Ramingining; we all share our experiences of how we do it and how we go about it before we're sitting the house owners in each household.*
>
> *Sharing amongst ourselves with the workers from each community was really helpful. It really did help us in a way in looking at other communities, how they went about doing it and so forth.*
>
> *Yolŋu do use their power and water quite frequently and maybe take it for granted, really it's a new resource to Yolŋu, maybe within the last say 60 years, I think it's pretty new, so it will take a bit of time.*

A summary of the key factors that contributed to the success of the staff training in this project include the following:

- Training must be conducted in local language.
- The content should be planned and structured to meet the needs of the target group, starting with a complete explanation of the motivators for its delivery.
- Context should include the foundational concepts of power generation and distribution and the existing Yolŋu understandings of power and water.
- It should commence with practical training that can be put to immediate use and built on over time. Accreditation should only be included if there are clear links to likely future job opportunities.
- Training should be as practical as possible.

## 19.3 Household Engagement and Education Approach

Across the six communities, YEEWs approached a total of 564 of the 633 eligible households, equating to 89 per cent of eligible households having been engaged by the project (excluding the 30 transitional houses that were built and installed with data loggers in Galiwin'ku late in 2015). Typically, only the principal tenant rather than household members were approached for various reasons, including the cultural appropriateness of speaking to the 'house boss' first and the high levels of mobility of residents. Limiting engagement to the

[83] See the various key forum reports of the Garma Festival held at Gulkula in August each year and produced by the Yothu Yindi Foundation.

[84] Refer to the implementation section for more discussion on this topic.

[85] This approach is consistent with the Yolŋu systems of learning by doing, observing, modelling, and correcting.

principal tenant meant that while the project exceeded its objective of engaging over 80 per cent of the community households, it is more accurate to say that the project engaged over 80 per cent of principal tenants.

YEEWs conducted 2779 household visits in total[86]. The average number of times a household was visited by the YEEWs was 4.4. The average number of household visits varied between communities. A total of 2.4 visits were achieved per household in Galiwin'ku, while in Gunyangara an average of 8.2 household visits were reported. A total of 533 appliance surveys were conducted with households. A total of 589[87] houses received some aspect of energy education during 2254 visits. A total of 463 houses received water education spread over 666 visits.

The YEEWs preferred to do the household visits in teams. Depending on the numbers that attended each day, they would either split into smaller groups or go out on the household visits as one large group. Doing the household visits in teams was especially important during the earlier household visits as they were building up their confidence.

On the whole, feedback from household participants about this project was extremely positive. Residents viewed the project as well-needed, helpful and useful. In strong contrast to many projects conducted in Indigenous communities, it addressed a real need in ways that were culturally appropriate, respectful and responsive.

> *I was very grateful for the Yolŋu energy efficiency workers that they came around to my place and did the educating about the power and water because I was not aware of all this before.*
>
> *Well, I used to never think about how much usage of power I was using. Everything was on. The fan and everything was left on and we used to go out to a card game and after when I heard about the information that was given that they were talking about then it made me realise how much power and water I was going through and now I make sure I don't use so much power.*
>
> *The educators have opened our minds to using big devices and how to use it. Things such as fridge, washing machine and other smaller electrical appliances, and they have also helped us, bringing us the message and helped us how we are going to save money and power. It's good that they do the rounds around the community telling us the message.*

In particular, the communities appreciated that the project:

- explained how power and water works, how to use power and water wisely, and how the provided devices function
- employed local Yolŋu in meaningful jobs that helped people in their community and educated them to help Yolŋu rather than non-Indigenous people doing that work
- delivered the education in Yolŋu Matha to the Yolŋu using a team of Yolŋu and non-Indigenous educators rather than non-Indigenous people delivering training in English
- responded to the expressed needs and ideas of Yolŋu and adapted in response to feedback
- had the project team repeatedly coming back to the communities to support the workers.

[86] The numbers of house visits are inconsistent and possibly over-report the number of house visits due to issues in classifying the content of visits and reporting issues. See results for a more detailed explanation.

[87] More houses than approached (564) having received energy education visits (589) is related to pre-participation visits such as notification of upcoming retrofit installations being classified as energy education due to these visits potentially involving discussion on energy concepts related to the retrofits.

These features of the project addressed concerns identified in the pre-project interviews—most importantly that non-Indigenous people generally do not explain the new services provided to Yolŋu or explain it in ways alien to Yolŋu.

> *It's good that they [YEEWs] talk to people in their own language. Because if a white person talks to them about these things, they don't even know. They can't understand.*

> *Sometimes people or Balanda come around and explain things that some people don't understand, because of the language barrier.*

As a result, the community members perceived the project as 'doing the right thing' and thus increasingly trusted the project and supported the project. The very high participation rates attest to this. More Yolŋu now have a better understanding of how power and water works and how to use power and water more wisely, reducing disconnection times and saving money.

> *When YEEWs came around, whenever they were bringing all the information—that really went into my brain. It penetrated. I received the new information. It was so inspiring and exciting to me.*

> *All this education that was going around—that was really good; really useful and helpful. And I thank you mob for reminding us, helping us how to look after power wisely—how we can help ourselves look after power wisely. Thank you for reminding us, for supporting each other, helping each other power-wise and contributing towards paying for the power.*

> *What I found was this project was this project really helped me a lot to do with water and power. This project has really opened up my mind, so by the time this year has ended and we go into the new year, I know how to look after power and water wisely. It also opened my mind to anything else and everything else as well. Financially and how to go about doing the right way of spending my money and always be alert and aware [about power and water use]. I personally saw that this project was really helpful. It has helped me a lot, how to look after power and water and teach the new generations because they will be the future.*

> *When the educators came… they were also talking about the usage of power and water wisely. So we took their word and we started to act on it. We started turning off the lights and the water in the bathroom, the stove and the fan and other electrical appliances that were using power.*

> *There were a lot of changes we saw after going around each household. We saw a lot of changes that were happening, even people who were going to another community for a funeral or somewhere else, we would see their place and everything off, the place looked dark. Now they were learning more of looking after power and water wisely and how to look after power and water wisely.*

Despite the overall positive view of the project, participants and YEEWs articulated several factors that limited its impact. Some of these were factors that were being addressed in the evolution of the project such as the changes in the training approach. Householder feedback included that they had not received an understanding of the underlying motivators for the project. As one YEEW pointed out:

> *Before everything else, we had to explain to the household, what's the reason for us; who we are and what we are bringing. All of this has to be open and clear as possible to the household,*

*the owner or the residents. Everything has to be clear before we proceed. We have to tell them all there is without hiding anything. That way they can always trust us next time and be ready to participate with the interview, or eager to participate to do with the project.*

Many other factors were beyond the control of the project team and were factors that were obvious from the outset, namely, that the project:

- was top-down, driven by the needs and interests of non-Indigenous Australians rather than being community-initiated
- was limited to a three-year window for planning and implementation, rather than taking a long-term approach
- focussed on only one issue rather than holistically considering existing problems and also the strengths inherent in the communities
- did not address systemic issues of importance to Yolŋu, such as community stores selling inefficient appliances or the lack of Yolŋu employed as maintenance personnel
- focussed on power consumption of Yolŋu rather than also considering power usage by non-Indigenous service providers (e.g., police, schools, clinic) and by non-Indigenous people living in communities
- did not follow the Yolŋu traditional approach of passing knowledge directly from the owner of that knowledge to those who need it; instead the project passed knowledge from the project team through non-Indigenous trainers to Indigenous trainers and interpreters to the YEEWs and then to householders
- focussed mostly on the principal tenant rather than the entire household and many visitors.

**Milingimbi house visit to introduce the BEEBox**

The desire for staff and households to participate in a long-term project came up many times throughout the project. This was both from the householder and the employee perspectives identified during evaluation. The following quotes illustrate this common sentiment:

*I want to say to those who gave the funding or the people who organised this project: I would really want this project to be a long-term project because we don't really know, we don't really understand what it's all about. We're just learning about this, how the power works and also we are on a smaller income as well. Also there are a lot of changes happening as well, other changes that are happening… the knowledge that we're getting is not enough and we don't* *even really know. There are also new houses going up, who will be the educators for those people that will be getting the new houses? The education doesn't stop there because there's the new generation as well… So if there's any more funding, we would like that to continue, continue the education. When I say for this to be an ongoing project or to be permanent, it's because we... want to learn more about it. We don't really understand it because it's very new to us.*

*We want more education; keep it going until we really understand what it's all about. Not only once, get education once, but maybe three or four times a year, that way you have to keep on reminding yourself.*

*We had to find our way, our path to understand it because this is not what our ancestors used to live by, this is a system that has just started recently.*

Based on the trials undertaken in this project and feedback from participants, the following recommendations are made regarding education and behaviour-change projects in remote Indigenous communities:

- Energy efficiency education in a cross-cultural context should be delivered in local language, by local people.
- Recognise that household electricity consumption is an enabler for livelihood, health, safety, improved comfort and entertainment outcomes. In this context (bearing in mind the current low relative per capita consumption), the focus of education must be on assisting people to make informed decisions about efficient use rather than a uniform 'use less' message.
- Understand the hierarchy of needs and competing priorities in the lives of participants, including overcrowding, unemployment and access to services. These factors will affect people's priorities for participation.
- Similarly, it is useful to link energy education to other motivators for change, including health and safety co-benefits and sustainability outcomes.
- Education needs to be designed and based on existing knowledge and belief systems. Allow sufficient time and consultation in community to achieve this.
- End-user training is as important as any technology retrofits themselves—engagement should happen early in order to achieve best outcomes.
- Ensure that households do not feel targeted while other community groups are excluded from education programs. Similarly, include a range of targeted approaches to cover the different needs and priorities within the community, including both genders and all age groups.
- For efficiency and economies of scale, combine energy education with other programs (money management or health) to achieve economies of scale.

## 19.4 Educational Materials

Building on the consortium's experience of working with remote Indigenous communities on energy education, significant consultation and effort went into producing educational resources that were meaningful and useful for the participants. The project's primary educational tool both for the workers and for households was a poster kit with high visual appeal and minimal text (example in Figure). During evaluation interviews, participants made the following comments about the educational materials used in the project:

*I did get the information from the educators, but when they were talking verbally. The minute they showed posters and pictures, then we came about to understand the information that they were delivering and about everything to do with the housing as well.*

*All the posters and the pictures, the information that they were delivering, showing us, that was all very useful and helpful.*

*They were talking to us and also they were showing us pictures. Pictures of a mobile phone, fans, air-conditioners, and how many power that these devices use. And what the book did was really open our minds.*

Additional feedback on the poster kit included that there was some confusion regarding how much power costs, as some posters presented it as a weekly amount and other posters over a 24-hour time period. A more consistent approach would have been beneficial.

The project also produced a set of videos where the YEEWs explained the project in their own words. These are available on YouTube as an ongoing legacy of the project.

***Figure 12: Using power in a good way poster from the project poster kit***

# 20 Evaluation of Technology Trials and Recommendations Emerging

The project included trials of a range of appliance and energy efficiency retrofits. These are discussed in two sections.

First, the energy efficiency retrofit technologies, which include major retrofits like ceiling insulation, solar hot water systems and heat pumps, and minor retrofits including stove timers, efficient bulbs and appliance control devices.

The second section looks at the in-house displays where the impact on energy consumption depends on educational benefit. The in-house displayfor this project was a specially developed device called the BEEBox targeted to meet the needs of remote Indigenous community residents.

Due to the project's saturation approach, a number of households received combinations of the trials, with the bulk of households also receiving energy efficiency education visits from the YEEWs. In addition, the community of Ramingining, which was initially envisaged as serving as a 'control', was eventually included in the project's trials in full. The ability to rigorously identify the impact of individual trials and confidence level of the analysis results is therefore limited.

During retrofit and BEEBox installations, YEEWs either visited each household prior to installation and/or during installation to ensure the resident was aware of the work and understood what was being installed and why (this was important even if the household had opted in to the installation previously) and to provide some education on the benefit of the technology.

A key learning from the technology trials overall was that when working with external contractors, it was important that they are aware of project requirements for respectful community engagement with YEEWs and householders. This takes time that needs to be budgeted for. Contractors not based in a community will cost their competitive quotes based on a time efficient approach to minimise mobilisation costs, aiming to complete the job and leave in as short a time as practical. It is therefore important to ensure there is explicit provision for community engagement stand down time in contract pricing.

## 20.1 Energy Efficiency Retrofits

The project undertook a significant retrofit program across all participating communities and included installation of major and minor retrofits. A summary is presented in the table below.

*Table 31: Number of major and minor retrofit installations*

| Retrofit category | Description | Number of installs |
|---|---|---|
| Major | Solahart 302J thermosiphon hot water system | 114 |
| | Quantum 340L heat pump system | 87 |
| | Ceiling insulation R3.5 pink batts | 47 |
| Minor | Custom stove timer | 209 |
| | Heater Mate 'Cool-bro' thermostatic controller | 16 |
| | Eco-switch standby power control board | 12 |
| | LED 18W PAR-38 floodlight replacements | 13 |
| | **Total retrofits** | **498** |
| | **Total number of houses receiving a retrofit** | **448** |

Discussion around the various technology trials included below forms a strong evidence base for future projects working in Indigenous communities in the tropics.

Interestingly, while retrofits were a specific discussion point to be raised by the research team, interviewed residents said little about the retrofits, apart from the BEEBox. This low response rate could be due to a number of factors. Some of the retrofits, such as insulation and hot water systems, are not visible in day-to-day energy use and therefore not recalled at the time of interview. Additionally, the principal tenants may not have been aware that the retrofits were part of the LIEEP program but thought they were a Department of Housing program. Of all retrofits installed by the project, solar hot water systems and stove timers were most frequently discussed in evaluation interviews.

Key participant feedback related to the BEEBox in-house display, which was a strong focus of household training and a visual device installed into people's living space. This dominated evaluation interviews and is discussed subsequently.

## 20.2 Major Retrofits: Insulation, Solar and Heat Pump Hot Water Systems

### *Ceiling Insulation*

Residents did not report any feedback on the ceiling insulation installed through this project. Ceiling insulation was assigned to older houses based on the presence of at least one air-conditioner and a suitable ceiling space, not through offer and acceptance by the occupants (although notification was provided in person, in language, to houses receiving insulation as per other retrofits).

This assignment process resulted in installation in a narrow section of the overall housing stock. Analysis of the impact of this retrofit was complicated by the lack of rigorously matched control houses with equivalent data logging.

Initial analysis against the broad group of housing did not show any comparative savings. A more targeted analysis was completed by utilising data through to April 2016 and comparing consumption before and after the installation to that of houses with comparable build type and importantly a comparable number of air-conditioners (but not matching by occupancy or other factors).

The limited analysis showed a saving of between 1 and 4 kWh per day was achieved after installation, depending on the batch and time of year. While not a high confidence analysis, this forms sufficient evidence to suggest that a saving of around 2 kWh per day averaged over the year was achieved by the ceiling insulation installation.

The cost and difficulties of retrofitting as well as maintenance concerns around loose ceiling batts do not provide a strong recommendation for further roll-out as a retrofit to older buildings, but it does support the case for providing ceiling insulation in new builds where air-conditioning is likely to be installed.

### *Solar and Heat Pump Hot Water Systems*

Hot water system upgrades represented a significant part of the project, with 201 houses receiving an upgraded unit; either a Solahart 302J thermosiphon (114 houses) or a Quantum 340L heat pump (87 houses). The upgrades were in place of a range of pre-existing units, including the replacement of 90 electric hot water units and around 100 aged solar hot water units.

The upgrades were exclusively on older housing from the ‘refurbished’ or ‘legacy’ categories identified through the NPARIH housing program—the 250 new houses delivered by NPARIH in the participating communities had relatively new heat pump or solar hot water systems already in place. A significant legacy of the project is that almost every house in the project’s scope now has an efficient solar or heat pump hot water system in place.

Analysis of the energy data shows that the heat pump retrofits, which were predominantly replacements of electric hot water systems, achieved an 11 per cent reduction in household energy consumption, saving households an average of 2.8 kWh per day.

The solar hot water system upgrades, which were predominantly replacement of ailing existing solar units, achieved an average 8.5 per cent reduction in total household consumption, saving households 1.7 kWh per day.

The savings estimates from solar hot water system upgrades should be interpreted in light of several factors that were not measured through the project. First, some of the replaced electric hot water and solar hot water units were faulty to the point of not drawing any power before the upgrade. This would reduce the overall energy savings that could be measured. Second, the solar to solar upgrades are expected to achieve a smaller saving than replacement of electric hot water systems due to the potential for some solar energy input still being delivered by the pre-existing system[88]. Third, water leaks had the potential to be accounting for a high energy consumption of the pre-existing units that were still electrically functional.

From the participant perspective, householders felt that the solar hot water system was an improvement over the electrical hot water system. In particular, they appreciated that their hot water was now generated by the sun and recognised that they are saving power and money because of them.

> *That one [electric hot water system] is being controlled by the electricity and the other one [solar hot water system] is free, the Solarhart is getting energy from the sun and they’re both used to make the water hot. The Solarhart is free because it’s getting energy from the sun.*

Most householders believe that they understand the solar hot water system, but a minority did not. Participants living in households with a new hot water system reported that it added to their quality of life because people living in the household were now able to have a hot shower or a hot bath in their own house. They no longer were forced to have cold showers or use the house of a kin to have a hot shower.

Based on the energy efficiency outcomes and findings of the evaluation, solar hot water systems and heat pumps are recommended as an energy-saving measure, particularly in replacing existing electric hot water systems and older solar units. These decisions should be made by with reference to an evidence base indicating the demonstrable lifespan and maintenance requirements. Further detail about the roll-out and energy consumption of these systems are in the results section of the report.

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[88] Refer for example to findings from the Alice Solar City Final Report – Residential Solar Hot Water (www.alicesolarcity.com.au/research-and-reports, where solar to solar upgrades achieved similar savings that were lower than savings achieved by comparable electric to solar upgrades).

## 20.3 Minor Retrofits

### *Ecoswitches, Heater Mates and Efficient Floodlights*

Quantitative analysis could not be conducted for the small number of standby power control and thermostatic control appliances (Ecoswitch and HeaterMate) that were deployed because they were all deployed to houses that also received a major retrofit. They generally had little buy-in from the YEEWs and residents and were not commented on during the evaluation interviews. The standby control switch concept was of little relevance to the participating households, who generally had few appliances to which they could be applied.

The thermostatic controller was conceptually difficult and imposed a start-up delay on use of the air-conditioner. They are, therefore, not recommended as a priority in further energy efficiency projects in this context. An opportunity exists to trial alternatives such as timer buttons or a more appropriate feedback indicator and/or controller.

Most participating households already had efficient bulbs installed as standard in their homes, and damaged bulbs had already been replaced by efficient bulbs purchased from the local store. No energy savings are able to be determined for these as a retrofit from this project.

The project made limited in-roads into the topic of controls for lighting, particularly outdoor lighting, which is observed to be left running in some houses during the day. A plethora of control systems with limited labelling and explanation is likely to lead to confusion and incorrect use. This therefore remains an opportunity for further investigation, education and potentially retrofitting with alternative, more suitable controls.

### *Stove Timers*

Reports from residents and the DHsg indicated that the average life expectancy of electric stoves in participating communities was less than 18 months, with the barrier survey finding 35 per cent of stoves were faulty. Householders expressed concerns of stoves being left on for long durations by house guests or children. Given the significant contribution that electric stoves make to household energy consumption, timer switches that turn stoves off after a set period were selected as a useful retrofit in this context.

A suitable off-the-shelf option was not available that had the required functionality, so the project designed and commissioned the building of a stove timer for use in the project. The implementation section of this report provides a detailed explanation of the process of designing and deploying stove timers and the lessons learned through the process.

A key finding and lesson from the stove timer trial is the importance of using technologies that are tried and tested in communities. Remote communities, with challenging consumption profiles, extreme weather and distant from most qualified tradespeople are not the ideal location to trial technologies. Despite good performance in experimental conditions or even urban areas, the rigors of community life mean that devices should be robust and very well field tested and with adequate local technical support before they are rolled out into these locations.

Analysis of the relative before and after energy consumption of batches of the 70 households that received only a stove timer, in comparison to houses without a technology trial over the relevant period, showed a range of savings. Initial calculations suggested savings of 3.1kWh per day on average; however, further work with different controls and additional data resulted in a figure of 1.35 kWh per day on average. Further analysis with longer-term data will assist with confirming this quantum, but it is clear the devices achieved measurable savings for the group of houses that opted to have the technology.

Qualitative findings showed that householders who had a stove timer installed believed it was both a good way to monitor their power and remind them to turn off the stove. In particular, they value that the stove timer turns the oven off after a certain period of time.

> *I really liked the stove timer part because when I'm cooking something and I'm busy with other things, it tells me—the stove timer tells me when the cooking is finished. If I'm doing washing or I'll go shopping, the stove timer tells me when the cooking's done. It automatically stops.*

> *It [the stove timer] is very useful. It helps us so that way we cannot use the stove all the time because the stove timer, it only lets you use the stove for an hour and if you want to use it again, you have to turn the switch on and turn it off after you have used it. We turn the stove on only when if we really need to use it, but if we don't, we turn the switch off altogether.*

Residents reported that the stove timer reminds them to only turn the stove on when they need it and to switch the stove off when they had finished cooking. Participants living in households who had the stove timer installed valued the device, believing it helped them save power in the kitchen.

> *One thing I found out about the stove timer is if you cook something for too long, the stove turns itself off. The people with the blue uniforms told me about the stove timer before they gave me the stove timer, they explained to me what the stove timer was all about. The stove timer to me is good as well. It's really good because it's useful too. They told me about it, how to use it and when it gets really hot, it turns off by itself.*

However, responses indicate that some participants are confused about the purpose of the stove timer and that the stove timer might increase power usage and ironically be a health and safety hazard. Some households believed the stove timer might waste power, as they believe that they have to wait for the timer to switch off the oven rather than switching the oven off themselves. Yolŋu sometimes need to turn the stove timer on again and the second round is typically longer than they would usually need for cooking.

Interview accounts also suggest that the stove timer might lead to undercooking meals. It seems that when the timer turns the stove off before the meal is cooked, some Yolŋu do not turn the stove timer on again because they believe that they have cooked food long enough. In addition, some participants thought that the stove timer turns the stove off when the stove gets too hot. Some householders questioned the purpose and usefulness of the stove timer. Other householders perceived the stove timer to be patronising.

Concerns were expressed in some of the qualitative interviews that not all houses had received one that needed this technology.

The interview results suggest that the stove timer helps people when they forget to turn the stove off, but conclusions cannot be made as to what change in circumstances and behaviours was leading to the energy savings identified—specifically whether it was addressing the anecdotal barrier of the stove being left on by casual users, including visitors and children, or whether other factors identified above were more significant.

## 20.4 In-House Displays - Beeboxes

Prior to its implementation in east Arnhem Land, the BEEBox was trialled in 30 households in the Utopia homelands of Central Australia. During that trial, residents also reported high levels of satisfaction with the devices and resulting decrease in frequency and duration of disconnections.[89]

Through this project, a total of 252 houses received a BEEBox installation after it was offered to households by the YEEWs in combination with some level of energy efficiency education.

Reports from end users indicate that BEEBoxes have improved householder understanding of appliance consumption and their ability to manage periods of high energy use (with extended visits by family groups, for example).

> *What I've seen in my family's household is that the device is really helping them power-wise and what you have introduced to the community [the BEEBox] that is really good for the community.*
>
> *I need the BEEBox. Because sometimes I put the TV on, the fans, the lights, I don't know how much power I am using. Anything that I use, including the water, how much water usage I have, unaware of how much I am using.*
>
> *I keep an eye on the BEEBox all the time, check the BEEBox all the time whether the colour changes*
>
> *The BEEBox's purpose was to indicate how much power we use, and it tells us, where the meter box never told us anything.*
>
> *Then the BEEBox came and we then realised just by looking at it as the indicator changed that means it was using too much power. We started turning all the switches off and then the indicator light turned green on the BEEBox.*


***BEEBox demonstration display kit connected to an electric jug***

[89] Source: CAT

Most Yolŋu who received the BEEBox found the device beneficial. It assisted them to use power wisely by showing them when they had used too much power and prompting or reminding them to turn off appliances, especially lights. The BEEBox has made it easier for households to monitor their power usage because it indicates to them how much power they are using per day and whether they are using too much power. These indicators are useful in helping Yolŋu to be aware and stay alert regarding their power usage.

> *With the indicator colours on the BEEBox, they [YEEWs] did explain it to me clearly and I did understand what they were talking about, about the green light that everything that I'm using is alright—I'm using less power.*

The visibilty of the BEEBox to all householders has helped householders to learn about using power wisely, to watch their power usage and to contribute equitably towards paying for power. Some participants did not see changes in their power consumption; whereas other participants reported that they are saving power and their power cards are lasting longer.

> *The other thing is we have the communication just in the one household is getting better because of the indicator lights, especially when it's orange. That's the time when we communicate. Especially power wisely. Before something happen, we ask each other who is going to buy power cards. Not only that, but we also ask if anybody has to go around to the back and see how much credit we've got left. That's when we can know whether to get new power card or not. Just switch the switches off. The orange indicator makes us alert so we have to see what is happening. It makes us check everything. Make us go around check the credit as well. It makes us alert.*

Some YEEWs reported that it was a useful talking point for delivering energy education.

> *When we give education, we use their appliances in the house. If they've got a toaster, stove, microwave or any other power point appliances. For example, we just put them on. Turn them on all and then you can see the power speed on here, it just comes and then we tell them you're using too many power in your house. For the first day, they find it really hard, in maybe two or three weeks they start to understand, yeah. When we do our second house visit, we get the feedback from them.*

## *Energy consumption Impact of BEEBox*

Analysis of the household energy data using Before-After Control-Impact is detailed in Appendix A. The analysis showed conflicting results, with analysis for some batches of houses that received a BEEBox indicating a saving of over 7 kWh per day, while other batches increased consumption by an average of over 3 kWh per day. On average, a small saving of around 0.6 kWh per day was observed from the combination of the BEEBox and associated education for an initial period after installation.

### *1.1.1 BEEBox impact on disconnection time*

A comparison between 2014 and 2015 for houses with a BEEBox installed and houses without a BEEBox showed a reduction in the number of disconnection hours in all houses. However, houses with a BEEBox reduced by a greater amount (14 minutes less per day) than houses without a BEEBox (two minutes less per day). In other words, the BEEBox houses reduced disconnection time by an average of 12 minutes per day more than baseline.

The data extracts from the BEEBoxes in Milingimbi showed that the BEEBox in-house displays were left turned on for the majority of houses (median house was 97 per cent on-time), and the qualitative interviews showed that a number of residents were responding to the signals:

> *Also this device, the BEEBox, it lets me know to be always aware. I have to be always alert… It indicates, letting me know. It has helped me a lot by letting me know that I have to be always alert, when the colour changes to orange or red, that's a warning signal that I have to turn everything off. Also it tells me that I have to go and get a new power card as well.*

The BEEBox informational display improved household awareness of credit consumption and prompted more rapid procurement of more credit, thereby reducing disconnection times.

### Challenges of the BEEBox

A number of problems and challenges were identified by residents relating to the BEEBox. Most of them relate to misunderstandings or problems in the communication process. These findings reiterate the importance of a simple in-house display that is supported by strong training, follow-up and support.

Findings of the qualitative interviews included:

- Some residents reported not knowing about the BEEBox at all.
- In some cases, only the principal tenant was approached and educated about the device, at the exclusion of others.
- Some YEEWs did not explain the device adequately; perhaps because of deficits in their own training.
- Some Yolŋu did not understand the purpose of the BEEBox or how it worked, resulting in inaccurate stories circulating throughout communities.
- There seemed to be a general lack of awareness that the BEEBox measures power consumption against a pre-determined budget.
- The red light function on the device triggered anxiety and distress in some Yolŋu.
- Some residents ignored, forgot about or switched off the BEEBox.
- Some households who had the device removed were confused about the reason and resorted to pre-existing power use (a total of six BEEBox displays were removed at household request, with an additional eight removed from houses damaged during the cyclones).
- Some householders that did not have a BEEBox believed that, as a consequence, they couldn't save power
- There were a small number of residents who said that YEEWs did not ask for permission but told principal tenants that the BEEBox would be installed
- A number of households interviewed expressed concern about the ongoing maintenance responsibility for the BEEBox.

Several key findings arise from the challenges associated with the BEEBox.

As with all technology retrofits, it is critical to approach and notify the householder in a culturally appropriate way prior to installation and provide training to residents on the 'rules' of that appliance.

Despite the best efforts of the YEEWs and community engagement officers to train and educate appropriately, misunderstandings about the BEEBoxes remained with some residents. Consequently, recommendations relating to the in-house display include:

- consumption feedback displays need to be simple and relate directly to the energy meter

- a strong and relatable story about in-house display use and meaning needs to be developed that resonates strongly with residents
- related training needs to build awareness of underlying concepts, including budgeting.

There were some delays in the supply and installation of BEEBoxes, and this was compounded by the need to establish and train the YEEWs and recruit households before the BEEBox could be offered. As a result, initial installations were completed in haste in order to meet milestone targets.

It is recommended that future deployments allow for the delay in household recruitment and deploy a small number, initially to YEEW households, to facilitate their training and experience with the device.

### *Household Recruitment for BEEBoxes*

Once the YEEWs explained the BEEBox to householders, the majority of them accepted the BEEBox, but a few initially declined to have it installed. The main reasons for accepting the BEEBox was that in contrast to the meter box, because the BEEBox is installed inside the houses, it gives a visual indication of how much power is being used and when a new power card is needed. Those householders who declined the installation of the BEEBox did so through a combination of unfamiliarity, lack of understanding its purpose and distrust in the motivation behind it. Furthermore, there were concerns that the BEEBox could cause a house fire or lead to power overload. Some participants were offended because they perceived the BEEBox implied that they could not manage their own power and water usage.

Given the limitations of the trial, there were a set number of BEEBoxes available to be installed. This meant that there was not enough for every household, and various selection processes were undertaken to attempt to ensure equity. Unfortunately, the limitations did cause conflict, upset and anger among some households who wanted but did not receive a BEEBox. Some residents thought that they would receive one but did not. Residents reported that at the completion of the project, some households were still hoping to receive a BEEBox.

### *Other BEEBox Findings*

The BEEBox was not designed to connect into the existing pre-payment meter technology in place in the project communities in order to receive consumption data or to receive information on the credit status of the meter, as the meters do not have a suitable electrical output for this function. This limited the ability for the BEEBox to relay information directly relating to the credit status of the meter, but instead provided a total daily consumption, which was a fundamental source of confusion for participants.

During the roll-out of this project, a new type of 'smart' pre-payment meter was being trialled and scheduled to roll-out across all remote communities in the Northern Territory. Future iterations of the BEEBox will ideally interact directly with the meter for a more seamless operation.

Installation of the first batch of BEEBoxes so close to the end of the year in Milingimbi was not ideal, as during the Christmas period, most of the project staff and workers were on leave. This meant that post-install engagement was delayed by a significant period.

In Ramingining, the overall experience of BEEBoxes seems to have been positive, but in the later stages of the project, three households requested the removal of the BEEBox display as they felt they were consuming more power since its installation. The in-house display component was therefore removed for these three houses during final visits as well as for one house in Galiwin'ku at the householder's request.

At the conclusion of the project in response to the overall positive findings, the consortium agreed to leave the BEEBoxes in place for the ongoing benefit of households but with agreement that the devices would not be maintained by DHsg and would be disabled and/or removed upon failure.

# 21 Project Impact on Community Power Consumption

## 21.1 Impacts of Climate and Weather Events

2015 was an exeptionally hot year. Much of the Northern Territory experienced above average temperatures during most months of 2015 as well as record mean daily maximum temperatures during March, October and November[90]. The data analysis highlights the connection between higher temperatures and increased power consumption. Mapping the mean maximum temperatures and daily household energy consumption across each month for 2014 and 2015 shows that 2015 was hotter and power consumption increased accordingly.

In February 2015, Cyclone Lam struck the Northern Territory, including several participating Arnhem Land communities. Cyclone Lam was a classified as a category 4 cyclone by the Australian Bureau of Meterology. Up to 230 km/h-strong winds knocked down many trees, damaged and destroyed several houses, and left residents without power and water.[91]

***Trees fallen in Milingimbi during Cyclone Lam***

These impacts occured particularly in Galiwin'ku because Cyclone Lam made landfall between Galiwin'ku and Milingimbi at peak intensity. In Galiwin'ku, more than 250 people were displaced, residing in shelters for over a week and in tents for several weeks. [92] Approximately 60 per cent of houses were damaged, with 10 houses seriously damaged and six houses destroyed beyond repair.[93] The power and water supply was restored after six days howevermany residents continued to live in demountables and temporary structures for an extended period.

[90] Bureau of Meterology, 2016
[91] ABC Australia, 2015
[92] Turzon, 2015
[93] Vanovac, 2015

## 21.2 Impact on Total Community Consumption

Participating communities' (excluding Gunyangara) 2014 and 2015 energy consumption compared to adjacent control communities is detailed in Table 32 below.

The analysis of participating communities' total power generation for 2014 compared to 2015 showed a small increase of 2.1 per cent. However, in comparison to the total consumption of four nearby non-participating communities that experienced a 3.4 per cent increase, this represents a potential net saving of 1.3 per cent (253 MWh including all communities) attributable to the project's activities.

It should be noted that the bulk of the project's trials were in the process of rolling out during the course of 2015, so this saving represents only part of the potential impact of the project's full activities.

*Table 32: Community energy use yearly comparison and BACI analysis*

| Community | 2014 generation (kWh) | 2015 generation (kWh) | Increase | Per cent change |
|---|---|---|---|---|
| Total of four participating communities | 18585480 | 18969110 | 383630 | +2.1 % |
| Total nearby non-participating | 15838179 | 16375762 | 537583 | +3.4 % |

## 21.3 Impact on Power Disconnection Periods

Galiwin'ku experienced a significantly higher percentage of disconnection periods in 2015 compared to 2014. This is attributed to the effect of cyclones Lam and Nathan resulting in vacated homes. Details of the exact dates of vacation were not obtained, resulting in consumption for empty houses appearing as a disconnection period.

After excluding the Galiwin'ku data, the data for the other five participating communities indicates that the average intra-day disconnection periods declined from 40 minutes per day in 2014 to 36 minutes per day in 2015. Multi-day disconnections also reduced by 18 per cent.

The drop in shorter disconnections may be due the community engagement and energy efficiency education. The qualitative analysis suggests that these strategies are successful, as discussed further below.

The reduction in multi-day disconnections is skewed by the significant increase in disconnections in February 2015 from cyclones.

*Table 33: Participating communities (excluding Galiwin'ku) household disconnection*

| Period | Mar 14 to Feb 15 | Mar 15 to Feb 16 |
|---|---|---|
| Average number of houses with data | 381.0 | 385.6 |
| Days in period | 365 | 366 |
| Total hours of data | 3337463 | 3387087 |
| Adjusted intra-day disconnect time (hours) | 91887 | 83485 |
| Number of disconnections | 24704 | 23833 |
| Average number of disconnections per lot | 64.8 | 61.8 |
| Average minutes per day per house | 39.6 | 35.5 |
| Multi-day disconnect time (hours) | 68241 | 56283 |
| Average minutes per day per house | 29.4 | 23.9 |
| Total disconnect hours | 160128 | 139768 |
| Average minutes per day per house - total (mins) | 69.1 | 59.4 |

# 22 Impact on Water Consumption

In most communities, the direct impact on community water demand as a result of the water education house visits is difficult to quantify. Smart meters in Milingimbi provide water consumption data at a household level and therefore can be analysed to identify if house visits resulted in a water use reduction in lots. Analyses of smart water meter data and information provided by the YEEWs in Milingimbi through four water loss reports revealed that of 37 house visits, eight lots were identified as having a water leak (22 per cent).

There was an eight per cent reduction in water use in the week after the YEEWs completed the education visit, compared to the week prior to the water loss report.

There was a one per cent reduction in water loss in lots that were not identified as having a water leak (lots with behavioural-related loss rather than a maintenance issue). This suggests that visits by YEEWs by themselves have limited impact and a more comprehensive and nuanced approach to behavioural issues is required, building cultural and peer norms for efficient use of supplied water.

# 23 Co-Benefits

## 23.1 Co-Benefits For Participants

Interviews with households, YEEWs and non-Indigenous community members across the six communities indicate that the LIEEP project created co-benefits for the communities beyond the identified energy savings outcomes. These community co-benefits include:

- improved understanding of community power systems, of how appliances use electricity and how that relates to consumption of credit at the power meter
- improved understanding of budgeting concepts
- a positive experience with a project initiated outside the communities but responsive to community needs and priorities
- employment:
    - the project provided short-term employment opportunities for approximately 90 Yolŋu across the six communities, with more than 25 000 hours of paid employment and training

    - employment provided additional income for YEEWs and their kin, potentially easing household pressures
- increase in experience and expertise in:
    - Yolŋu educating Yolŋu, in language
    - Yolŋu conducting research with Yolŋu, in language
    - Yolŋu working together in partnership with non-Indigenous people.

Research suggests that it is likely the project also produced some measure of follow-on benefits for the participating communities, including an increase in thermal comfort, health and school attendance. However, these outcomes are difficult to measure and are yet to be evidenced by systematic research.

## 23.2 Co-Benefits for Consortium Members

The project was the first energy efficiency trial of this scale to be delivered in remote Indigenous communities and captured valuable lessons on community engagement and the use of technology to achieve energy efficiency in remote communities. The project delivery model rated highly with consortium members, and there was an overall increase in the capacity of members to engage with communities in remote Indigenous communities.

### *Engagement and Education*

The project produced a unique model of employment and training that varied between each community depending on their needs. This adaptability, in conjunction with flexible positions, a focus on outcomes, an understanding and acceptance of staff's cultural obligations and enabling staff to lead delivery in their communities resulted in great respect between consortium members and project staff. The consortium gained the unique opportunity to work with YEEWs and Indigenous co-researchers over an extended duration. This opportunity resulted in significant increased knowledge and capacity to work with Indigenous communities. This increased knowledge is likely to be used for projects among consortium members in this and other areas.

### *Employment and Training*

The project provided experience and expertise in employing Yolŋu, including recruitment, employment, use of flexible teams, training/education and working together over time and distance.

Trained local Yolŋu YEEWs and co-researchers across the six participating communities bring increased capacity for a range of organisations to improve the delivery of future projects. The staff can be engaged in future projects, both for household engagement and education as well as for delivering future research in east Arnhem Land.

### *Retrofits and BEEBox*

The outcomes of the retrofit program provided insight and increased understanding of technologies that proved to be successful in achieving reduced energy consumption and were appropriate for use in remote Indigenous communities. Important knowledge was also gained on the energy efficiency implications of different house designs.

The BEEBox had previously only been trialled on a smaller scale, and the project enabled a consortium-designed and manufactured piece of technology to be tested in multiple environments at a larger scale.

The BEEBox proved to be an effective talking point and tool for understanding how different appliances use energy and is likely to be used in future energy efficiency and engagement projects in remote communities. It proved an effective tool to reduce disconnection rates.

Lessons learnt around technology have built a strong empirical base that will inform policy for new build and energy efficiency retrofits into remote communities for years to come.

### *Energy Efficiency and Data Capture*

The project captured a large amount of useful qualitative and quantitative data that developed new knowledge on low-income household energy use and the energy implications of technologies and house designs. The consortium members' access to data meant assumptions and anecdotal evidence about energy consumption patterns and disconnection rates were empirically tested for the first time at a large scale. This exchange of information and expertise has increased skills and understanding of energy use and will provide a baseline and strengthen future projects in this area.

The learnings from the project and its research approach will be incorporated into research and teaching national and international students. Data provides publication opportunities for CDU and a base to apply for grants for future research projects in this. In addition, the project has improved co-ordination of Indigenous research approaches across the University.

### *Relationships*

Valuable relationships were built between all consortium members and participating communities, and as a result, consortium members' knowledge and capacity to engage with and deliver projects in remote communities has been significantly improved. In particular, the unique opportunity to have government, non-government and research Institutes working together resulted in consortium members having a better understanding of organisations' culture and drivers and insights into working on multi-partnered service delivery projects at a large scale.

Importantly, the project provided an opportunity to improve its relationship with customers and community stakeholders and to improve senior staff's understanding of the real issues faced by residents in communities served by PWC.

## 23.3 Benefits to Australian Suppliers

The project invested heavily in products and services from Australian companies and organisations, both Northern Territory based and national.

- The BEEBox product was designed and managed through CAT and its subsidiary CAT Projects based in Alice Springs. The manufacture of the BEEBox was completed in Australia.
- Data logger technology was purchased from the Australian company, Taggle Systems Inc.
- The project's retrofits included procurement of 114 Solahart hot water systems and 87 Quantum hot water systems—both businesses with significant Australian presences. The ceiling insulation product was Pink Batts, also manufactured in Australia.
- The installation contractors for these various technologies were all Northern Territory based.
- The Heater Mate product that was trialled in some households under the project's nickname of 'Cool Bro' was an Australian innovation.

- Foodstuff, catering and minor items were predominantly purchased through the local ALPA stores in each community.
- The project's travel and accommodation expenditure was predominantly through Airnorth and Hardy Aviation for regular passenger transport services, Northern Territory or Australian-based charter companies, and locally owned accommodation providers in the communities and in Nhulunbuy.

# 24 Evaluation Against Funding Agreement Deliverables

## 24.1 Performance Against Milestone Deliverables

IES submitted the bulk of the required milestone reports on time, and all milestone reports were ultimately approved for payment of the full LIEEP funding amounts associated with them.

Table 36 below provides a breakdown of the outputs against the performance measures per funding agreement milestones as per the project's final revised targets. A discussion of the revisions that were made to this table is provided subsequently.

*Table 34: Summary of milestone achievements per month*

| **Milestone** | | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **Total** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Activity** | | **Dec 2014** | **Mar 2014** | **May 2014** | **Sep 2014** | **Dec 2014** | **Mar 2015** | **May 2015** | **Sep 2015** | **Dec 2015** | |
| Data logger installs | *Target* | | *300* | *250* | | | *70* | | | | *620* |
| | Actual | **0** | **615** | **0** | **12** | **1** | **2** | **2** | **1** | **30** | **663** |
| Barrier surveys completed | *Target* | *40* | | | | | | | | | *40* |
| | Actual | **42** | | | | | | | | | **42** |
| Stores surveyed | *Target* | *2* | | | | | | | | | *2* |
| | Actual | **3** | | | | | | | | | **3** |
| Ambassadors trained | *Target* | | *0* | *10* | *0* | *0* | *0* | *10* | *0* | *0* | *20* |
| | Actual | | **0** | **15** | **0** | **17** | **15** | **19** | **14** | **0** | **80** |
| Households approached to participate in education program and incentive scheme | *Target* | | *0* | *50* | *40* | *40* | *40* | *90* | *90* | *90* | *440* |
| | Actual | | **0** | **52** | **52** | **110** | **18** | **210** | **99** | **23** | **564** |
| In-house display installs | *Target* | | *0* | *0* | *50* | *50* | *0* | *40* | *60* | *50* | *250* |
| | Actual | | **0** | **0** | **0** | **109** | **0** | **49** | **94** | **0** | **252** |
| Households receiving retrofit | *Target* | | | *0* | *90* | *90* | *0* | *60* | *100* | *100* | *440* |
| | Actual | | | **0** | **17** | **204** | **0** | **35** | **97** | **95** | **448** |

As can be seen, the barrier and store surveys were completed above target to the revised delivery date, and the data loggers were rolled out ahead of targets, with the bulk completed in March 2014. While ahead of target, completion of these by January 2015 or earlier would have assisted the quantitative analysis by providing two full years of data in time for submission of this report.

The ‘ambassadors trained’ milestone was delivered above target and ahead of target timeframes but only after negotiation of a delay to the commencement of the first team. Retrofits and BEEBox implementation were not able to meet their milestone 7 September 2014 targets; however, this was compensated for by additional activity completed for milestone 8.

The BEEBox technology was not available to the project until September 2014 due to delays in its development. These delays ensured a fully compliance-tested product and resulted in a product that experienced a minimal number of failures during operation. The late availability of the BEEBoxes made achievement of the milestone 7 target impractical without completely compromising community engagement goals.

Retrofits were similarly delayed in their commencement, owing to the complexity of establishing the framework for delivery of the major retrofits and in development of a suitable solution to the stove timer. Deployment of lower-value opt-in retrofits could have been prioritised in order to meet this target earlier, which would have also been at the expense of community engagement goals.

## 24.2 Delivery Against Data Collection and Reporting Requirements

The project provided energy, dwelling and other quantitative and qualitative trial data to CSIRO as required under the funding agreement and as agreed through discussion with the LIEEP program office and with CSIRO representatives. Final data was uploaded to the CSIRO portal on 2 March 2016.

## 24.3 Trial Governance and Management

Project governance operated at two levels: through the formal structure of the Consortium Management Committee meeting quarterly and through the weekly meetings and day-to-day operation of the project team based at the PWC’s Ben Hammond Complex in Darwin.

An additional layer of governance and consultation was originally envisaged via the formation of a stakeholder advisory board. This was not implemented as described earlier in the report, because its objectives were designed to be met through regular travel to community and meetings with key stakeholders.

The project was led by PWC as a service provider to IES Pty Ltd. The project team was embedded within the existing Water and Energy Demand Management team within the Remote Operations division, where team members had been heavily involved in the original trial design and successful bid. This provided the newly appointed project team with direct access to the existing knowledge of and relationships with key communities and consortium members.

The project operated within the PWC procurement framework and through its existing financial, ICT and other business systems. It was supported by its existing corporate communications, legal, ICT and procurement teams. Operation within this large organisation provided many benefits, including access to well-established and supported systems, access to internal expertise, and the benefit of its focus on accountability, reporting, compliance and zero harm.

PWC business systems required upskilling of the project team, who were all new to these systems. Delays arose while establishing a clear project-specific methodology for how to treat the commitments for sourcing through the consortium and associated agencies.

## 24.4 Delays and Scope Changes

The project scope and roll-out was originally designed based on commencement in January 2013. The funding agreement was not executed until May 2013 and the project team not fully in place until July 2013. This compressed the timeframe for project deliverables.

A key decision in context of this delay was to maintain the overall scope of the project and deliver the agreed trials in the shorter timeframe. This was based on several factors: to maximise benefit for the low-income participants, to demonstrate the capacity of the lead agent and consortium as effective grant recipients, and to leverage the economy of scale benefits of a larger project.

The project plan submitted for milestone 2 incorporated this delay in comparison to the roll-out originally envisaged in the funding bid. However, during the project operation, further adjustments and delays had to be negotiated for many of the milestone key performance deliverables.

The first of these was linked to the completion of the barrier and store surveys, which were delayed by several weeks as a result of it being initially linked to a delay in approval for the original data collection and reporting plan. The survey approvals were subsequently uncoupled from the plan approval because of their primary role of informing the project design as opposed to forming a data deliverable for the project.

Once initial planning for the retrofit roll-out was completed in December 2013, negotiation for a reduction to the overall retrofit target resulted in this target being reduced from 550 to 440 households. The Commonwealth priority was to ensure benefits for the maximum number of households; however, agreement for the reduction was obtained on the basis of the target being higher than the number of households in the project's overall engagement target. It also reflected the high cost of delivery in communities, and that initial scoping confirmed that the majority of housing was already provided with many efficient fixtures, including more than 220 new energy star compliant houses delivered through recent housing programs. The opportunities remaining to the project were predominantly higher-cost items, such as installing solar hot water systems and retrofitting ceiling insulation.

Another early scope change was acknowledging that the proposed status of the community of Ramingining as a baseline control community was of limited value in evaluation terms and had significant issues with perceptions of inequity. It was therefore initially flagged as being scheduled to receive the education and employment components towards the end of the project trials. As the project roll-out progressed, it was identified that its inclusion into retrofits and BEEBoxes trials was also important in order to meet the desire from other communities for equity treatment—something that was communicated to the project team from multiple sources and stakeholders. Inclusion in the retrofits was also important in order to meet the overall target with high value retrofits, and this was particularly important in light of the effect of cyclones Lam and Nathan on Galiwin'ku, where 80 houses were effectively removed from the project at a critical juncture in assigning retrofits.

A key scope change was in the approach to the project's evaluation. The initial project design was not explicit on how and by whom the qualitative/human research would be carried out. An initial trial of having the workers in Milingimbi conduct surveys at the commencement of the project—the KAB survey—proved difficult to implement effectively, especially in the context of it not being explicitly identified as part of the employment role and not integrated into the design of their training.

Qualitative data collection was not included in the YEEW employment and training model for Galiwin'ku (October 2014 onwards). After trailing a direct research visit to Milingimbi, a proposal was developed to add a Yolŋu lead co-researcher to the CDU research team. A new approach was designed using local co-researchers in each community to be selected directly by the Yolŋu co-researcher. Discussions were had on how to best integrate the new dedicated researchers as team members into the employment contracts for Gunyangara and Yirrkala (January/February 2015). However, EARC was unable to incorporate the requirement for pre-identified employees to be appointed outside of its normal recruitment approach. The proposed researcher pay scale was also difficult to reconcile with the YEEW contracts.

On this basis, the proposal evolved into CDU directly employing and managing the co-researchers themselves as a revision to their role in the activity. The interview approach successfully incorporated pre- and post-trial interviews of 10 houses in each community. This approach was agreed to by the Commonwealth and consortium and resulted in reallocation of funding from the ambassador program to surveys activity through CDU.

The original project concept envisaged energy audits being conducted as part of the household engagement, which would assess how householders used their appliances, the implications of the building envelope along with the number, type and condition of appliances. This was not incorporated into the role of the YEEWs nor addressed through any parallel approaches. It was identified as a gap in the project's ability to evaluate household level energy data during the early 2015 review process, which recommended a tracking study be run in parallel to the co-researcher interview approach. Given the ambitious nature of the new approach, this was not formally adopted initially. During a final review planning session in July 2015, it became clear that some additional data on appliance-level consumption habits along with household perceptions of thermal comfort and appliance use would be important additions to the overall final report analysis. The project team was therefore directed to implement the tracking study for six houses within a short timeframe, using existing capacity in the data logger and surveys activity funding.

## 24.5 Scope Changes Not Implemented

The project's key participant pool was limited to houses within the communities that were serviced by both DHsg and PWC. This was a somewhat artificial boundary in relation to housing in nearby outstations and satellite communities, whose occupants were closely connected with residents within the main community housing. This was of particular interest in relation to Birritjimi (Wallaby Beach) which is located near to Gunyangara, for which the housing, power and water are fully managed by the Bunuwal Association but whose occupants were closely aligned with the project's footprint. The outstations near to Ramingining are powered by PWC, but the housing is managed by a separate service provider. The YEEWs questioned the limits of the project scope, and consequently, consideration was given to including these houses in the delivery of education and potentially more. However, that did not eventuate.

## 24.6 Resourcing

The project team initially consisted of two full-time PWC employees, one CAT employee and a part-time CDU research officer. DHsg participation was absorbed by existing staff.

EARC was unable to take on the initial in-kind role envisaged for it of providing supervisory support from its existing staff in each community, in part because of workloads but also due to significant changes occurring with the contractual arrangements between EARC and DHsg for the provision of housing maintenance services. Funding for a position within EARC was not directly discussed initially, in part because of this and also because early community consultations highlighted that EARC may not be the employer of choice in all communities, particularly Gunyangara. However, its strength as a consortium member proved beneficial towards the end of the project through the four employment contracts it was awarded.

projectIt was identified early in the project that the CAT community engagement officer's role was an important one and a single position would not have provided adequate coverage of roll-out across six communities, taking into account travel time to and from each community and the need for several days on each occasion to build relationships and trust. The position was also tasked with supporting the design and development of the education and training approaches.

It was agreed in late 2013 that CAT would provide a second full-time community engagement officer, and the position was established as a 'senior' role in recognition of the need for additional capacity for the design and delivery of the training.

The second officer commenced in May 2014, five months after committing to the additional position, the delay reflecting the difficulties of implementing an additional position during a busy period including the New Year break. The experience of implementation in Milingimbi and the subsequent departure of the original engagement officer identified that even two positions would struggle with the workload and leave the project exposed to further turnover. Planning commenced for a third position to support the scale up to six community trials operating at the same time in 2015. With departure of another engagement officer in January 2015, the project found itself incorporating two new full-time staff in early 2015 for a one year or less operational period.

The three positions were all employed by CAT but were housed full time at the PWC offices in Darwin. The maintenance of three positions also required an increase in supervisory and administration overhead for CAT, and in effect another position within the CAT Alice Springs office was funded for 10 to 20 hours per week indirectly through allocations of LIEEP funding for their support across the trials.

The resourcing of the data collection, evaluation and research was a vexed issue and was under-resourced. The resource was initially envisaged as a full-time research officer, but the initial budget with CDU only allowed for a part-time position. Negotiations to provide additional operational evaluation support embedded within the project team were initially unsuccessful. Provision of casual data entry and operational data analysis support was successfully negotiated, and this evolved into a three-day per week casual position employed by CDU but based with the project team, handling data entry, database administration and the bulk of the quantitative data analysis. The original research officer left Australia after June 2014 and was replaced by a lead researcher subcontracted from another school within CDU. Subsequently, the interaction between the lead researcher and project team was limited to predominantly telephone meetings, with occasional in-person workshops and interactions in community.

## 24.7 Risks and Compliance

The project developed comprehensive risk and compliance plans required under the contract. Implementation of these plans was supported and encouraged by PWC's strong internal focus on risk and compliance. Controls put in place included monthly reporting to consortium representatives, with safety and compliance risks a key point of reporting. All contractors were required to submit safety plans, and provision of safety and compliance documents were generally linked directly to payment of invoices, encouraging evidence of compliance.

Staff were required to submit travel plans prior to field work, including a review of a safety checklist.

The project achieved a record of zero significant safety incidents, no lost time to injuries and obtained compliance documentation from all contractors for its retrofit roll-out.

## 24.8 Consortium Roles

The consortium approach successfully brought together diverse skills, experience and resources among the consortium members. The shared goal, shared risk and potential for positive customer outcomes helped improve relationships between the different parties.

Some key benefits each consortium member brought to the project:

### *Centre for Appropriate Technology*

CAT brought its prior experience with interpreting energy concepts, including associated materials and technologies. It brought its flexibility to rapidly take on additional staff, an ability to operate to and meet tight deadlines, and its organisational passion for respectful engagement and good outcomes for Indigenous peoples of Australia.

### *Department of Housing*

As the asset and tenancy operator for all of the eligible housing, DHsg was an essential partner. It provided access to its expertise and resourcing for the retrofit and initial housing stock scoping exercises, and it provided extensive data on the existing housing stock. It provided manpower for the detailed scoping for the selected retrofits

### *East Arnhem Regional Council*

The EARC governance area defined the project communities. Its staff and governance board (local authority) in each community along with its office and staff facilities were a significant benefit. While its initial involvement was uncertain and conflicted by other issues evolving at the time, it also brought an overall commitment to successful outcomes for its constituents and an evolving passion for the outcomes and benefits for the employees it hosted.

### *Charles Darwin University*

CDU provided access to staff with experience in evaluating energy data from the Solar Cities program and thermal comfort studies elsewhere. It provided a linkage to academia and the rigours of peer-reviewed and ethics committee-approved research. The project connected to CDU through its Research Institute for Environment and Livelihoods (RIEL), project and so obtained linkages to broad Indigenous research experience across the university. CDU was able to provide additional employees for the project, including the data officer and the employment of the co-researchers.

# 25 Project Budget

The table below compares the original and final budget for expenditure of LIEEP funding, along with the in-kind contributions as at the time of report preparation.

*Table 35: Comparison of original and final LIEEP funding budget*

| Category | Activity | Milestone 2 budget | Actual LIEEP expenditure | In-kind contributions |
|---|---|---|---|---|
| Governance and administration | Project team | 2,100,000 | 2,003,918.61 | 1,694,751.83 |
| | Travel costs | 240,000 | 536,839.40 | 4,122.23 |
| | Consortium governance | 87,500 | 8,779.66 | 157,404.48 |
| Community engagement and education | Marketing and communication | 150,000 | 161,942.74 | 49,940.96 |
| | Development of resources | 140,000 | 119,463.68 | 32,820.50 |
| | Incentive / rewards scheme | 250,000 | 180,784.10 | 227.00 |
| | Ambassadors program | 2,500,300 | 2,195,920.58 | 344,988.74 |
| | In-house displays (BEEBox) | 450,000 | 624,978.96 | 1,437.00 |
| Energy efficiency retrofits | Household retrofits | 2,901,000 | 2,649,470.16 | 92,117.00 |
| Monitoring and evaluation | Data loggers | 330,000 | 545,285.27 | 0.00 |
| | Water smart meters | - | 0.00 | 445,299.61 |
| | Surveys | 89,000 | 261,466.90 | 3,316.00 |
| | Data management | 162,500 | 148,599.75 | 86,552.00 |
| | Evaluation | - | | 122,769.36 |
| **Total expenditure** | | **9,400,300** | **9,437,449.81** | **$3,035,746.71** |
| LIEEP funding income | | 9,400,300 | 9,120,996.01 | |
| Interest income | | 0 | 115,053.80 | - |
| STC income | | 0 | 201,400.00 | - |
| **Total income** | | **9,400,300** | **9,437,449.81** | - |

Key changes to the budget included:

- a significant increase in travel costs in line with the additional community engagement officers and investment in co-research approach
- a reduction in the governance allowance as a result of scaling back the stakeholder advisory board approach
- a reduction in the ambassador program budget to support the increase in travel and the co-researcher approach (surveys)
- an increase in the BEEBox and data logger budgets to allow for installation costs
- a slight decrease in the retrofit budget to support the other increases
- an increase in the surveys activity for the co-researcher approach
- an increase in income from accounting for estimated interest earned in the IES bank account
- income from the decision to sell the STCs arising from the installation of hot water system retrofits separately rather than as a discount to contracted installation costs (in order to achieve better value).

# 26 Cost Benefit and Cost Effectiveness Analysis

The total cost of the project was $12.47 million, including consortium in-kind support. Across 633 eligible households, this equating to a spend of just under $20 000 per household.

The primary measurable benefit of the project is energy savings, which are projected to be 3,458 MWh over the life of the various installations and activities.

Additional benefits of the project were many and varied, as detailed in section 23. These included increases in utility, energy productivity and household comfort, employment outcomes, technologies developed, increased household understanding, consortium learnings, and ongoing evaluation of the collected data.

It is, however, difficult to quantify and place a direct economic value on these additional benefits, and for the purposes of the cost effectiveness and cost-benefit analysis, only the quantifiable energy savings attributable to the project's trials are assessed.

It should also be noted that many of the project's activities were new and custom designed for the project. Broader deployment would result in economies of scale that would significantly reduce some costs.

## 26.1 Cost Effectiveness

The primary quantifiable benefit of the project trials for a cost-effectiveness analysis is the measurable energy savings in kWh. It must be reiterated that this then does not take into account the many co-benefits of the project activities.

The project trials that were directly aimed at energy consumption impact were the energy efficiency retrofits, the BEEBox and the delivery of household education. The average energy savings attributable to these trials has been presented in the discussion section. In addition, the water education is treated as a discrete primary trial; however, no water savings were directly calculated.

The average cost of each trial has been calculated based on the methodology required by the department, involving attribution of the costs of the project to four levels. Details of this calculation are provided in Appendix F: Cost-benefit Analysis Details.

A summary of these costs and energy savings attributable to each trial is provided in Table 36 below. Based on the energy analysis results and direct costs, the highest cost effectiveness on an energy savings basis was achieved by the stove timer trial.

The energy savings from hot water system upgrades are uncertain given the operational status of pre-existing systems was not measured. On the basis of the identified savings, their cost-benefit ratio is greater than one at all levels even with the analysis having taken into account the design life of the units and the cost of 'business as usual' electric hot water systems.

Additional benefits of these units not taken into account in this analysis include the value of reducing peak load and the benefits of storage smoothing loads. Also of benefit to householders is the absolute value of the energy savings and also the value of higher hot water storage capacity giving users more resilience during power outages and self-disconnection.

No direct energy savings were observed for households receiving education only; however, interviewed households valued the education, and its impact on supporting the observed energy savings from the technology trials is difficult to untangle as it was provided along with all technologies.

## 26.2 Cost Benefit

The cost-benefit analysis is also based only on the value of kWh savings from the project activites. Additional benefits not reflected in this analysis are detailed in Section 23, and include:

- improved energy productivity and thermal comfort for residents
- social outcomes arising from improved appliances, financial savings and from householder knowledge
- employment and training outcomes for the 80 YEEWs
- knowledge gained from the project by consortium and stakeholders
- benefits to Australian suppliers and industry.

In regard to placing a value on kWh savings, the tariff faced by pre-payment meter consumers in 2015 was $0.2956 per kWh. However, this reflects a uniform tariff for the Northern Territory, and the underlying costs of service delivery are higher with the gap subsidised by government.

A more accurate representation of the benefit of energy savings is the underlying costs of power generation and the power system that are relevant to a reduction in energy consumption. These include diesel and other operational costs, and capital costs that vary directly with consumption (e.g. engine runtimes). An average figure for east Arnhem Land that represents the value of energy savings was provided by PWC as $0.45.

On that basis, the cost of average annual household energy consumption using an average of 26.8 kWh per day is $4402, and for the 633 eligible households, a total of $2 786 402 (two thirds of which is customer payments).

At the value of $0.45 per kWh, the cost-benefit ratio of the measured energy savings from the individual project trials and for the overall project is summarised in Table 37.

*Table 36: Summary of cost-effectiveness analysis*

| Trial | No. of houses or installs | Cumulative net[94] cost $ | | | | Benefit per unit kWh/ day | Presumed functional life (years) | Design life total savings (kWh) | Cost effectiveness ratio ($ per kWh) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Level 1 | Level 2 | Level 3 | Level 4 | | | | Level 1 | Level 2 | Level 3 | Level 4 |
| Ceiling insulation | 47 installs | 283,329 | 583,567 | 837,299 | 1,063,915 | 2 | 20 | 686,200 | 0.41 | 0.85 | 1.22 | 1.55 |
| Solar hot water upgrade | 114 installs | 737,134 | 1,977,312 | 3,025,391 | 3,961,463 | 1.73 | 15 | 1,079,780 | 0.68 | 1.83 | 2.80 | 3.67 |
| Heat pump upgrade | 87 installs | 454,034 | 1,168,718 | 1,772,699 | 2,312,135 | 2.84 | 10 | 901,842 | 0.50 | 1.30 | 1.97 | 2.56 |
| Stove timer | 209 installs | 190,399 | 502,717 | 673,227 | 825,514 | 1.35 | 5 | 514,924 | 0.37 | 0.98 | 1.31 | 1.60 |
| BEEBox | 252 installs | 624,979 | 1,385,384 | 1,945,077 | 2,444,956 | 0.6 | 5 | 275,940 | 2.26 | 5.02 | 7.05 | 8.86 |
| Energy education per house | 564 houses | 230,527 | 439,643 | 646,088 | 830,471 | 0 | 3 | - | - | | | |
| Water education per house | 463 houses | 174,541 | 332,871 | 489,179 | 628,783 | 0 | 3 | - | - | | | |
| **Total** | | **2,694,944** | **6,390,212** | **9,388,960** | **12,067,238** | | | **3,458,685** | **0.78** | **1.85** | **2.71** | **3.49** |

[94] Costs are net of the business as usual Level 1 cost for hot water systems being an electric hot water system. Refer Appendix for details.

*Table 37: Summary of cost-benefit analysis*

| Trial | No. of houses or installs | Saving per unit per annum $ | Design life saving total $ | Cost-benefit ratio | | | |
|---|---|---|---|---|---|---|---|
| | | | | Level 1 | Level 2 | Level 3 | Level 4 |
| Ceiling insulation | 47 installs | 329 | 308,790 | 0.9 | 1.9 | 2.7 | 3.4 |
| Solar hot water upgrade | 114 installs | 284 | 485,901 | 1.5 | 4.1 | 6.2 | 8.2 |
| Heat pump upgrade | 87 installs | 466 | 405,829 | 1.1 | 2.9 | 4.4 | 5.7 |
| Stove timer | 209 installs | 514 | 537,237 | 0.4 | 0.9 | 1.3 | 1.5 |
| BEEBox | 252 installs | 99 | 124,173 | 5.0 | 11.2 | 15.7 | 19.7 |
| Energy education per house | 564 houses | - | - | | | | |
| Water education per house | 463 houses | - | - | | | | |
| **Total** | | | **1,553,140** | **1.74** | **4.11** | **6.05** | **7.77** |

# SECTION 4: LESSONS LEARNT AND RECOMMENDATIONS

## 27 Lessons Learnt

Lessons learnt through this project apply to both the technical and social-cultural elements of energy efficiency in low-income Indigenous households. The emphasis on community engagement in this project was critical to its success. Without the careful and sustained engagement and employment of and with Yolŋu-speaking local people, the project would not have achieved whole-of-community participation and acceptance. Without householder education, even the best energy-efficient technologies can be rendered ineffective.

Behaviour change education is undoubtedly difficult to achieve, particularly in the cross-cultural context. This project showed that well-designed community engagement can achieve buy-in and trust that is the basis for working towards behaviour change outcomes. This report describes many of the detailed recommendations surrounding methods of engagement, but the overall lesson learned is that projects in the Indigenous domain cannot work without genuine, well-resourced and coordinated community engagement.

Technically, there were also many lessons learnt through the project roll-out. Overall, the experience shows that energy efficiency improvements can be made using technology approaches, but they must be suited to local conditions and able to be maintained and repaired. Remote Indigenous communities are not the right setting to first test new technologies.

Efficiency improvements were achieved through the roll-out of various devices, and these are detailed in this report. Further, the data loggers deployed by the project provided a valuable insight into energy consumption and improved our understanding the prevalence of disconnection due to lack of credit in pre-payment meters. The project found that while Yolŋu find the process of securing ongoing credit for the meter difficult, the actual occurrence of disconnection was less than one per cent of accumulated time, showing that households do manage the supply of credit to their meters effectively. This important finding lends empirical evidence to assumptions about disconnection rates in remote Indigenous community settings.

Based on the findings of this report, the following recommendations are presented to encourage better energy efficiency outcomes in low-income Indigenous communities. For clarity, they are divided into recommendations firstly relating to household technologies and secondly to education and behaviour change. These approaches cannot work in isolation; aspects of both are required to meet energy-efficiency goals. Recommendations are stated in order of importance.

The recommendations arising from this project describe elements of project design and management that may help achieve LIEEP goals in the roll-out of future projects. The recommendations are not limited to projects in the energy efficiency or Indigenous realms and could have broader usefulness for project managers.

# 28 Energy Efficiency in Low-income Households

## 28.1 Technology Recommendations

Based on the findings, the following technology-related recommendations are made:

1. Do not install untested technologies into remote Indigenous households without well-planned support and evaluation in place. Stick with tried technologies that are known to withstand the rigours of community life and suitable for relevant climatic conditions.
2. Housing maintenance is required for energy efficiency outcomes. There must be effective processes for reporting and prompt maintenance of issues affecting household energy efficiency[95].
3. Build on the evidence base and plan projects that fill gaps in existing knowledge.
4. Energy efficiency technologies that are recommended for use in Indigenous communities in tropical regions include heat pump and solar hot water systems, which should be installed in all new housing or to replace any existing electric hot water systems.
5. Stove timers are recommended as a useful tool to support energy efficiency.
6. Appropriate behavioural controls for air-conditioners should be investigated and trialled in future programs.
7. Allocate specific resources to work with local community stores in supply of efficient appliances, in particular air-conditioning units, which are a key consumer of energy.

## 28.2 Educational and Behaviour Change

Community engagement and education around energy efficiency was a key component of this project. The approach taken targeted the needs of remote Yolŋu communities, and while these recommendations are specific to that context, they may be helpful for other education and behaviour change programs. Again, recommendations are stated in order of importance.

1. Energy efficiency education should be delivered in local language, by trained local people.
2. Recognise that energy is an enabler for livelihood, health, social wellbeing, safety, comfort and entertainment—the focus should be on improving energy productivity rather than energy reduction.
3. Understand the hierarchy of needs and where energy efficiency will sit within people's priorities.
4. Link energy education to key motivators for change, including health and safety co-benefits, environmental co-benefits and environmental sustainability.
5. Design education materials and the approach to start from and build on existing knowledge and beliefs.
6. End-user training is as important as any technology retrofits themselves—community engagement needs to happen earlier in order to achieve best practice outcomes.
7. Energy efficiency educational resources should:
    a. engage early with the intended audience to help target and scope them appropriately

[95] In this context, the vast majority of remote housing is delivered and maintained by the Northern Territory Government, so residents have little control over maintaining or repairing the housing stock.

   b. provide an appropriate amount—but not too much information or too many educational materials—to convey the energy message
   c. use multimedia to engage the audience
   d. be judicious with what resources are used in a project—more is not necessarily better.
8. Provide a full explanation of the motivators and drivers for the initiative.
9. Provide tailored approaches to engage all sectors of the community—both genders and all ages (e.g. presentations to children in schools are helpful for engaging children).
10. Combine energy and water efficiency training with other community education programs (for example, money management) to improve economies of scale and build capacity in communities.
11. Focus on addressing the social and cultural norms and barriers around appliance use, including establishing responsibility and motivation for turning appliances off.

At the program level, a number of useful recommendations can be made for future policy makers and project managers. These recommendations are divided into community engagement, Indigenous employment and training, retrofits and in-house displays, consortium governance and project evaluation. In all sections, the recommendations are numbered according to importance.

## 28.3 Community Engagement

1. A tailored approach is required—urban, non-Indigenous approaches do not work in this context.
2. Indigenous participants need to be central to project design and delivery right from the beginning. Ideally, this should occur at the grant writing stage, or at least before the contract is signed off.
3. Engage a project partner that has bilingual experienced staff, both Indigenous and non-Indigenous.
4. Ensure that genuine community engagement is at the core of resource planning and decision making from the outset of a project. It requires adequate resources to undertake community engagement that is purposeful.
5. Understand how people in the community learn most effectively and from whom. A peer-to-peer learning model is ideal, and aim to build peer-based norms.
6. Question all assumptions, thoroughly explain concepts, and relate them to existing modes of understanding and worldview.

## 28.4 Indigenous Employment and Training

Indigenous employment was a significant outcome in this project, and an employment model was developed that met the needs of both Indigenous employees and project budgets and timelines. While these recommendations are presented in order of importance, these elements of the employment model are all critical to its success.

1. Provide an employment model that is suitable for the target group.
   a. Recognise the competing time and cultural obligations of staff, which means full-time employment may not always be appropriate.
   b. Preferably employ an adequate pool of part-time or casual staff to cover work requirements and to enable employees to undertake their cultural commitments.
   c. The larger group of staff should represent different genders, ages and clans to respectlocal customs and culture.

d. The selection process should always be done in collaboration with elders in the community as cultural advisors.
e. Utilise employment agencies or providers with appropriate skill sets and clearly written contracts that meet the needs of the project.
f. Workplace induction and training should be delivered in local language.
g. Have Indigenous and appropriately skilled and experienced non-Indigenous people working together with Indigenous people empowered to lead and drive the approach that suits their community.
h. Link temporary employment to future opportunities through accreditation and succession planning.
i. Provide meaningful employment that staff perceive to be useful to the broader community.
j. Appropriate resourcing needs to be sourced and provided, including uniforms, vehicle/s, office space and administrative support.

2. Provide employee training that is suitable for the target group.
    a. Training should be conducted in local language.
    b. Training should be adequately planned and of a duration that meets the needs of the target group.
    c. Commence with practical training that can be put to immediate use, build on this over time and only include accreditation if it links to known future job opportunities.
    d. Ensure training is as practical as possible.

# 29 Retrofits and In-House Displays

## 29.1 Technology Retrofits

1. Specify and install retrofits that have strong maintenance support. Minimising maintenance failures is as important as inherent efficiency, and local trades support and buy-in is essential.
2. Ensure technology decisions have a solid evidence base in the particular region of installation. Do not rely on anecdotal evidence when choosing technologies.
3. Local labour from Indigenous communities should be used wherever possible to install, maintain and repair retrofit items.
4. Approach and notify the householder in a culturally appropriate way prior to installation, and provide training to residents on the 'rules' for using that appliance.

## 29.2 In-House Displays

1. Consumption feedback displays need to be very simple and relate directly to the electricity meter.
2. Develop a strong and relatable story about in-house display units.
3. Trial only a handful of in-house displays initially to ensure timeliness and appropriateness of training and configuration.

## 29.3 Housing Design

1. Assume air-conditioning will be installed and used when designing building envelope.
2. Specify energy-efficient hot water systems, taking in to account demonstrable lifespan and maintenance requirements.
3. Use simple and intuitive controls for appliances such as outdoor lighting and solar hot water system boosters.
4. Provide timers where practical on other appliances such as stoves and air-conditioners.
5. Provide outdoor living and cooking areas to reduce mechanical cooling and electrical cooking consumption.

# 30 Consortium Governance, Project Planning and Budget

1. Ensure project consortium members and their allocated staff are selected on merit, relevant experience and skill.
2. Ensure all project planning milestones take into account impact of the wet season, including that many local organisations shut down for extended periods over Christmas.
3. Deploy an iterative project roll-out, with sufficient time to implement and evaluate and amend the project approach in each community before moving on to the next.
4. When writing funding applications, ensure that all costs are covered, including installation and mobilisation costs. This was pertinent to in-house displays but also more generally in project planning.
5. Ensure flexibility is built in to project design to account for unintended delays due to community or weather event delays.

## 30.1 Project Evaluation

1. Have a dedicated evaluation manager recruited for the purpose and integrated into the project team, with linkage to an academic research partner organisation and to experienced evaluator or researcher from the participating community(s).
2. Have an evaluation strategy established early in the project that can be referred to by the project team and adapted as the project rolls out. This makes sure the correct data is being collected and the project can have interim reviews to help inform roll-out.
3. Have trained local researchers conduct the field work in their communities.
4. Plan for capture of baseline data at commencement with ideally a year’s worth of data available before and after activities.

# APPENDICES

# APPENDIX A: QUANTITATIVE DATA RESULTS

This appendix summarises of the project's quantitative data and the analysis results. It is not intended to be read in isolation but as a support to the discussion section and cost benefit analysis. Some graphs and tables are presented in the discussion and are not repeated here.

Refer to the general implementation and quantitative methodology sections for specifics of data collection and handling.

## A.1 Demographics of Participating Communities and Region

The demographics for the east Arnhem Land region including participating LIEEP communities is provided in table A1 below. Data for all communities except Gunyangara was obtained through the 2011 Census, the 'local stats' website, population data from the Department of Local Government and Community Services (DLGCS) and the East Arnhem Region Economic Profile.

The East Arnhem Local Government Area region covers 33,596 square kilometres in the north-eastern corner of the Northern Territory. The region's population is 16,106, which is seven per cent of the Northern Territory total. The majority of the regional population is Yolŋu (the traditional owners of the region).

The project's six communities have an estimated combined population of 7,016 as at June 2015, including 187 people for Gunyangara. The six communities have an average age of 25.

*Table A1: East Arnhem demographics summary table*

| Location | Milingimbi | Galiwin'ku | Gapuwiyak | Yirrkala | Ramingining | Total/ average |
|---|---|---|---|---|---|---|
| Population[96] (n) | 1285 | 2517 | 1038 | 999 | 990 | 7016 |
| Median age (years) | 25 | 24 | 24 | 27 | 27 | 25 |
| Male (%) | 52.2 | 50.1 | 52.3 | 49.7 | 48.3 | 51 |
| Female (%) | 47.8 | 49.9 | 47.7 | 50.3 | 51.7 | 49 |
| Indigenous speaking (%) | 93.6 | 87.4 | 88.9 | 63.7 | 91 | 85 |
| English speaking (%) | 4.8 | 9.4 | 6.3 | 20 | 7.3 | 10 |
| Full-time work (%) | 39.9 | 56.5 | 18.1 | 56.4 | 27.1 | 40 |
| Part-time work (%) | 14.3 | 17.9 | 45 | 25.6 | 26.7 | 26 |
| Unemployed (%) | 41.1 | 12 | 18.1 | 5.9 | 44.3 | 24 |
| Median individual income per week ($) | 261 | 273 | 234 | 424 | 159 | 270 |
| Median household income per week ($) | 1550 | 1856 | 1421 | 1954 | 1152 | 1,587 |
| Median rent per week ($) | 80 | 23 | 25 | 40 | 88 | 51 |
| Average number of persons per bedroom[97] | 3.1 | 2.9 | 3.6 | 2.2 | 3.3 | 3.0 |

[96] Obtained from the Department of Local Government and Community Services, updated 9 June 2015

## A.2 Housing Summary Data

In total, 633 DHsg-administered, permanent houses were included in the scope of the project and fitted with a Taggle data logger. An additional 30 temporary dwellings in Galiwin'ku were also included late in the project. Details of the housing construction were obtained through existing DHsg data and through additional scoping conducted for the project's retrofit trials.

The variation in ages, construction styles and number of bedrooms is summarised in table A2, categorised by the upgrade status and by the building's wall construction / cladding status.

*Table A2: Houses by construction and category*

| Construction type | BER | Legacy | New | Refurbished | Total |
|---|---|---|---|---|---|
| Concrete block | | 3 | 250 | 114 | **367** |
| Fibro | 2 | | | 95 | **97** |
| Timber | | 12 | | 55 | **67** |
| Metal | | | | 20 | **20** |
| Unknown | 50 | 1 | | 31 | **82** |
| **Total** | **52** | **16** | **250** | **315** | **633** |

## A.3 Housing Styles

The main variations of housing are described through images below.

A total of 250 of the houses in the project's scope were near-new dwellings delivered through the National Partnership Agreement on Remote Indigenous Housing (NPARIH). These houses are a standard design, either three-bedroom or two-bedroom duplex design. The majority are fitted with heat pump hot water systems, though a minority are supplied with thermosiphon solar hot water units. The images below show the different styles of housing found in participating communities.

*Typical new three-bedroom house, with core-filled concrete block walls and heat pump hot water system.*

[97] The average number of persons per bedroom is calculated through survey data for the LIEEP communities. The average person per bedroom in Nhulunbuy and East Arnhem is obtained from http://www.dcm.nt.gov.au/__data/assets/pdf_file/0003/60447/Economic_Profile_A4_FA.pdf

*Beyond Ecomonic Repair (BER) three-bedroom house, slab-on-ground with cement fibre composite wall cladding.*

*Lightweight construction raised floor: refurbished.*

*Four-bedroom lightweight, raised floor, timber-framed refurbished house.*

***Refurbished concrete block slab-on-ground three-bedroom housing – three examples.***

*Four-bedroom concrete block slab-on-ground refurbished house.*

*Four-bedroom timber-framed elevated refurbished house.*


*Typical duplex, new housing style with two bedrooms per unit, core-filled concrete block walls and concrete slab, Bondor insulated panel ceiling.*

*Six-bedroom Galiwin'ku transitional demountable dwellings.*

## A.4 Appliances

Information on the appliances within homes was collected from a combination of the DHsg data and surveys conducted by the YEEWs.

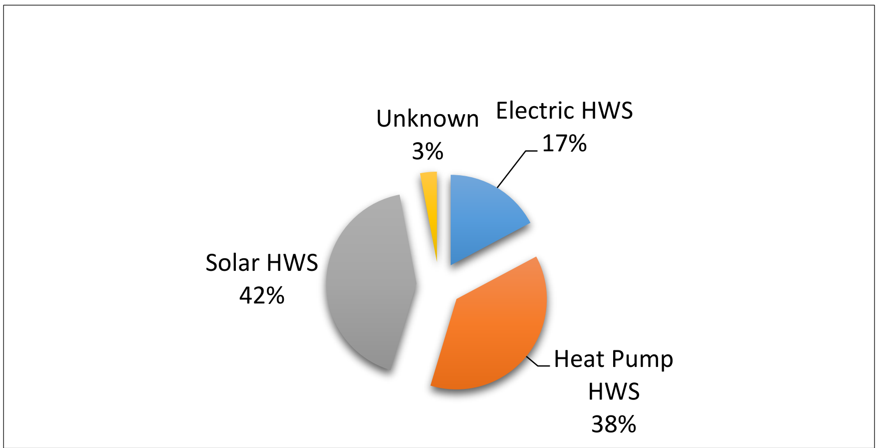
DHsg stock is supplied and maintained with fluorescent lamps and ceiling fans in each living space, an electric cooktop and oven (typically as a freestanding appliance) and a hot water system. These are a DHsg requirement and the evidence obtained supports the conclusion that these are installed in all homes, though the operational maintenance status varied.

Table A3 provides a breakdown of the pre-existing hot water system types installed per community, and figure 19 provides a visualisation of the relative proportions of each type overall.

*Table A3: LIEEP household existing hot water systems*

| Community | Electric HWS | Heat pump HWS | Solar HWS with one-shot booster | Solar HWS – booster control unknown | Unknown | Total |
|---|---|---|---|---|---|---|
| Galiwin'ku | 59 | 91 | 28 | 27 | 11 | 216 |
| Gapuwiyak | | 51 | 18 | 33 | | 102 |
| Gunyangara | | | 2 | 24 | 3 | 29 |
| Milingimbi | 28 | 68 | 8 | 11 | | 115 |
| Ramingining | 17 | 27 | 1 | 40 | | 85 |
| Yirrkala | 5 | | 16 | 60 | 5 | 86 |
| **Grand total** | **109** | **237** | **73** | **195** | **19** | **633** |

*Figure A1: LIEEP household per cent of existing hot water systems*




The average number of mobile phones per household could be used as indicator for the number of occupants in the house. This data is shown in table A4 below and compared to the average number of occupants per house in each community. The number of mobile phones per household is, on average, half the average number of occupants per house. This could be a result of children not owning mobile phones and not all adult occupants owning mobile phones.

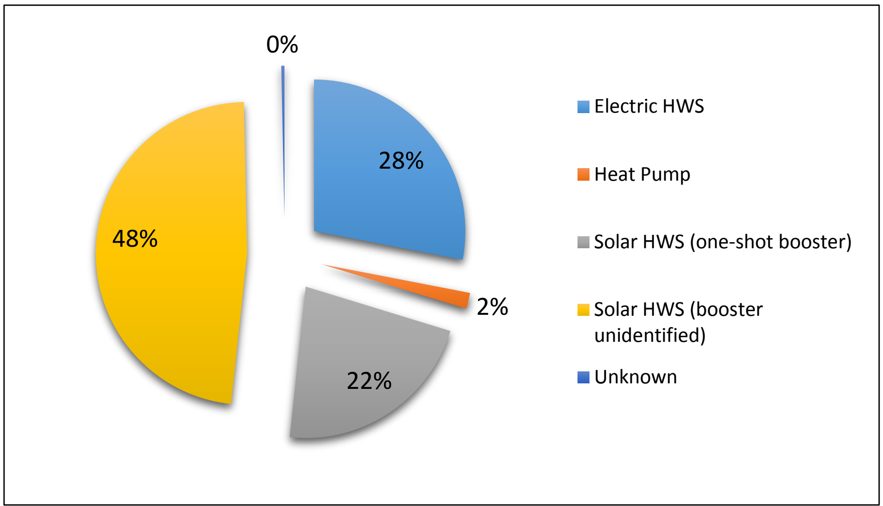
*Table A4: Average number of mobile phones per house*

| Community | Houses responded | Sum of mobile phones | Mobile phones per house | Average of max. occupants per house |
|---|---|---|---|---|
| Galiwin'ku | 130 | 572 | 4.4 | 9.1 |
| Gapuwiyak | 99 | 482 | 4.9 | 8.9 |
| Gunyangara | 22 | 63 | 2.9 | 9.4 |
| Milingimbi | 94 | 388 | 4.1 | 8.8 |
| Ramingining | 73 | 461 | 6.3 | 10.7 |
| Yirrkala | 68 | 255 | 3.8 | 6.8 |
| **Total** | **486** | **2221** | **4.6** | **9.1** |

## A.5 Correlation Between Hot Water Type and Construction Category

New housing was supplied with 97 per cent heat pump hot water systems and three per cent solar hot water systems. Figure A2 below provides a visualisation of refurbished housing, predominantly fitted with solar hot water units—mostly older units with an electric booster, but the presence of one-shot booster switches was not verified for all houses—and some electric hot water systems.

*Figure A2: Pre-existing hot water system for refurbished housing*

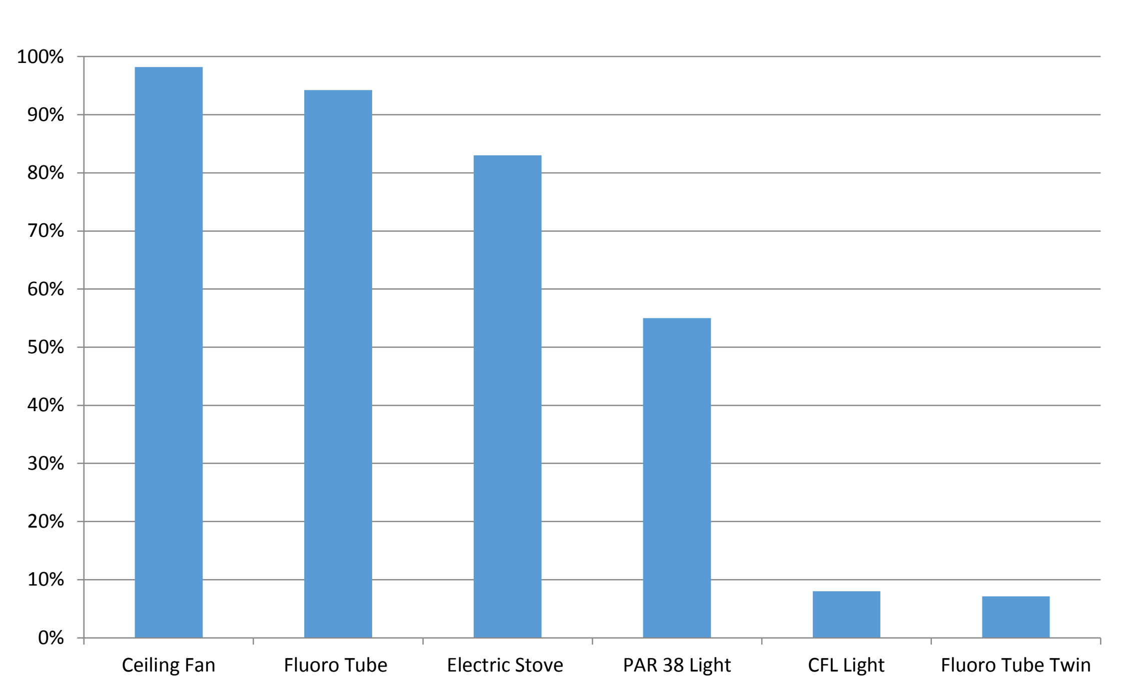



## A.6 Appliance Ownership from Appliance Surveys

Appliance surveys were conducted on the majority of households through an interview conducted by the YEEWs with a tenant.

The figure below provides a summary of the occurrence of the DHsg fixed appliances from these self-report appliance surveys (excluding hot water systems).

*Figure A3: Reported occurrence of DHsg-supplied appliances*




Additional analysis of the combined DHsg and YEEW data collected on ceiling fans shows that new houses were found to have fewer fans than the other housing types, along with fewer bedrooms in which to install them.

*Table A5: Average of number of bedrooms and number of fans by houses category*

| House category | Average number of bedrooms | Average number of fans |
|---|---|---|
| New | 2.5 | 5.1 |
| Beyond economic repair | 3.3 | 5.6 |
| Refurbished | 3.5 | 6.3 |
| Legacy | 3.8 | 7.0 |
| **Average** | **3.3** | **6.0** |

## A.7 Air-Conditioner Counts and Energy Use

Box-type air-conditioners were the predominant type identified, with few houses reporting split system units. A summary of air-conditioner prevalence and associated energy use is presented in table A6, only incorporating houses for which valid energy data was available.

Only 56 per cent of houses reported having an air-conditioner installed, with the average number of units overall at 1.03, but for houses with at least one unit, the average is 1.8 units per house.

*Table A6: Number of households by number and type of air-conditioners*

| Number of air-conditioners | Number of houses | Per cent of total | Total air-cons | Average of kWh per day per house[98] |
|---|---|---|---|---|
| Houses with no air-cons | 246 | 43.4 | 0 | 21.58 |
| Houses with 1 air-con | 147 | 26.0 | 147 | 25.89 |
| Houses with 2 air-cons | 95 | 16.8 | 190 | 31.12 |
| Houses with 3 air-cons | 62 | 11.0 | 186 | 37.05 |
| Houses with 4 air-cons | 16 | 2.8 | 64 | 48.74 |
| **Total / average** | **566** | **100.0** | **587** | **26.87** |

The presence of at least one air-conditioner per house type is presented in the following table.

*Table A7: Prevalence of air-conditioning units per house type*

| House category | Houses without air-cons | Houses with air-cons | Total houses | Percentage with air-cons |
|---|---|---|---|---|
| BER | 13 | 6 | 19 | 32% |
| Legacy | 8 | 8 | 16 | 50% |
| New | 124 | 107 | 231 | 46% |
| Refurbished | 101 | 192 | 293 | 66% |
| **Total** | **246** | **313** | **559** | **56%** |

The number of air-conditioners reported is positively associated with average daily household energy consumption. There is a strong linear relationship between the number of air-conditioners and increasing energy use, with each additional air-conditioner adding around 6.5 kWh per day of energy consumption on average. This is detailed in Figure , Section 18.6.

## A.8 Occupancy

Occupancy data obtained from the household visit forms is summarised in Table A8. The maximum value reported for each house was used as the figure for average occupancy. The result of this approach reconciles with the population statistics presented earlier obtained from DLGCS.

*Table A8: Average occupants reported compared to total population*

| Community | Average of max. occupants per house | Number of LIEEP houses | LIEEP houses population | Population (DLGCS) |
|---|---|---|---|---|
| Galiwin'ku | 9.1 | 216 | 1966 | 2517 |
| Gapuwiyak | 8.9 | 102 | 908 | 1038 |
| Gunyangara | 9.4 | 29 | 273 | 187 |
| Milingimbi | 8.8 | 115 | 1012 | 1285 |
| Ramingining | 10.7 | 85 | 910 | 990 |
| Yirrkala | 6.8 | 86 | 585 | 999 |
| **Total/average** | **9.1** | **633** | **5654** | **7016** |

[98] Average consumption is based on the full available data from March 2014 to Jan 2016

Correlation between the number of bedrooms per house and the number of reported occupants is presented in Table A9 for the subset of houses that had bedroom counts and occupancy data, showing a small increase in occupancy for more bedrooms.

*Table A9: Number of bedrooms per house compared to reported number of occupants*

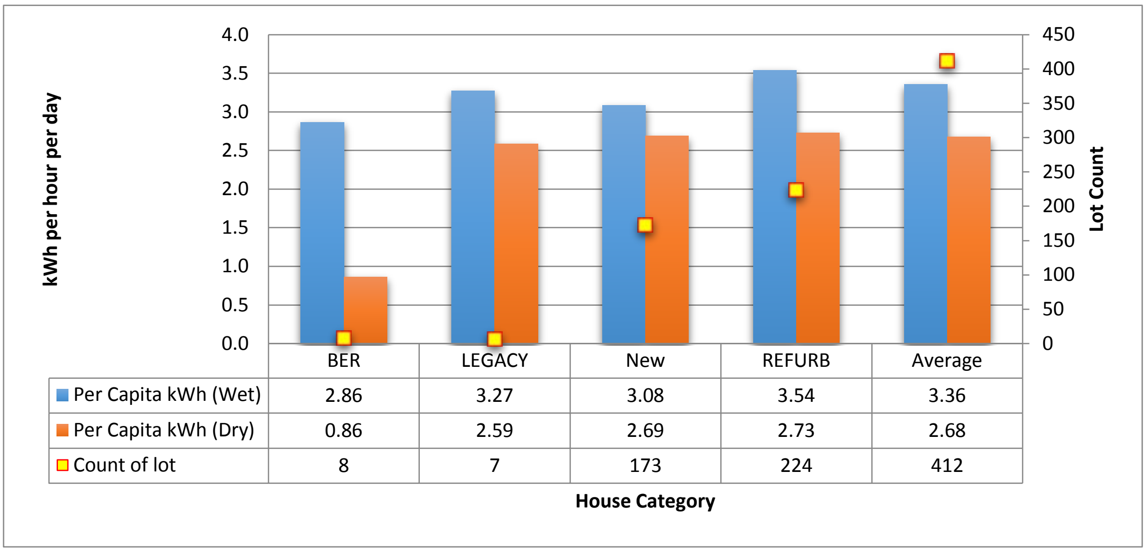
| Bedrooms | No. of houses | Average reported occupants |
|---|---|---|
| 1 | 7 | 4 |
| 2 | 99 | 8 |
| 3 | 199 | 9 |
| 4 | 81 | 11 |
| 5 | 17 | 14 |
| 6 | 8 | 13 |
| 7 | 1 | 20 |
| **Total** | **412** | **9** |

Table A10 and Figure A4 shows variation in energy consumption among different categories of houses in conjunction with the number of occupants in the dry (Apr 2014 to Oct 2014) and wet seasons (Oct 2014 to Apr 2015). During the dry season, energy consumption is recorded lower than the wet season in all categories of housing. During the wet season, the energy consumption per person is significantly higher in refurbished houses relative to other house categories. However, the difference in consumption between the two main house categories (refurbished and new) is not significant during the dry season.

*Table A10: Variation in energy consumption among different house categories per season*

| House category | Per capita kWh (Wet season) | Per capita kWh (Dry season) | Count of lot |
|---|---|---|---|
| BER | 2.86 | 0.86 | 8 |
| Legacy | 3.27 | 2.59 | 7 |
| New | 3.08 | 2.69 | 173 |
| Refurb | 3.54 | 2.73 | 224 |
| **Total/average** | **3.36** | **2.68** | **412** |

*Figure A4: Daily per capita consumption by house category*



## A.9 Summary of Taggle Data Logger Performance

Out of 663 Taggle data loggers installed by the project, the majority (more than 600) of the installations took place in the first quarter (Feb-Mar) of calendar year 2014. Only a few Taggles were installed during the rest of 2014 and most of 2015, with a batch of 30 Taggles installed towards the end of 2015 (in Galiwin'ku post-cyclone transitional housing).

A total of 98 Taggles were identified with either data issues or as having failed completely. However, at least 30 of these Taggles are from Galiwin'ku houses affected and eventually decommissioned after cyclones Lam and Nathan. As listed in the table below, nine faulty Taggles were replaced during the project, with 22 Taggles remaining as faulty but not replaced.

Of the 633 Taggle installations, approximately 15 Taggles failed each year of the project with a total of 44 Taggles failed, around 7 per cent.

*Table A11: Number of Taggles identified as non-functional*

| Community | Count of Taggles | Count of Taggle replaced | Count of replacement required | Count of demolished/ vacant houses |
|---|---|---|---|---|
| Galiwin'ku | 56 | 5 | 9 | 36 |
| Gapuwiyak | 1 | | 1 | |
| Gunyangara | 11 | | 3 | 3 |
| Milingimbi | 7 | 2 | | |
| Ramingining | 8 | 1 | 3 | 2 |
| Yirrkala | 15 | 1 | 6 | 2 |
| **Total** | **98** | **9** | **22** | **43** |

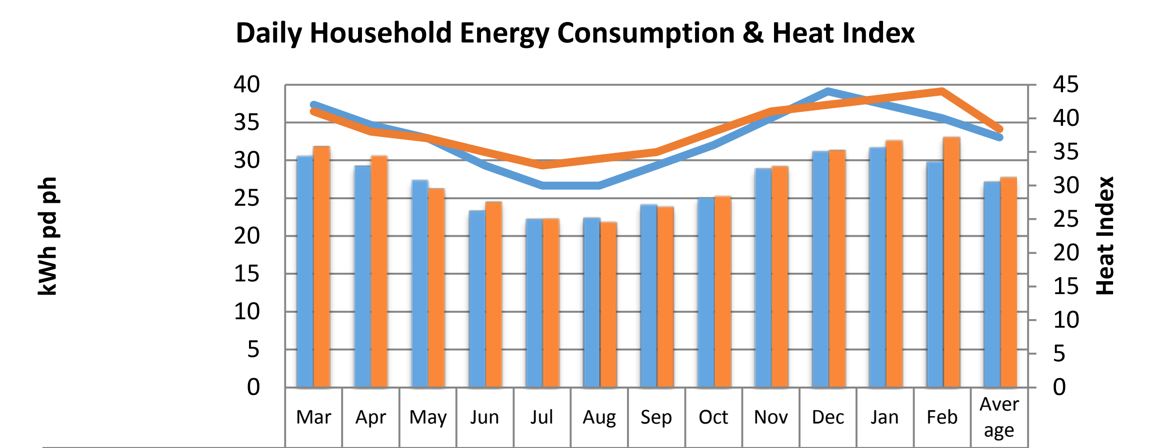
## A.10 Taggle Consistency in Number of Reads per Day

Ideally Taggle energy consumption data is transmitted every 30 minutes, with a nominal 48 transmissions per day. However, due to network strength and other technical reasons, the interval of data transmission and hence data receival has a variance in consistency. Analysis of the number of reads received per day per Taggle for the project shows 53.6 per cent of days achieved 46-48 readings, and 98.1 per cent of days receiving 40 or more reads.

## A.11 Climate and Average Household Consumption

The figure below provides average daily consumption per month across all communities for the period March to February, which reflects the availability of the Taggle data. It compares 2014-15 to 2015-16 with the average daily heat index also provided per month. The figure highlights the correlation between higher heat index and higher consumption, as well as showing the overall higher apparent temperatures for 2015 and the 2015-16 wet season.

*Figure A5: Average daily consumption and heat index per month (Mar 2014 to Feb 2016)*

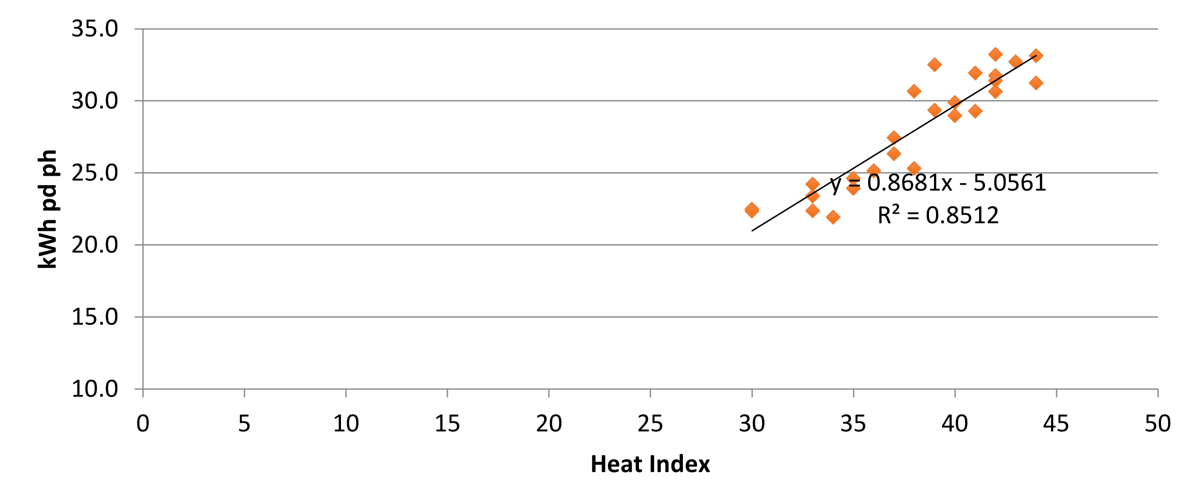



| | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Jan | Feb | Average |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2014-15 kWh pd ph | 30.7 | 29.4 | 27.4 | 23.4 | 22.3 | 22.5 | 24.2 | 25.1 | 29.0 | 31.3 | 31.7 | 29.9 | 27.2 |
| 2015-16 kWh pd ph | 31.9 | 30.7 | 26.3 | 24.6 | 22.4 | 21.9 | 23.9 | 25.3 | 29.3 | 31.4 | 32.7 | 33.1 | 27.8 |
| 2014-15 Heat Index | 42 | 39 | 37 | 33 | 30 | 30 | 33 | 36 | 40 | 44 | 42 | 40 | 37 |
| 2015-16 Heat Index | 41 | 38 | 37 | 35 | 33 | 34 | 35 | 38 | 41 | 42 | 43 | 44 | 38 |

The daily average consumption for all participating households is presented for the period March 2014 (when the Taggle installations were completed) to December 2015, with 2014 and 2015 data provided as side-by-side columns per month. They are overlaid with the heat index—a combination of temperature and humidity—as calculated for each month. This combination shows the strong correlation between the heat index and average daily consumption for both years, and it also shows that the dry season (May-October) of 2015 was substantially hotter than that of 2014.

Figure A6 below provides an alternative view of the strong correlation between heat index and energy consumption, using data for March 2014 to April 2016.

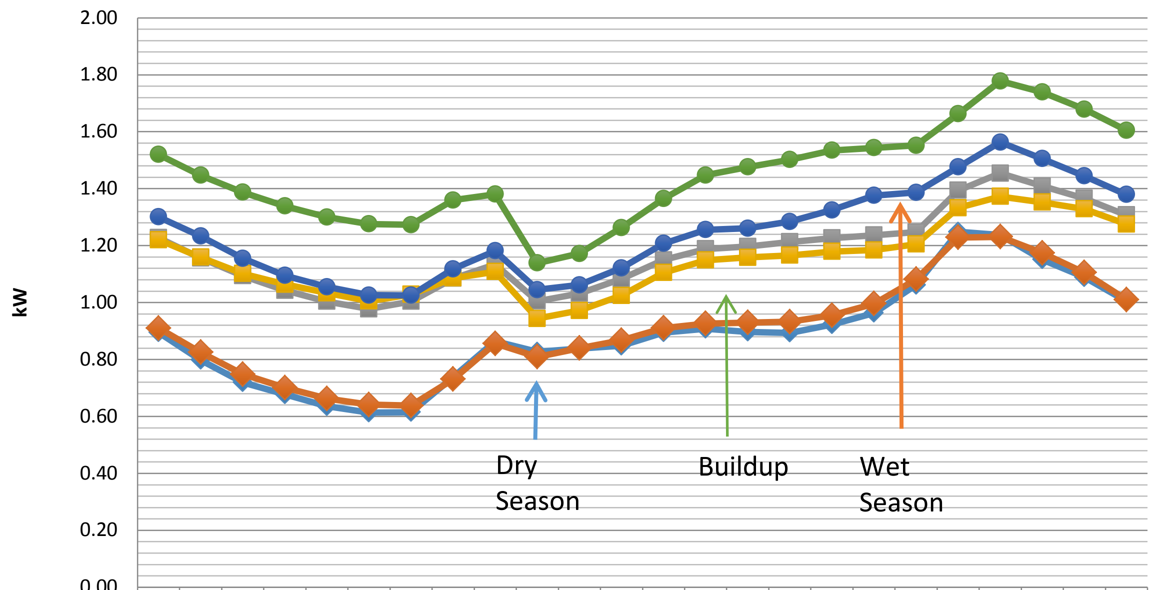
*Figure A6: Correlation between heat index and average daily consumption*



## A.12 Household Power Load Curve

The average household intra-day load curve is derived from the Taggle data from March 2015 to February 2016 for all communities. It represents the average house power load (kW) within a day from left to right and variation along the months and years as separate lines, as shown in the figure below. The daily pattern of consumption is similar between different periods, but the magnitude varies between the dry season, build-up and then wet season months. Unsurprisingly, the highest load can be observed for February 2016, which was also one of the hottest recorded to date for that month.

*Figure A7: Household intra-day demand load curve*




| | 12:00 AM | 1:00 AM | 2:00 AM | 3:00 AM | 4:00 AM | 5:00 AM | 6:00 AM | 7:00 AM | 8:00 AM | 9:00 AM | 10:00 AM | 11:00 AM | 12:00 PM | 1:00 PM | 2:00 PM | 3:00 PM | 4:00 PM | 5:00 PM | 6:00 PM | 7:00 PM | 8:00 PM | 9:00 PM | 10:00 PM | 11:00 PM |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| July-14 | 0.89 | 0.80 | 0.72 | 0.68 | 0.64 | 0.61 | 0.61 | 0.74 | 0.86 | 0.83 | 0.84 | 0.85 | 0.89 | 0.91 | 0.90 | 0.89 | 0.92 | 0.96 | 1.06 | 1.25 | 1.24 | 1.15 | 1.09 | 1.01 |
| July-15 | 0.91 | 0.83 | 0.75 | 0.70 | 0.66 | 0.64 | 0.64 | 0.73 | 0.86 | 0.81 | 0.84 | 0.87 | 0.91 | 0.93 | 0.93 | 0.93 | 0.96 | 1.00 | 1.08 | 1.23 | 1.23 | 1.17 | 1.11 | 1.01 |
| Nov-14 | 1.23 | 1.16 | 1.09 | 1.04 | 1.00 | 0.98 | 1.00 | 1.08 | 1.13 | 1.01 | 1.03 | 1.08 | 1.15 | 1.19 | 1.20 | 1.21 | 1.23 | 1.24 | 1.25 | 1.39 | 1.45 | 1.41 | 1.37 | 1.31 |
| Nov-15 | 1.22 | 1.16 | 1.10 | 1.06 | 1.03 | 1.01 | 1.03 | 1.09 | 1.11 | 0.94 | 0.97 | 1.02 | 1.11 | 1.15 | 1.16 | 1.17 | 1.18 | 1.18 | 1.21 | 1.33 | 1.37 | 1.35 | 1.33 | 1.28 |
| Feb-15 | 1.30 | 1.23 | 1.15 | 1.10 | 1.05 | 1.03 | 1.03 | 1.12 | 1.18 | 1.04 | 1.06 | 1.12 | 1.21 | 1.26 | 1.26 | 1.28 | 1.32 | 1.38 | 1.39 | 1.48 | 1.56 | 1.51 | 1.44 | 1.38 |
| Feb-16 | 1.52 | 1.45 | 1.39 | 1.34 | 1.30 | 1.28 | 1.27 | 1.36 | 1.38 | 1.14 | 1.17 | 1.26 | 1.36 | 1.45 | 1.48 | 1.50 | 1.53 | 1.54 | 1.55 | 1.66 | 1.78 | 1.74 | 1.68 | 1.60 |

July-14 July-15 Nov-14 Nov-15 Feb-15 Feb-16

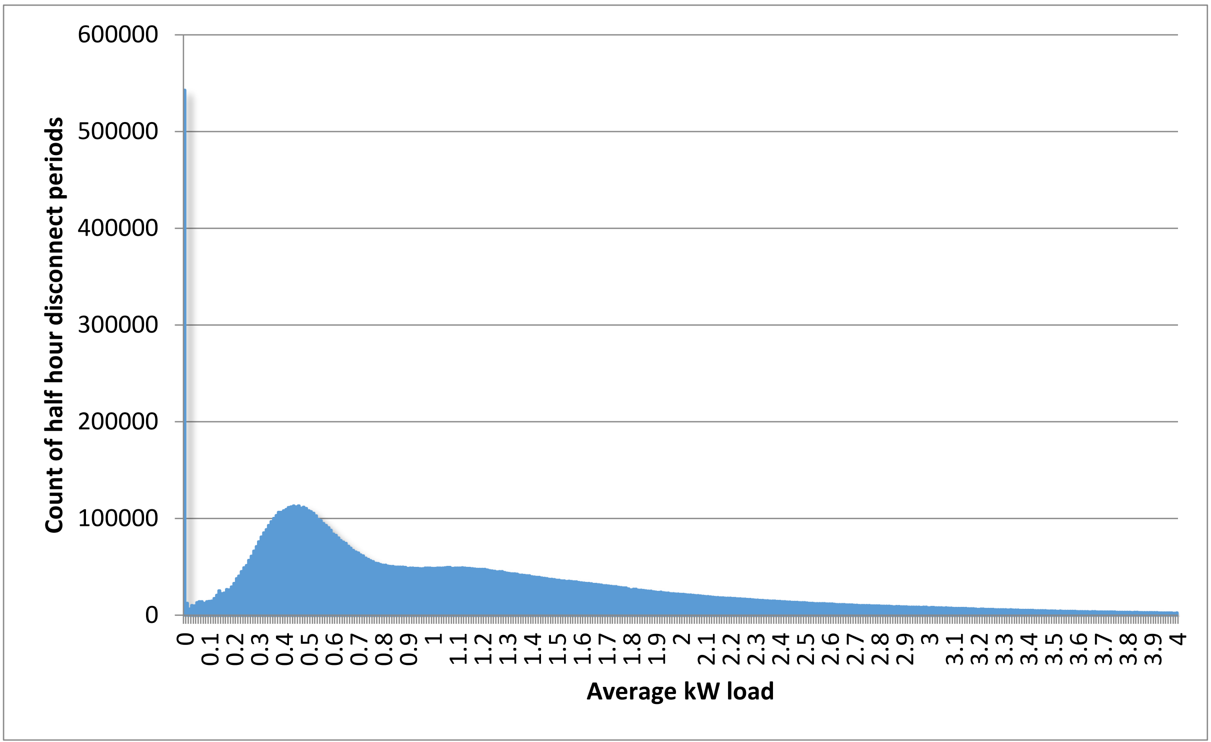
## A.13 Taggle Average Load Histogram

Figure A8 provides a histogram of half-hourly average power load for Taggle reads from March 2014 to February 2016, excluding Galiwin'ku as a whole due to the significant data issues from damaged and vacated houses and any other houses with known data issues.

A prominent feature is the spike at zero, representing periods of no or very low consumption due to power outages and to the occurrence of disconnection of the pre-payment meter due to no credit. The bulk of the graph can be thought of as two overlaid bell curves, one for houses without air-conditioning that peaks at 0.44kW, and a second broader, flatter curve for houses with one, two or more air-conditioners. The long tail would include Taggle reads that have collated energy consumption over a long period but that is interpreted as being within a day.

The average is 1.17kW, which translates into a daily average consumption of 28 kWh for this subset of data.

*Figure A8: Histogram of average load (2 years of data, 5 communities)*




## A.14 Disconnection Events

The following analysis of disconnection events uses Taggle data from March 2014 to February 2016. Only houses with useful data have been included, and Galiwin'ku as a whole is excluded because of the impact of Cyclone Lam on its housing situation in 2015. Community-wide planned and unplanned outages time periods have not been removed from the analysis.

The project did not have access to actual disconnect event data from the meters, so disconnections are inferred from the presence of an average power load of less than 0.003kW (three watts). Disconnections that occur partway through a half-hourly Taggle read period will result in a reduction in the average power for that period. It should be noted that relying on the reads below 3W is therefore an underestimate of disconnection length.

On the simple assumption that most disconnections would only span one half-hour period, and that on average they would extend 15 minutes either side of the full zero read, then the average disconnection length should be increased by 30 minutes.

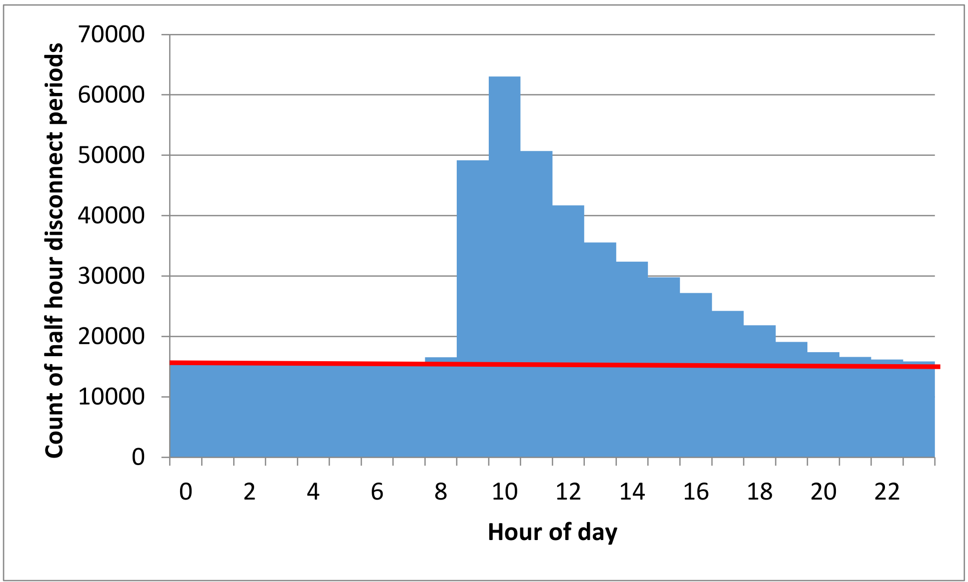
The average length of disconnections was calculated and is summarised in Table A12. The odd result in the one to two-day band is a distortion of the data due to the effects of Cyclone Lam in late February 2015, which resulted in loss of resolution of the Taggle system due to the central receiver being down. The salient feature is that disconnections are bunched around intraday disconnections combined with a set of longer multi-day disconnections, with one to two-day disconnections rare.

*Table A12: Length of disconnection events*

| Days spanned | Number of occurrences | Total hours of disconnect | Adjusted hours of disconnect | % of total disconnect | Adjusted average length |
|---|---|---|---|---|---|
| 0 | 48537 | 151104 | 175373 | 59.1% | 3.61 h |
| 1 to 2 | 23 | 1318 | 1329 | 0.4% | 2.41 d |
| 3 to 7 | 597 | 47074 | 47372 | 16.0% | 3.31 d |
| 8 to 14 | 78 | 19414 | 19453 | 6.6% | 10.39 d |
| 15 to 21 | 24 | 10771 | 10783 | 3.6% | 18.72 d |
| > 21 | 42 | 42622 | 42643 | 14.4% | 42.30 d |
| **Total** | **49301** | **272302** | **296952** | **100.0%** | **6.02 h** |

A summary of the starting time of disconnections helps clarify this result, as shown in the figure below. The figure displays a consistent baseline of full-day disconnections capped with a peak that aligns with the 9am end of the no-disconnect overnight grace period programmed into the meters. The pre-payment meters actually disconnect after the next full kWh is consumed past 9am, which would result in many disconnections happening at 9:30 am or later and thus only appearing in Taggle reads labelled as (the half hour leading up to) 10am and later.

*Figure A9: Disconnections by time of day (2 years of data, 5 communities)*




The area of the peak above the base-line represents 38 per cent of all disconnection/no power reads. This can be interpreted as representing the proportion of disconnection time resulting from the 9am end of no-disconnect period.

Average daily disconnection time per month is presented in the Figure A10, separating 2014-15 and 2015-16. This highlights the spike in February 2015, as well as a general reduction in 2015.

*Figure A10: Relative disconnect time by month*

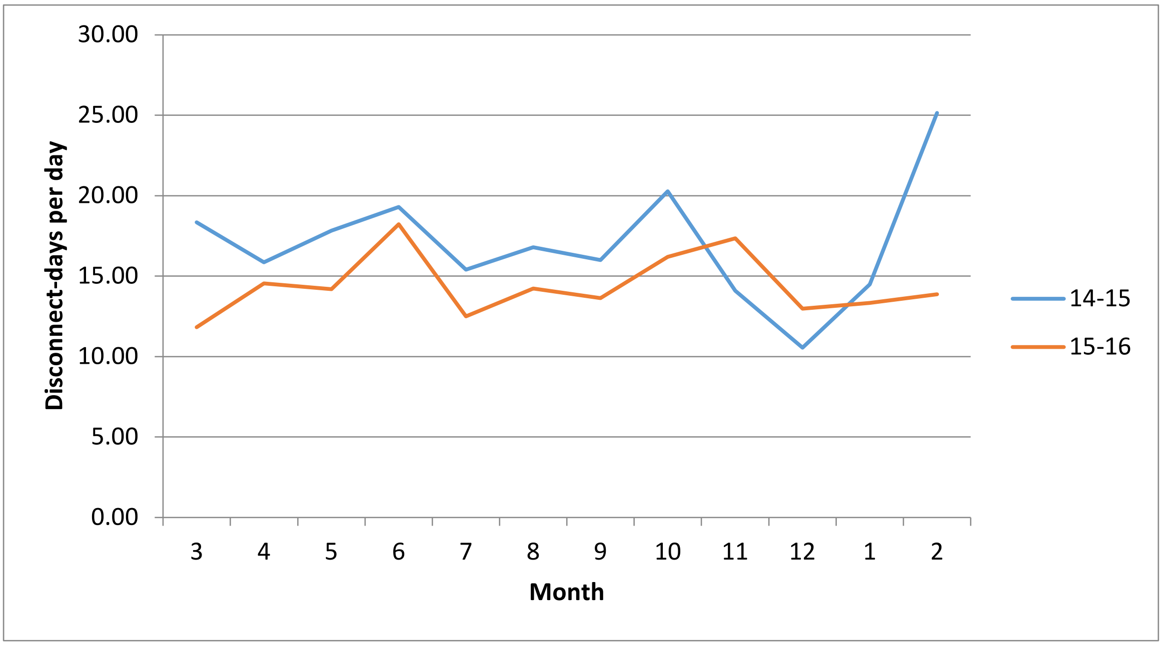



Table A13 summarises disconnections, comparing 2014-15 to 2015-16. It separates disconnections lasting less than one day from multi-day events. Note again that known power system outages have not been removed from this initial analysis.

Average daily disconnection was around 40 minutes per day early in the project and reduced to just over 35 minutes per day per house on average for 2015-16. In addition, the smaller group of houses experiencing multi-day disconnections amounted to an additional average of 29 minutes per day per house.

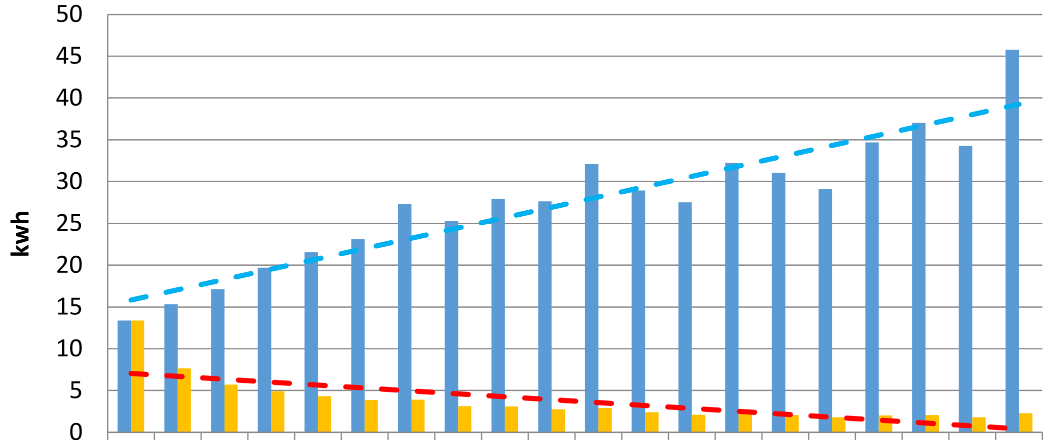
*Table A13: Disconnection data for LIEEP communities excluding Galiwin'ku*

| Period | Mar-14 - Feb-15 | Mar-15 - Feb-16 |
|---|---|---|
| Average # houses with data | 381.0 | 385.6 |
| Days in period | 365 | 366 |
| Total hours of data | 3337463 | 3387087 |
| Adjusted intra-day disconnect time (hours) | 91887 | 83485 |
| Average minutes per day per house | 39.6 | 35.5 |
| Number of disconnections | 24704 | 23833 |
| Average # disconnections per lot | 64.8 | 61.8 |
| Multi-day disconnect time (hours) | 68241 | 56283 |
| Average minutes per day per house | 29.4 | 23.9 |
| Total disconnect hours | 160128 | 139768 |
| Average minutes per day per house - total (mins) | 69.1 | 59.4 |

## A.15 Occupancy Vs Energy Consumption

Figure A11 presents a comparison of number of occupants per house against average daily consumption. The blue trend line indicates that as the number of occupants increases, household energy consumption rises as well. In contrast, as the number of occupants increases, energy consumption per person tends to diminish.

*Figure A11: LIEEP household average daily kWh per day per house and per capita per day*



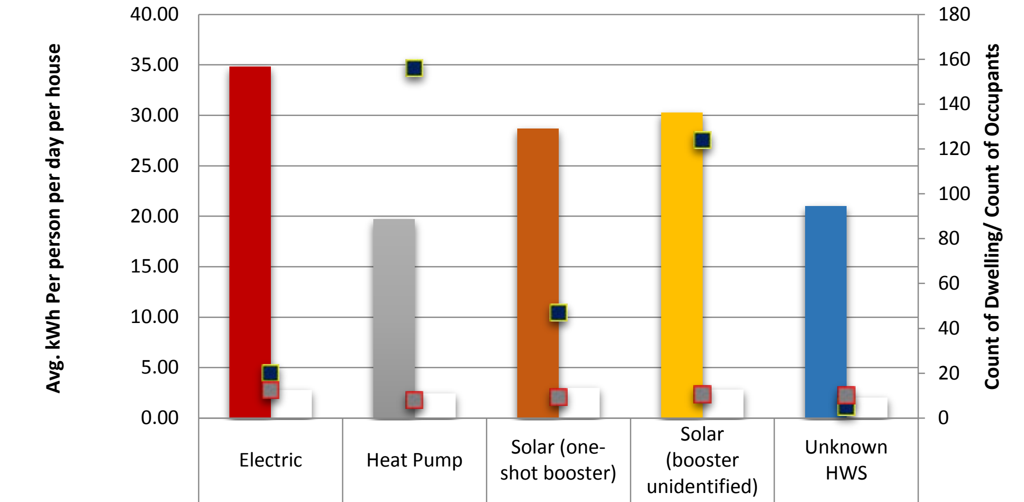

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Average kWh pd ph | 13.4 | 15.3 | 17.1 | 19.7 | 21.6 | 23.1 | 27.3 | 25.3 | 28.0 | 27.6 | 32.1 | 28.9 | 27.5 | 32.2 | 31.1 | 29.1 | 34.7 | 37.0 | 34.3 | 45.8 |
| Per Capita kWh pd | 13.4 | 7.7 | 5.7 | 4.9 | 4.3 | 3.9 | 3.9 | 3.2 | 3.1 | 2.8 | 2.9 | 2.4 | 2.1 | 2.3 | 2.1 | 1.8 | 2.0 | 2.1 | 1.8 | 2.3 |

## A.16 Pre-Existing Hot Water System vs Energy Consumption

Figure A12 shows the average household energy consumption grouped as a function of the hot water systems. The smallest sample, only 24 houses, is those with a conventional electric hot water system. Energy consumption in these houses is especially high. Energy consumption in the 151 houses with an existing heat pump hot water system is especially low. These represent new houses, with the average age of the heat pumps correspondingly low. New households also have lower occupancy and fewer air-conditioners.

A significant number of houses had a solar hot water system installed, with one-shot electric booster control or an unknown booster control status. The energy consumption of these houses is higher than houses with the heat pump. However, information on the age and condition of the solar hot water system and its effective solar gain is limited.

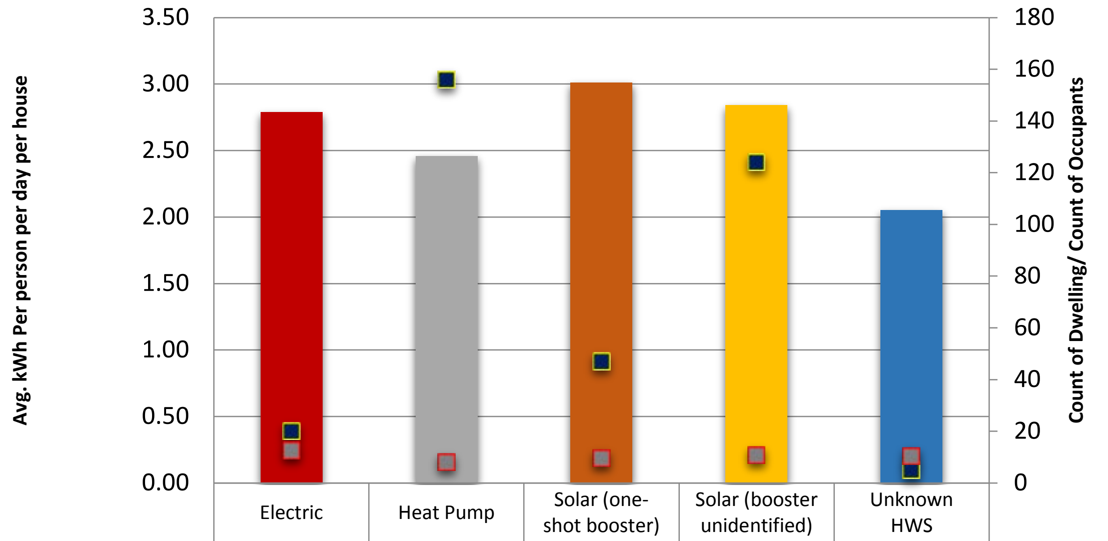
*Figure A12: Average household energy consumption (kWh) grouped as a function of the hot water systems (April 2014 to April 2015)*




| | Electric | Heat Pump | Solar (one-shot booster) | Solar (booster unidentified) | Unknown HWS |
|---|---|---|---|---|---|
| Avg. kWh pd ph | 34.85 | 19.70 | 28.70 | 30.28 | 21.01 |
| Avg. kWh pp pd ph | 2.79 | 2.46 | 3.01 | 2.84 | 2.05 |
| Count of Dwellings | 20 | 156 | 47 | 124 | 5 |
| Avg. of Occupants | 12.5 | 8.0 | 9.5 | 10.7 | 10.3 |

Figure A13 provides the same data converted to per-occupant per day consumption, which shows that houses with an older solar hot water system are using more power per person per day than those with an electric system.

*Figure A13: Average household energy consumption (kWh) for hot water systems compared to per-occupant per day consumption (April 2014 to April 2015)*



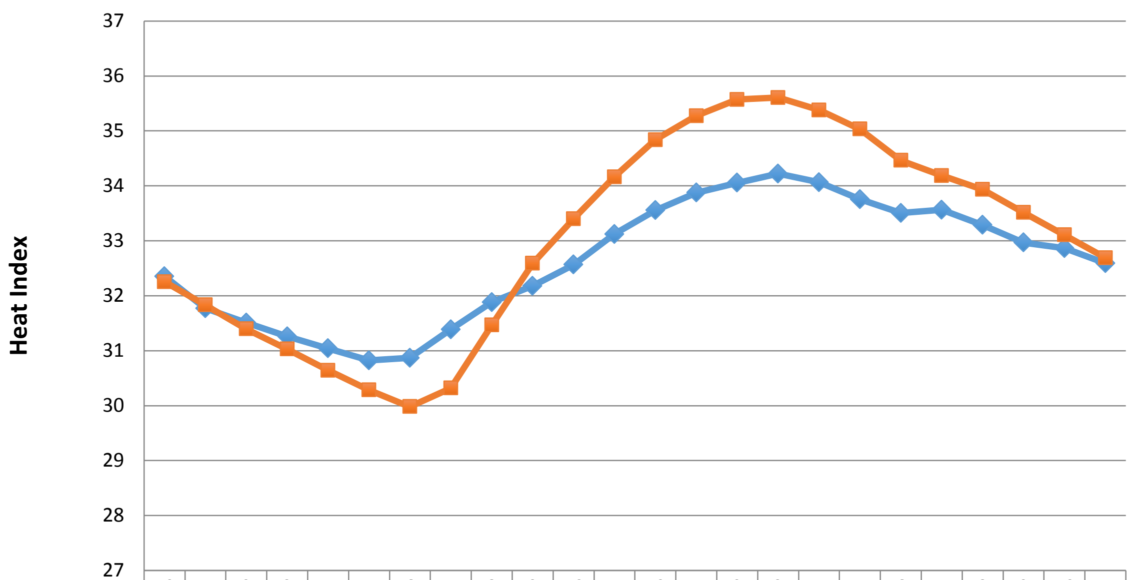

| | Electric | Heat Pump | Solar (one-shot booster) | Solar (booster unidentified) | Unknown HWS |
|---|---|---|---|---|---|
| Avg. kWh pp pd ph | 2.79 | 2.46 | 3.01 | 2.84 | 2.05 |
| Count of Dwellings | 20 | 156 | 47 | 124 | 5 |
| Avg. of Occupants | 12.5 | 8.0 | 9.5 | 10.7 | 10.3 |

## A.17 Ramingining Thermal Comfort and Tracking Study Results

Temperature and humidity data was obtained from the six houses participating in the thermal comfort study in Ramingining, with separate loggers installed in living area and bedrooms. The temperature and humidity was combined to construct an average internal heat index, comparing new houses and refurbished.

The heat index in living areas was found to be higher in refurbished houses during peak electricity consumption hours of the day, as shown in Figure A14. However, further analysis is required to discount the potential for air-conditioning to have been contributing to this finding—one house was identified as having an air-conditioner in the living space.

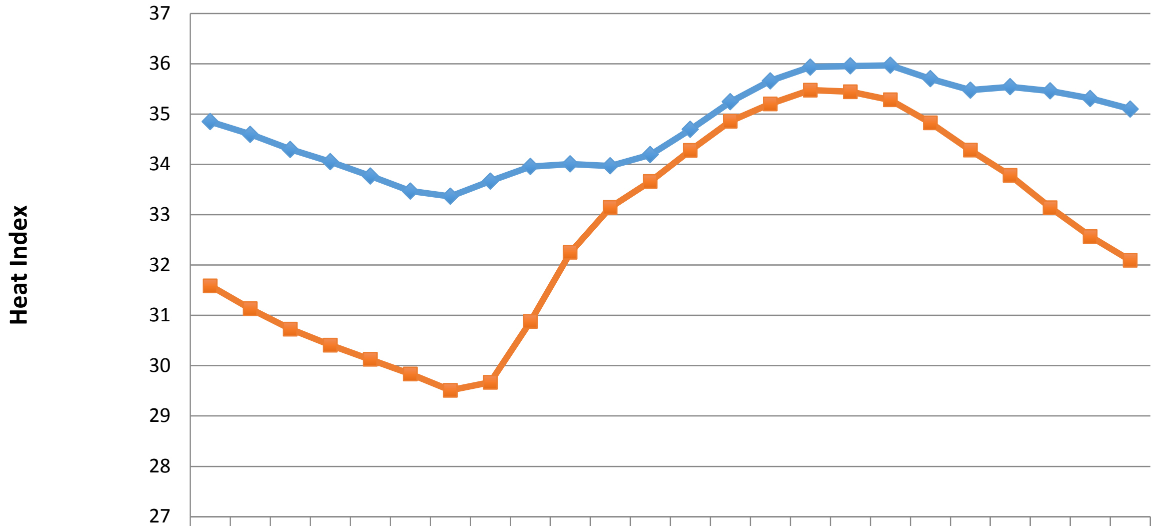
*Figure A14: Intra-day heat index for living areas in six Ramingining study houses*




| | 12 AM | 1 AM | 2 AM | 3 AM | 4 AM | 5 AM | 6 AM | 7 AM | 8 AM | 9 AM | 10 AM | 11 AM | 12 PM | 1 PM | 2 PM | 3 PM | 4 PM | 5 PM | 6 PM | 7 PM | 8 PM | 9 PM | 10 PM | 11 PM |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| New | 32 | 32 | 32 | 31 | 31 | 31 | 31 | 31 | 32 | 32 | 33 | 33 | 34 | 34 | 34 | 34 | 34 | 34 | 34 | 34 | 33 | 33 | 33 | 33 |
| Refurb | 32 | 32 | 31 | 31 | 31 | 30 | 30 | 30 | 31 | 33 | 33 | 34 | 35 | 35 | 36 | 36 | 35 | 35 | 34 | 34 | 34 | 34 | 33 | 33 |

The heat index in bedrooms is similar to the heat index in the living area for refurbished houses. However, the heat index is significantly higher in new house bedrooms compared to refurbished houses, as shown in Figure A15.

*Figure A15: Intra-day heat index for bedrooms in six Ramingining study houses*




| | 12 AM | 1 AM | 2 AM | 3 AM | 4 AM | 5 AM | 6 AM | 7 AM | 8 AM | 9 AM | 10 AM | 11 AM | 12 PM | 1 PM | 2 PM | 3 PM | 4 PM | 5 PM | 6 PM | 7 PM | 8 PM | 9 PM | 10 PM | 11 PM |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| New | 35 | 35 | 34 | 34 | 34 | 33 | 33 | 34 | 34 | 34 | 34 | 34 | 35 | 35 | 36 | 36 | 36 | 36 | 36 | 35 | 36 | 35 | 35 | 35 |
| Refurbished | 32 | 31 | 31 | 30 | 30 | 30 | 30 | 30 | 31 | 32 | 33 | 34 | 34 | 35 | 35 | 35 | 35 | 35 | 35 | 34 | 34 | 33 | 33 | 32 |

The study included energy logging on hot water systems and stoves for the second half of 2015. These appliances were chosen because they are wired on a dedicated circuit at the switchboard and because of the project's focus on hot water and stove timer retrofits. Table A14 provides a summary of the results. Due to the small sample size, these results provide a limited insight, but they do demonstrate the variability of consumption patterns between appliances, the impact of hot water system type and the significant consumption from the stove.

*Table A14: Energy consumption of individual appliances from Ramingining study*

| House status | Bedrooms | Occupants | Existing HWS | Capacity (L) | Retrofit (19-21 Nov 2015) | Avg. kWh pd | HWS kWh pd | HWS kWh pp pd | HWS KL pd | HWS L pp pd | HWS kWh/kL | Stove kWh pd | Stove kWh pp pd | % HWS | % stove |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Refurb | 4 | 9 | Solahart Black Chrome | 300 | Ceiling insulation | 36.1 | 3.8 | 0.422 | 0.1 | 11.1 | 38 | 1 | 0.11 | 12% | 3% |
| Refurb | 4 | 16 | Solahart Black Chrome | 300 | Solahart 302J | 55.6 | 11.6 | 0.725 | 0.3 | 18.8 | 38.7 | 6.6 | 0.41 | 26% | 13% |
| Refurb | 4 | 11 | Solahart Black Chrome | 300 | Solahart 302J | 65.5 | 13.6 | 1.236 | | | | | 0.00 | 23% | |
| Refurb | 5 | 13 | Solahart | 300 | Solahart 302J | 27.7 | 0.5 | 0.038 | 0.3 | 23.1 | 1.7 | 1.8 | 0.14 | 2% | 6% |
| New | 2 | 6 | DUX | 160 | PAR 38 LED | 26.1 | 0.8 | 0.133 | 0.2 | 33.3 | 4.0 | 0.9 | 0.15 | 3% | 3% |
| New | 2 | 3 | DUX | 160 | None | 11.8 | 0.6 | 0.200 | | | | 2.4 | 0.80 | 5% | 19% |
| Average | 3.5 | 9.7 | | | | 37.1 | 5.2 | | 0.2 | | 26.0 | 2.5 | 0.26 | 12% | 9% |
| SHW average | | 12.25 | | | | 46.2 | 7.38 | 0.61 | 0.23 | 17.65 | 26.11 | 3.13 | 0.17 | 16% | 7% |
| HP average | | 4.5 | | | | 19.0 | 0.70 | 0.17 | 0.20 | 33.33 | 4.00 | 1.65 | 0.48 | 4% | 11% |

## A.18 Comparison of Energy and Water Use in Milingimbi

The Manymak Energy Efficiency Project included the installation of smart water meters in Milingimbi as an in-kind activity by IES Pty Ltd. The data from those meters did not form part of the deliverables of the project but is analysed here to identify correlations between energy and water use.

The initial analysis is comparison of average daily energy consumption and average daily water consumption by each of the 110 identified lots in Milingimbi for the 2014-15 financial year. In Milingimbi, 110 houses are identified as having good quality energy consumption data through the Taggle system and water consumption through the Itron water meter system. The two data sources are combined with information collected through LIEEP, such as reported occupancy and analysed through various approaches below.

The overall correlation between energy consumption and water consumption is not strong as shown in Figure A16.

*Figure A16: Correlation between average daily energy and water use in Milingimbi*

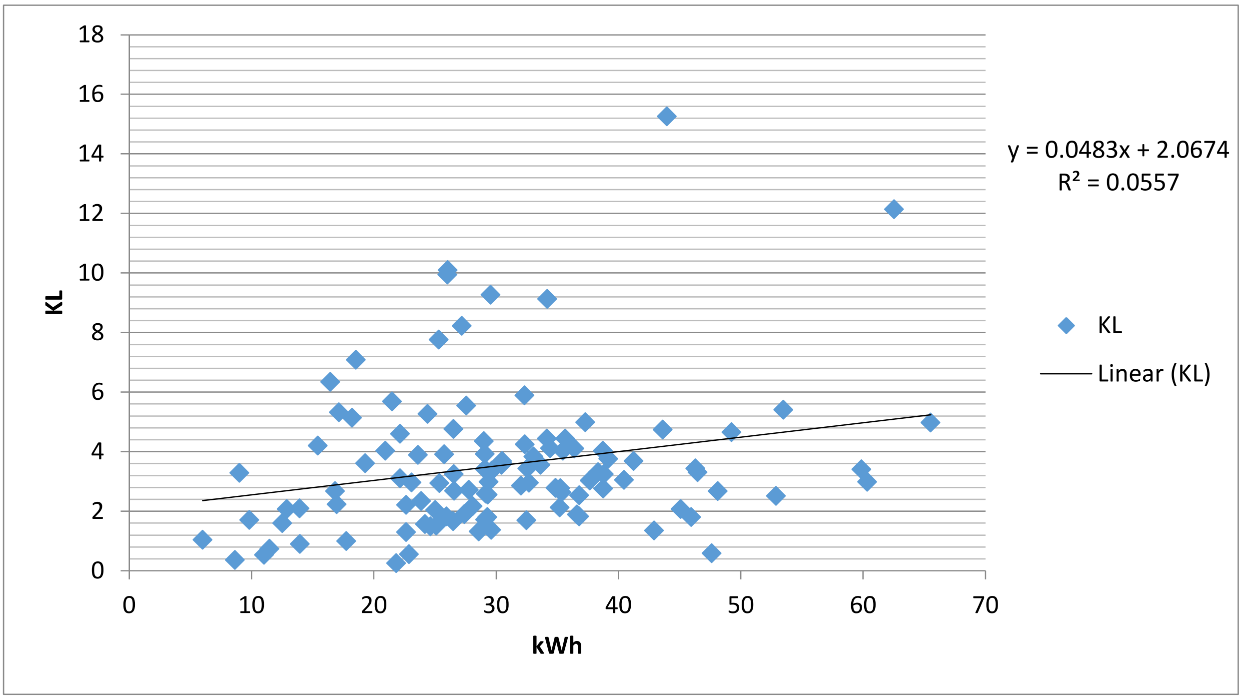
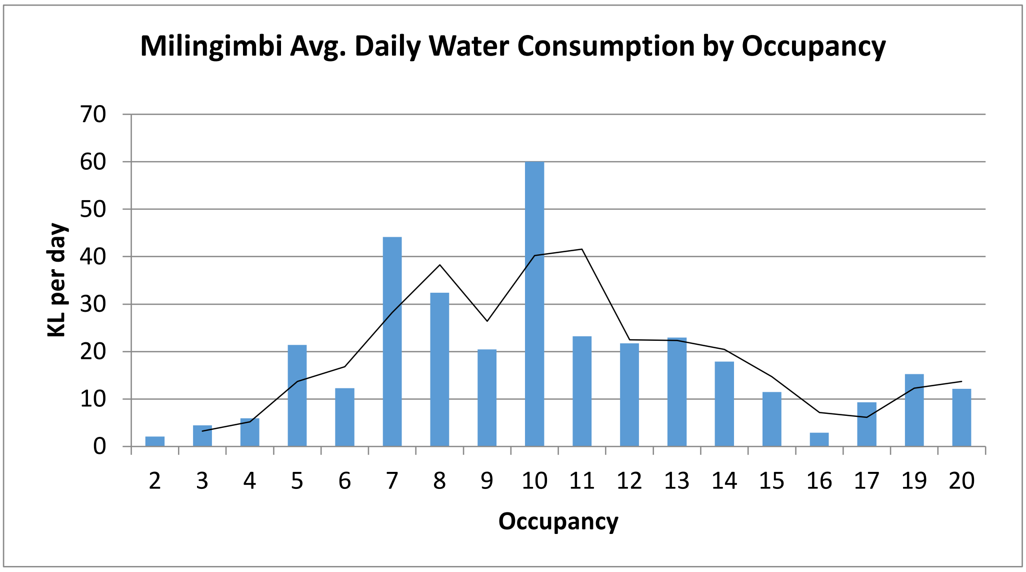



Figure A17 shows the correlation analysis is between water consumption and reported occupancy. The data is grouped by number of reported occupants and average daily water consumption for each occupancy group. No significant correlation between occupancy and water consumption is apparent in comparison to the significant correlation identified between occupancy and energy.

*Figure A17: Correlation between average daily energy and water use in Milingimbi*




Water consumption was analysed against the housing type, with the results summarised in Table A15. The reported occupancy is found to be a bit higher in refurbished houses compared to new houses, which translates to about 21 per cent lower energy consumption in new houses. However, the difference in water consumption is 51 per cent between new and refurbished houses.

*Table A15: Water and energy use average by house type*

| House status | Count of lot | Average occupancy | Average kWh pd | Average KL pd |
|---|---|---|---|---|
| New | 65 | 8.8 | 27.60 | 2.92 |
| Refurbished | 45 | 10.0 | 33.57 | 4.42 |
| **Total/average** | **110** | **9.3** | **30.04** | **3.53** |

## A.19 Data Results from Project Trials

**Community engagement activity summary**

Table A16 lists the number of eligible houses in each community (all of which were fitted with energy loggers), the number of barrier surveys conducted, the number of houses approached and the number of households in which an appliance survey was completed. The table also indicates the number of transitional houses in Galiwin'ku built after the cyclone to accommodate people after their houses were demolished. Furthermore, the table specifies the number of initial knowledge and behaviour (KAB) and final KAB surveys, which were completed only in Milingimbi.

*Table A16: Summary of household engagement trials*

| Community | Data loggers installed | Barrier survey | Houses approached | KAB survey initial | KAB survey final | Appliance survey |
|---|---|---|---|---|---|---|
| Galiwin'ku | 216 | 23 | 159 | | | 150 |
| Gapuwiyak | 102 | | 102 | | | 102 |
| Gunyangara | 29 | | 24 | | | 22 |
| Milingimbi | 115 | | 114 | 111 | 49 | 111 |
| Ramingining | 85 | | 83 | | | 76 |
| Yirrkala | 86 | 19 | 82 | | | 72 |
| Galiwin'ku transitional | 30 | | | | | 0 |
| Total | 663 | 42 | 564 | 111 | 49 | 533 |
| **Target** | **620** | **40** | **440** | | | |

*Table A17: Technology trials summary*

| Community | SHWS | HPHWS | Stove timer | Cool-bro | Eco-switch | Batts | PAR-38 | Total retrofits | BEEBox |
|---|---|---|---|---|---|---|---|---|---|
| Galiwin'ku | 10 | 52 | 74 | 10 | | | | 146 | 80 |
| Gapuwiyak | 34 | | | | | 16 | 7 | 57 | 39 |
| Gunyangara | 8 | | 19 | 3 | 9 | 3 | | 42 | 10 |
| Milingimbi | 14 | 32 | 76 | 3 | 3 | | | 128 | 59 |
| Ramingining | 35 | | | | | 12 | 6 | 53 | 26 |
| Yirrkala | 13 | 3 | 40 | | | 16 | | 72 | 38 |
| **Total** | **114** | **87** | **209** | **16** | **12** | **47** | **13** | **498** | **252** |

All hot water system installations were a replacement of an existing system. The breakdown of the type of system replaced per retrofit type is given in Table A18. It shows that the majority of heat pump installs were replacements of electric storage hot water, while the majority of solar installs were replacements of older existing solar hot water units (like for like).

*Table A18: Hot water system retrofit categories*

| Retrofit | Replace electric storage HWS | Replace heat pump HWS | Replace old solar HWS | Total retrofits |
|---|---|---|---|---|
| Heat pump HWS | 74 | 1 | 12 | **87** |
| Solar HWS | 16 | 0 | 98 | **114** |
| **Total** | **90** | **1** | **110** | **201** |

**Overlap and timing of technology trials**

The project aimed for a saturation approach, with technology targets representing 80 per cent of potential houses receiving a retrofit and 40 per cent receiving a BEEBox. The resultant overlap of the trials is explored by grouping technology treatments in to three categories as BEEBox trial, stove timer trial and major retrofits (heat pump HWS, solar HWS and ceiling insulation). This is presented in Table A19. The minor retrofit items, Ecoswitch and Heater Mate, are excluded due to the low numbers and low confidence in their successful implementation by households.

Further, the number of houses with quality Taggle energy consumption data is identified and included in the table.

*Table A19: Summary of technology trial overlap*

| Combination | BEEBox | Stove timer | Major retrofit (HWS upgrade or insulation) | Count # houses - all | Count # houses - with useful Taggle data |
|---|---|---|---|---|---|
| No technology trial | N | N | N | 150 | 118 |
| Major retrofit only | N | N | Y | 142 | 135 |
| Stove timer only | N | Y | N | 81 | 72 |
| BEEBox only | Y | N | N | 56 | 48 |
| BEEBox and major | Y | N | Y | 76 | 70 |
| BEEBox and timer | Y | Y | N | 98 | 91 |
| Dual retrofit only | N | Y | Y | 8 | 7 |
| All three | Y | Y | Y | 22 | 22 |
| | | | **Total** | **633** | **563** |

*Table A20: Summary of houses without retrofit or BEEBox approached*

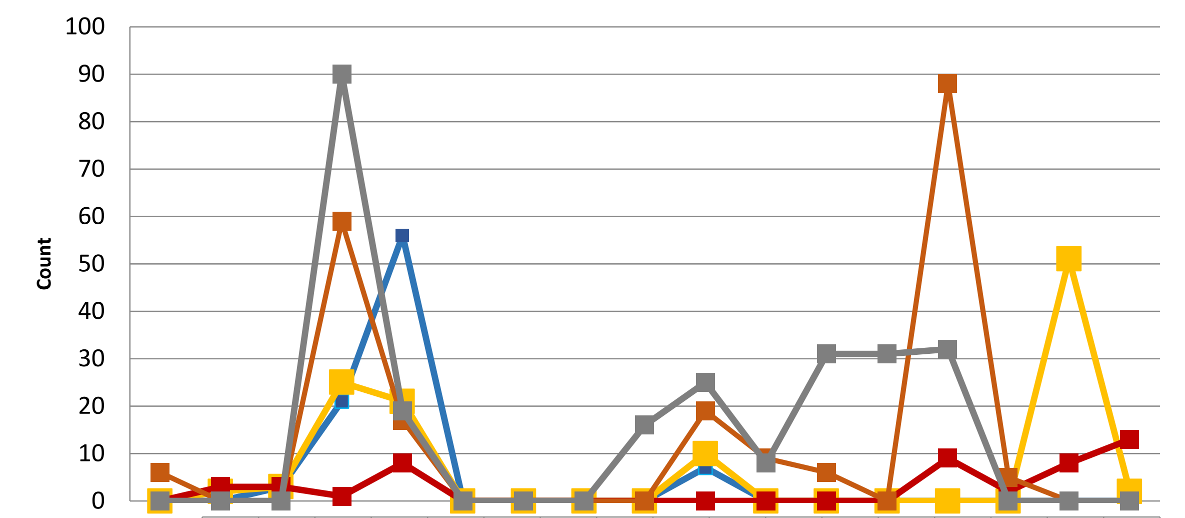
| Community | Lots | No retrofit or BEEBox | Approached | Not approached |
|---|---|---|---|---|
| Milingimbi | 115 | 8 | 7 | 1 |
| Galiwin'ku | 216 | 55 | 29 | 26 |
| Gapuwiyak | 102 | 33 | 33 | 0 |
| Gunyangara | 29 | 7 | 3 | 4 |
| Yirrkala | 86 | 16 | 13 | 3 |
| Ramingining | 85 | 31 | 29 | 2 |
| **Total** | **633** | **150** | **114** | **36** |

In total, 57 houses in Galiwin'ku were not approached to participate. However, 24 out of these 57 houses were vacated or unoccupied during the cyclone period.

Ideally, the impact of each of these combinations would be analysed individually. However, an additional complexity was the gradual roll-out of the trials with limited opportunity to set baseline and comparison data after treatment. Therefore, the majority of the impact analysis presented below is done by setting intermediate baselines and comparable after treatment period depending on time and type of treatment.

The roll-out of the technology trials over the duration of the project is summarised in the Figure A18.

*Figure A18: Timeline of technology trial roll-out*

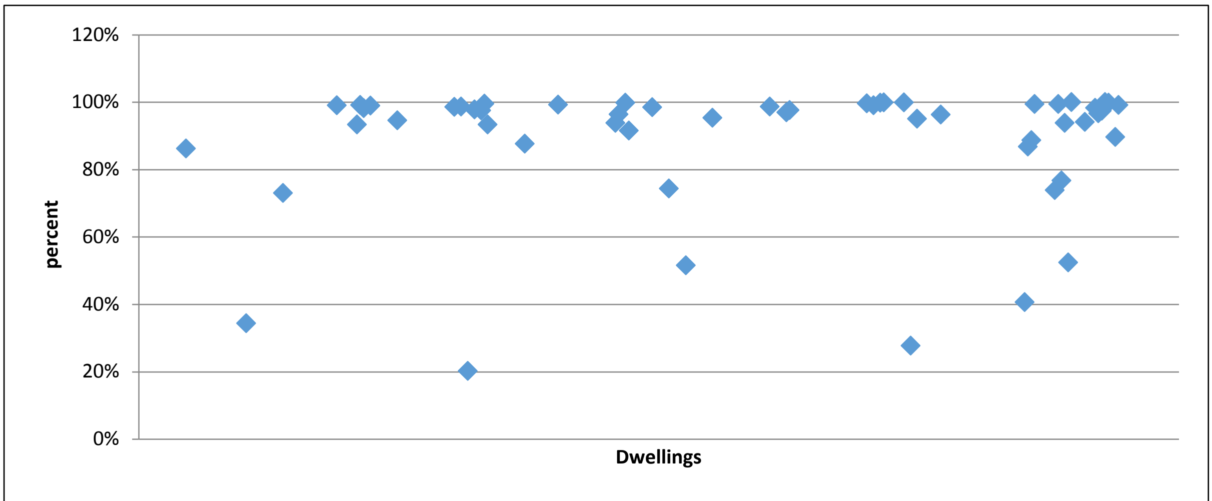



| | Aug-14 | Sep-14 | Oct-14 | Nov-14 | Dec-14 | Jan-15 | Feb-15 | Mar-15 | Apr-15 | May-15 | Jun-15 | Jul-15 | Aug-15 | Sep-15 | Oct-15 | Nov-15 | Dec-15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Heat Pump | 0 | 0 | 3 | 21 | 56 | 0 | 0 | 0 | 0 | 7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Solar | 0 | 2 | 3 | 25 | 21 | 0 | 0 | 0 | 0 | 10 | 0 | 0 | 0 | 0 | 0 | 51 | 2 |
| Insulation | 0 | 3 | 3 | 1 | 8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 9 | 2 | 8 | 13 |
| Stove Timer | 6 | 0 | 0 | 59 | 17 | 0 | 0 | 0 | 0 | 19 | 9 | 6 | 0 | 88 | 5 | 0 | 0 |
| BEEBox | 0 | 0 | 0 | 90 | 19 | 0 | 0 | 0 | 16 | 25 | 8 | 31 | 31 | 32 | 0 | 0 | 0 |

**BEEBox data extract results**

The data extraction from 55 BEEBoxes out of the 59 BEEBoxes installed in Milingimbi was received in April 2015. The level of energy consumption derived from the BEEBox aligns with the level of energy consumption derived from Taggle data. In addition, the BEEBox data included display status of the display unit, with this information used to calculate the percentage of time a BEEBox is operational in a house. The average duration in which BEEBoxes were operational was 89 per cent, and the median time was 97 per cent. Figure A19 shows the frequency of house display status on as per cent of total run period.

*Figure A19: Percentage of BEEBox display status that were active in Milingimbi*



## A.20 BEEBox BACI Analysis

The period of BEEBox installation varied between participating communities. Table A21 describes the period in which BEEBox installations occurred and the number of installations in each community.

*Table A21: BEEBox installation period and count*

| Community | Min installation date | Max installation date | Number of installations |
|---|---|---|---|
| Galiwin'ku | 18/11/2014 | 26/06/2015 | 80 |
| Gapuwiyak | 21/05/2015 | 8/09/2015 | 39 |
| Gunyangara | 9/04/2015 | 20/05/2015 | 10 |
| Milingimbi | 4/11/2014 | 12/11/2014 | 59 |
| Ramingining | 6/07/2015 | 26/08/2015 | 26 |
| Yirrkala | 9/04/2015 | 18/09/2015 | 38 |
| **Total** | | | **252** |

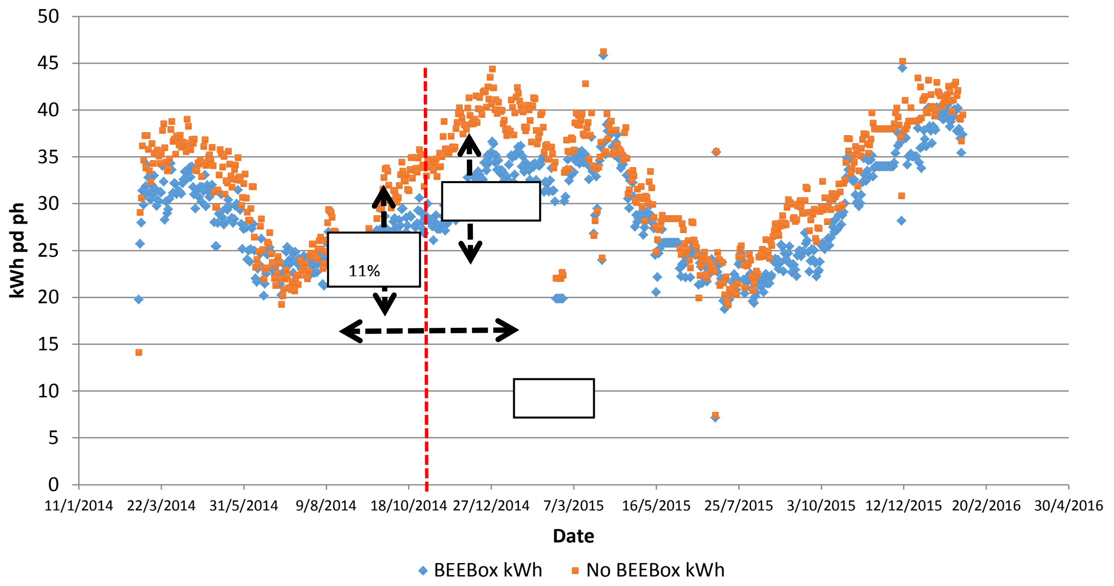
**Milingimbi BEEBox BACI Analysis**

Figure A20 shows the average daily per house energy consumption for houses, with BEEBox installation represented by blue data points and the houses without BEEBox installation represented by orange data points. Most of the BEEBox installations in Milingimbi took place during November 2014—shown by dotted orange line. The data points in figure A19 show that the average energy consumption for both the groups of houses was similar during the cooler dry season months. Further, the pattern ruptures along the wet season, which coincides again during the dry season.

The visual qualification appears to suggest that the two groups of houses maintains a gap in energy consumption during the wet season and converges during the dry season months. However, the band-gap was significant immediately after the installation of BEEBoxes in the community.

Average energy consumption of three months (August to October 2014) before BEEBox installation is compared with three months (December to February 2014-15) after installation. It is found that houses after installation consumed 17 per cent less than the houses that did not receive BEEBox—compared to 11 per cent less consumption by the same houses before installation. This is an overall six per cent reduction before and after BEEBox installation and a saving of 2.66 kWh per day per house. However, the savings are not attributable to the impact of BEEBox alone, since 56 houses of the total 59 houses installed with a BEEBox in Milingimbi were also fitted with a stove timer.

*Figure A20: Milingimbi-energy consumption trend, houses with and without BEEBox*




Similar analyses have been carried out for all the other communities over periods related to time BEEBox installation batches. Table A22 lists the consumption comparison between houses with and without a BEEBox and the associated relative changes in daily energy consumption. Although efforts were made to exclude houses with retrofits in this analysis, some houses with a major retrofit as well as a BEEBox are included. The results show considerable variation; overall the average finding is a small saving of approximately 0.6 kWh per day.

*Table A22: Summary of BACI analysis for each tranche of BEEBox installations*

| Community | Period | Before or after trial | BEEBox kWh | No BEEBox kWh | Difference kWh | Per cent change | Saving pd ph (kWh) |
|---|---|---|---|---|---|---|---|
| Milingimbi | Aug 14 to Oct 14 | Before | 25.77 | 28.64 | -2.87 | -11 | |
| | Dec 14 to Feb 15 | After | 32.06 | 37.59 | -5.53 | -17 | 2.66 |
| Galiwin'ku | Aug 14 to Oct 14 | Before | 22.69 | 20.18 | 2.51 | 11 | |
| | Jan 15 to Mar 15 | After | 30.55 | 24.80 | 5.75 | 19 | -3.24 |
| Galiwin'ku | Jan 15 to Mar 15 | Before | 30.55 | 24.80 | 5.75 | 19 | |
| | Jun 15 to Aug 15 | After | 20.86 | 19.53 | 1.34 | 6 | 4.41 |
| Gapuwiyak | Feb 15 to Apr 15 | Before | 29.65 | 30.61 | -0.96 | -3 | |
| | Jun 15 to Aug 15 | After | 21.29 | 21.23 | 0.06 | 0.3 | -1.01 |
| Gapuwiyak | Jun 15 to Aug 15 | Before | 21.29 | 21.23 | 0.06 | 0.3 | |
| | Oct 15 to Dec 15 | After | 25.96 | 27.30 | -1.33 | -5 | 1.39 |
| Ramingining | Apr 15 to Jun 15 | Before | 38.25 | 24.50 | 13.75 | 36 | |
| | Sep 15 to Nov 15 | After | 36.76 | 25.23 | 11.53 | 31 | 2.22 |
| Yirrkala | Jan–15 to Mar–15 | Before | 29.04 | 33.49 | -4.45 | -15 | |
| | Oct–15 to Dec–15 | After | 24.98 | 27.16 | -2.17 | -9 | -2.28 |
| Gunyangara | Jan–15 to Mar–15 | Before | 31.84 | 32.02 | -0.17 | -1 | |
| | Jun–15 to Aug–15 | After | 19.90 | 27.67 | -7.76 | -39 | 7.59 |

**Impact of BEEBox on disconnection periods**

A simple comparison of the disconnections being experienced from 2014 - 2015 is provided in Table A23. This uses all disconnection data regardless of disconnection length and excludes January and February of each year because data for these months was not collected in 2014 and because of cyclone impacts to data in February 2015. The results show a larger reduction for houses with a BEEBox than without, with the net decrease for BEEBox houses being 12 minutes of reduction per day compared to the non BEEBox.

*Table A23: Comparison of disconnections between 2014 and 2015*

| Year | 2014 | | 2015 | |
|---|---|---|---|---|
| Period | Mar- Dec | | Mar - Dec | |
| Treatment | No BEEBox | BEEBox | No BEEBox | BEEBox |
| Disconnection hours | 65840 | 54873 | 62936 | 42606 |
| Total hours | 1602769 | 1187184 | 1570625 | 1146475 |
| Per cent disconnection | 4.11% | 4.62% | 4.01% | 3.72% |
| Months of data | 10 | 10 | 10 | 10 |
| Number of houses | 222 | 165 | 222 | 165 |
| Disconnection minutes per day per house | 58 | 65 | 56 | 51 |
| Difference | | | -2 | -14 |

## A.21 Solar HWS Before and After Analysis

The analysis of the impact of solar hot water system (HWS) installations is based on the installations that occurred in November and December 2014. This is because installations in this period allow comparison of energy consumption for a reasonable length of time before and after installation and for both control (no retrofits installed) and impact groups.

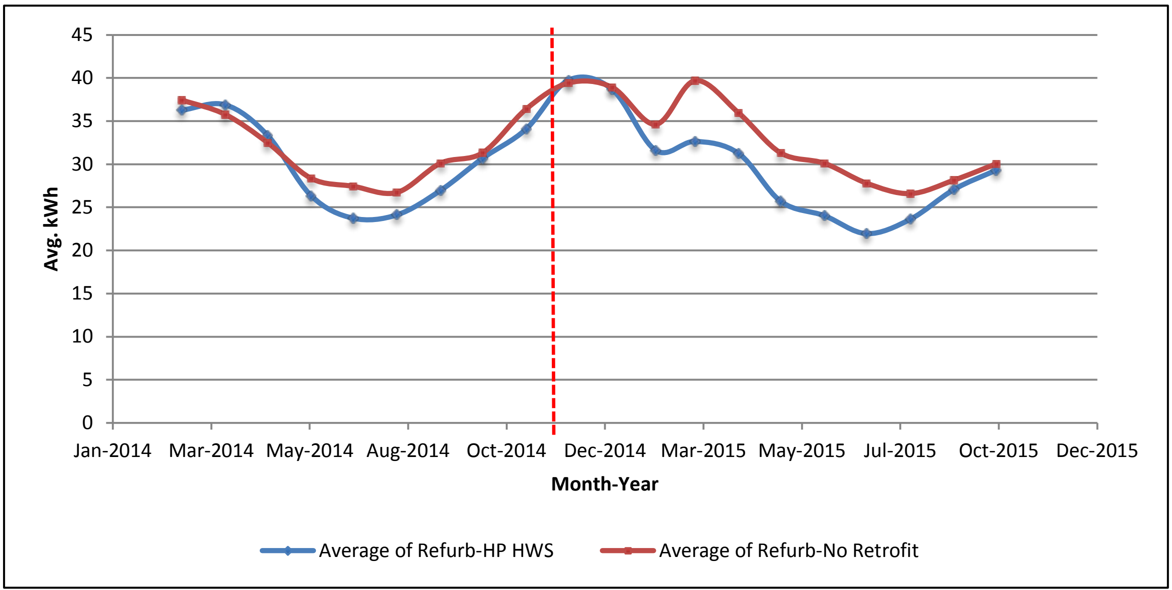
Analysis for the batch of houses that received installations in the year 2015 is a future opportunity, with additional energy data collected in 2016.

## A.22 Heat Pump HWS Before and After Analysis

The analysis of the impact of heat pump HWS installations is also based on the installations in November and December 2014 only, as per the solar hot water analysis.

The analysis and figure A21 compares the average energy consumption of 70 refurbished households that received a heat pump retrofit between November 2014 and December 2014 to that for 95 comparable refurbished houses that did not receive a retrofit for the period between April 2014 and October 2015.

*Figure A21: HP HWS batch-1 before and after houses with and without retrofit (refurbished houses)*




Average energy consumption of months March to October 2014 before installation is compared with average of months March to October 2015 after installation. The before installation average energy consumption of impact and control groups were 29.80 kWh and 31.21 kWh (5 per cent less than the control group). After installation, the average energy consumption of impact and control groups improved to 26.94 kWh and 31.20 kWh (16 per cent less consumption than the control group). This is overall 2.84 kWh per day consumption reduction or an 11 per cent saving after HP installation.

## A.23 Stove Timer BACI Analysis

Analysis of the impact of stove timers on total household energy consumption was based on comparison between batches of stove timer installs and houses that did not receive a stove timer or other technology retrofit. It should be noted that the control batches were selected based on house design, without matching for the other factors strongly correlated with energy (occupancy and number of air-conditioners).

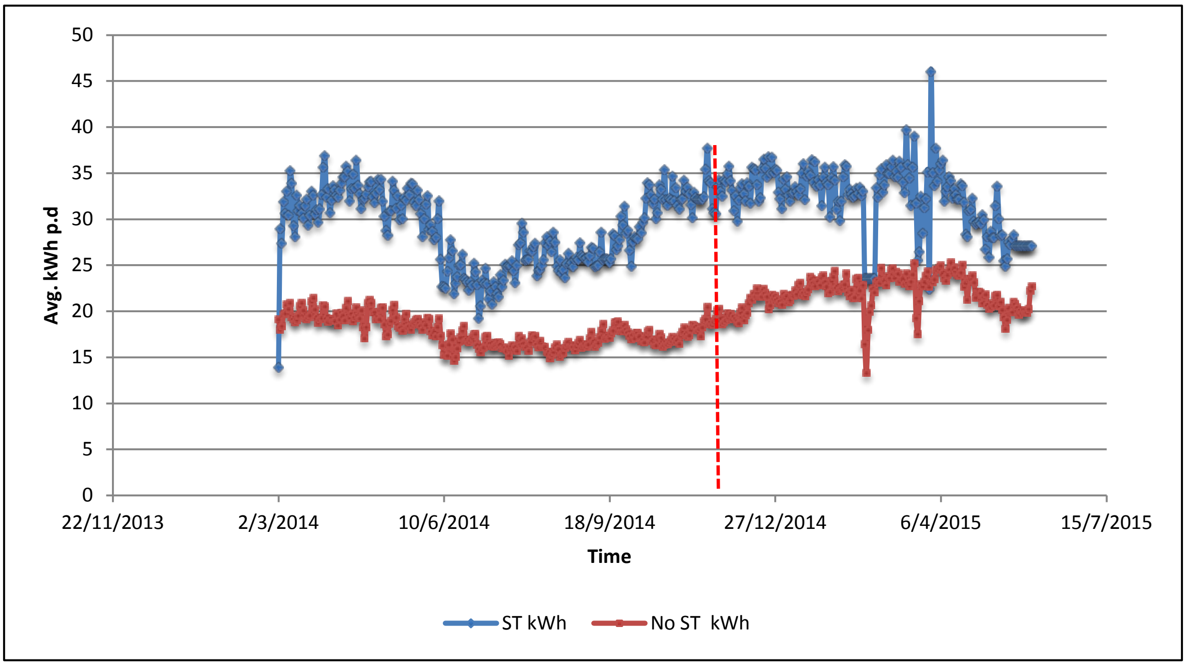
The comparison presented below is for the first batch of 20 new households that received a stove timer between November 2014 and December 2014 against 126 new houses that did not receive retrofits or a BEEBox for the period between March 2014 and May 2015.

The average daily energy consumption for these two groups is presented in the Figure A22. The impact of cyclones Lam and Nathan can be clearly seen as brief dips in the data.

Average energy consumption of three months (Mar-May 2014) before stove timer installations is compared with the equivalent three months (Mar-May 2015) after installation. The houses with stove timers, on average, consumed 31.97 kWh per day, and houses without any major retrofit or BEEBox consumed 19.34 kWh per day. After the stove timer installation, the houses with stove timers' consumption was reduced to 31.40 kWh per day and houses without stove timers increased to 22.45 kWh per day. The difference between the average daily energy consumption of the two groups of houses within the new house category was 40 per cent (12.64 kWh pd) before installation. The difference between the same groups after installation was 29 per cent (or 8.95 kWh pd). This is an overall 11 per cent difference or a 3.68 kWh a day reduction after stove timer installation.

The significant difference in average energy consumption between the two groups reduces confidence in the finding of this analysis.

*Figure A22: Energy consumption impact of stove timer installation before and after in houses with a stove timer and without a stove timer or BEEBox*




Analysis was completed for a second batch of households (nine new and refurbished houses) that received stove timers in May 2015. The daily energy consumption is grouped separately for houses with a stove timer and houses without retrofits or BEEBox (199 new and refurbished houses) for the period between February 2015 and August 2015. Average energy consumption of three months (February to April 2015) before stove timer installation is compared with three months (June to August 2015) after installation.

The third batch of households (41 new and refurbished houses) that received a stove timer between September 2015 and October 2015 are then compared to 133 new and refurbished houses that did not have a technology trial for the period between June 2015 and December 2015.

The results of these three analyses are summarised in Table A24.

*Table A24. Summary of stove timer energy savings analysis*

| Install | Data periods | House type | # lots impact / control | Net before kWh/day | Net after kWh/day | Net saving kWh/day |
|---|---|---|---|---|---|---|
| Nov-Dec 2014 | Mar-May 2014<br>Mar-May 2015 | New | 20 /126 | +12.64 | +8.95 | 3.68 |
| May 2015 | Feb-Apr 2015<br>Jun-Aug 2015 | New and Refurb | 9 /199 | +1.53 | +0.04 | 1.49 |
| Sep-Oct 2015 | Jun-Aug 2015<br>Oct 15-Jan 16 | New and Refurb | 41 /133 | -2.60 | -5.86 | 3.26 |
| | **Summary** | | **70** | | | **3.15** |

A second set of analyses for these installations were later completed, incorporating additional Taggle data for January to April 2016 and using the largest matching before-after periods available in the data. These are summarised in Table A25.

*Table A25. Summary of stove timer energy savings analysis with additional months*

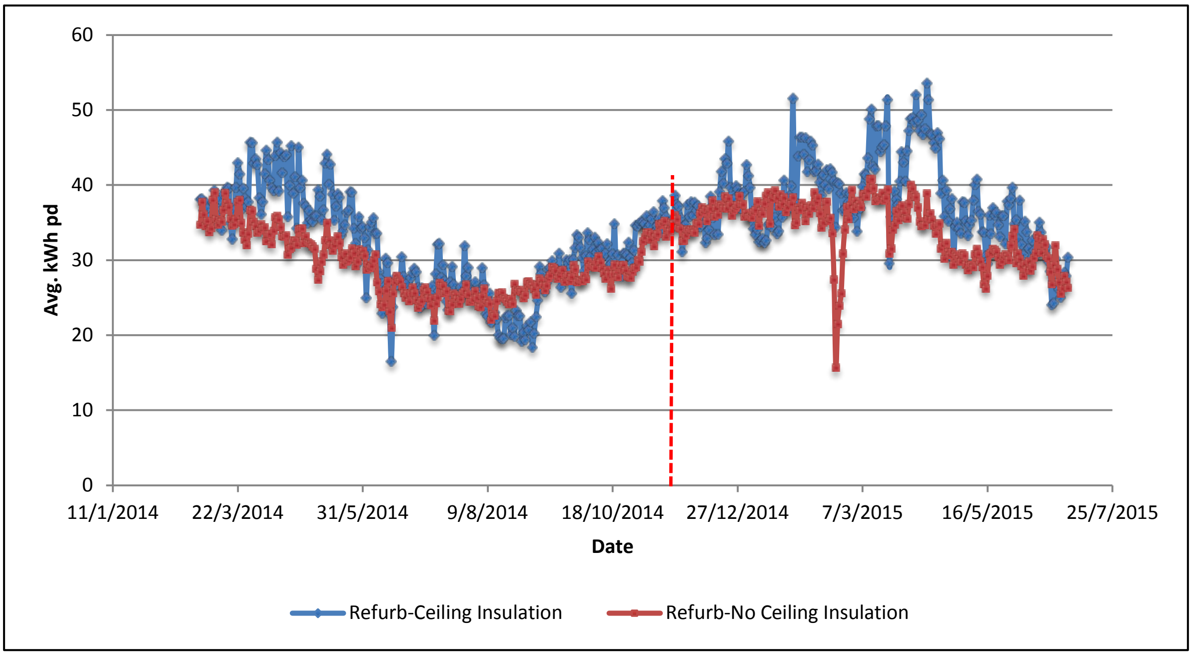
| Install | Data periods | House type | # lots impact/ control | Net before kWh/day | Net after kWh/day | Net saving kWh/day |
|---|---|---|---|---|---|---|
| Nov-Dec 2014 | Mar 14-Oct 15<br>Mar 15-Oct 16 | New | 20 /6 | +1.41 | +0.05 | 1.36 |
| May 2015 | Jul 14-Apr 15<br>Jul 15-Apr 16 | New and refurb | 13 /41 | +1.55 | +0.69 | 0.86 |
| Sep-Oct 2015 | Oct 14-Apr 15<br>Oct 15-Apr 16 | New and refurb | 42 /85 | -0.10 | -1.95 | 1.85 |
| | **Summary** | | **75 /132** | | | **1.35** |

## A.24 Ceiling Insulation Before and After Analysis

The analysis discussed here through Figure A22 involves all the 44 houses (three houses have a Taggle data issue) installed with ceiling insulation from September 2014 to December 2015.

The first iteration compares the average energy consumption of first batch of 13 refurbished households, which had two air-conditioners on an average and received ceiling insulation between September 2014 and December 2014. The daily energy consumption is compared with that of 141 refurbished houses without insulation or other retrofits for the period between March 2014 and June 2015. It should be noted that no attempt was made to match with houses with an equivalent number of air-conditioners, which is important given that ceiling insulation was deliberately targeted at houses that had at least one air-conditioner in place. The relative daily energy consumption over the period is presented in the figure below.

*Figure A22: Ceiling insulation batch 1 before and after houses with and without insulation (refurbished houses)*



Analyses of the second and third batches without controlling for air-conditioners produced similar results.

A subsequent analysis was completed using additional Taggle data in 2016 and selecting control houses with comparable air-conditioner numbers. It involved 30 houses in total out of the 47 ceiling insulation installations, with three houses excluded due to data quality issues and further trimming of house lots done to match the impact and control group of houses in terms of house category and number of air-conditioners reported.

The analysis was done in two batches based on installation periods. The results are summarised in the Table A26. The first analysis relies on data from the cooler months of March to August and shows a substantial 'before' difference in average energy consumption between impact and control cohorts. The second analysis relies on data from the peak air-conditioning months of January to April and has a very small 'control' cohort due to the limited number of houses with similar air-conditioner numbers available, but the average consumption prior to install is comparable.

Confidence in this analysis is therefore low, but an average between the two is most likely to represent the annual savings that could be attributed to the installation of the insulation.

*Table A26. Summary of additional ceiling insulation impact analysis*

| Ceiling insulation | Data period | Impact houses | Impact kWh | Control houses | Air-con | Control kWh | Diff. | % Change | Saving kWh pd ph |
|---|---|---|---|---|---|---|---|---|---|
| Before | Mar 14-Aug 14 | 12 refurb | 37.18 | 36 refurb | 1 to 4 | 26.77 | 10.41 | 28.01 | |
| After | Mar 15-Aug 15 | 12 refurb | 37.78 | 36 refurb | 1 to 4 | 28.39 | 9.39 | 24.85 | 1.03 |
| Before | Jan 15-Apr 15 | 18 refurb | 39.08 | 5 refurb | 1 to 3 | 39.59 | -0.51 | -1.31 | |
| After | Jan 16-Apr 16 | 18 refurb | 38.15 | 5 refurb | 1 to 3 | 42.47 | -4.32 | -11.32 | 3.81 |

## A.25 All-of-community Energy Data

Table A27 presents the total energy consumption or generation in communities for the years 2014 and 2015. This table presents information about each of the six LIEEP communities as well as four neighbouring communities that did not participate in this project. The analysis excludes Gunyangara because of issues with data quality for 2015.

The analysis shows a 2.1 per cent increase in community consumption from 2014 to 2015 for participating communities but a 3.4 per cent increase for non-participating communities as a whole. The inference is that the LIEEP communities made a 1.3 per cent energy saving compared to non-participating communities, or approximately 253 MWh (including Gunyangara). This should be interpreted in the context of the project being in the process of rolling out the bulk of its trials during 2015, with many activities occurring in the second half of the year and so only being able to have an effect on energy consumption for part of the year.

*Table A27: Community energy use yearly comparison and BACI analysis*

| Community | 2014 generation (kWh) | 2015 generation (kWh) | Decrease / increase | Per cent change |
|---|---|---|---|---|
| Milingimbi | 3283000 | 3227000 | 56000 | -1.71 |
| Galiwin'ku | 6277000 | 6419000 | 142000 | 2.26 |
| Gapuwiyak | 2834480 | 2949110 | 114630 | 4.04 |

| Community | 2014 generation (kWh) | 2015 generation (kWh) | Decrease / increase | Per cent change |
|---|---|---|---|---|
| Yirrkala | 3054000 | 3205000 | 151000 | 4.94 |
| Ramingining | 3137000 | 3169000 | 32000 | 1.02 |
| Total participating communities | 18585480 | 18969110 | -383630 | 2.1 |
| Maningrida | 8153639 | 8343855 | 190216 | 2.33 |
| Gunbalanya | 4873005 | 4775037 | 97968 | -2.01 |
| Warruwi | 1582380 | 1811280 | 228900 | 14.47 |
| Minjilang | 1229155 | 1445590 | 216435 | 17.61 |
| Total nearby non- participating | 15838179 | 16375762 | -537583 | 3.4 |
| Gunyangara | 865409 | N/A | N/A | N/A |

In Table A28, energy data from the Taggle data loggers is combined with the total community power data. The Taggle data was only available from the completion of installation in March 2014, and so, for consistency, the 2015 data is only summarised for March to December also. In addition, Gunyangara is not included in the analysis because comparable data on its monthly total consumption is not available because this community is supplied power under a power purchase agreement with quarterly billing.

On average, the participating household energy consumption accounts for 30 per cent of the total power generated per community, with a slight decrease in the proportion for 2015.

*Table A28 Total community power generation and LIEEP household consumption Mar–Dec 2014 and Mar–Dec 2015*

| Community | 2014 generation MWh | 2015 generation MWh | 2014 LIEEP MWh | 2015 LIEEP MWh | LIEEP 2014 (per cent) | LIEEP 2015 (per cent) |
|---|---|---|---|---|---|---|
| Milingimbi | 2728.0 | 2726.0 | 1005.43 | 1014.78 | 36.86 | 37.23 |
| Galiwin’ku | 5227.0 | 5428.0 | 1300.34 | 1238.54 | 24.88 | 22.82 |
| Gapuwiyak | 2385.7 | 2491.3 | 744.25 | 781.79 | 31.20 | 31.38 |
| Ramingining | 2572.0 | 2671.0 | 705.93 | 706.88 | 27.45 | 26.46 |
| **Total** | **12912.7** | **13316.3** | **3755.88** | **3742.00** | **30.09** | **29.47** |

Comparing year to year, the total consumption increases by 3.13 per cent from 2014 to 2015, within which LIEEP consumption drops by 0.37 per cent and non-LIEEP is thereby inferred to have increased by 4.56 per cent.

It is not possible to conclude that the effects identified above represent an even larger net saving for LIEEP households without also having an equivalent breakdown of consumption between households and the rest of the community for non-LIEEP communities.

As all communities were receiving trials in 2015, there is no comparable household-only data to use as a control for the household LIEEP data between 2014 and 2015.

# APPENDIX B: RESULTS OF BARRIER AND STORE SURVEYS

# 1 Barrier survey results

The following is a summary of the analysis of the 42 barrier surveys conducted across Galiwin'ku and Yirrkala in October 2013.

## 1.1 Demographics

Eighty per cent of the time, the person surveyed was considered the main tenant or house boss. Everyone surveyed was over 18 years of age, 71.8 per cent of the people surveyed were adults and 28.2 per cent were identified as elders. The respondents were skewed toward females, with 62 per cent female and 38 per cent male. The average household size was 10 people (median 9.5). Households had an average of three children, one young person, five adults and one elder. Most households had some income from employment, with 70.7per cent of respondents indicating one or more people in the household were employed.

Members of the households travel, with 78 per cent of householders travelling away for days or weeks at a time. Most householders travel infrequently, but 11.9 per cent of householders indicate they are away often. The most common reasons for travelling include festivals or ceremonies (66.7 per cent), work (16.7 per cent) and visiting family (16.7 per cent).

14.3 per cent of respondents have no visitors, while 38.1 per cent have visitors sometimes, 28.6 per cent have visitors often, 9.5 per cent have visitors very often and 9.5 per cent have visitors for ceremonies. Most visitors, 68.6 per cent, stay a week or more and 28.6 per cent stay a few nights, while only one household had visitors that stay more than a month.

## 1.2 Pre-Payment Meters and Power Cards

Questions on pre-payment meters indicate that a majority of households run out of credit at their house (88.1 per cent) while only 11.9 per cent of households never run out of credit. Only 11.8 per cent of households said they run out of credit infrequently, while 8.8 per cent run out monthly, 11.8 per cent fortnightly, 44.1 per cent weekly and 23.5 per cent more than once a week. When households do run out of credit 56.8 per cent of households buy a new power card the same day, 27.0 per cent take more than a day, 2.7 per cent take a week, 8.1 per cent cannot buy a new power card until they are paid and 5.4 per cent wait until someone brings them another card. Of the households that run out of credit, a third (33.3 per cent) are without power for more than a day once a week or more.

The loss of energy has consequences for households: 54 per cent said food in the refrigerator or freezer has perished due to power loss, and 5.4 per cent said it happens often or very often. Half of the respondents did not have suggestions on what might make it easier to ensure the power did not run out but other respondents suggested it might help if visitors helped out (11.9 per cent), people remembered to turn things off (9.5 per cent), households were better at saving money (9.5 per cent), or they had more information on energy (7.1 per cent). Other things mentioned by respondents that might help residents avoid power disconnections included shops being open more, bigger value power cards, and in-home displays to indicate power usage. The suggestion that in-home displays would be useful may have been suggested by the interpreter, but respondents did agree it would be help avoid power disconnections.

Power cards are available at local stores in the community in denominations of $5, $10, $20 and $50. The $50 power card is not available in all communities, including Yirrkala and Nhulunbuy. Residents prefer to buy them from the local store. 77.8 per cent indicated it was easy to buy power cards when they need them, but several respondents stated they buy them from the taxi drivers when the shops are closed. Buying power cards is shared among members of the household; only 12.5 per cent indicated that only one person purchased the cards and 68 per cent said long-term visitors contribute power cards.

Most households (82.9 per cent) buy a $20 power card, while 14.6 per cent prefer $50 cards, 2.4 per cent buy $10 cards and no respondents preferred $5 cards. The power cards last an average of one week, but 9.8 per cent said the card lasts one day and 22 per cent said it lasts two days. Respondents that indicated they prefer buying the $10 power card said the power lasted an average of two days, while the residents that purchase $20 cards said it lasted an average of 4.9 days.

## 1.3 Energy Efficiency

Households were asked questions about the things they currently do to track energy usage or to be more energy efficient. Most residents (80.5 per cent) do not know how much energy they are using and are not keeping track of power card usage. Residents try to keep track of energy usage by leaving the cards in the box (9.7 per cent) and trying to remember (4.8 per cent). Only one resident had a reliable system of only buying power cards on pay day in order to track power card usage. A third of respondents (34.1 per cent) thought the amount they spend on energy had gone up recently. The reasons for the increase in energy were an increase in visitors, suspected problems with the meter, using the air-conditioner more, using more appliances, sharing power with the neighbours and a switch to digital television. Respondents were interviewed about the things they do to use less energy, and 31 per cent are not doing anything to try to use less energy. The respondents that are trying to use less energy said they try to turn things off when not in use (61.9 per cent), go outside instead of turning on the air-conditioner (14.2 per cent), hand wash clothes or do less laundry (7.1 per cent) or use appliances less (4.7 per cent).

Respondents were asked for ideas on the kind of information and tools that would help them save money and energy, and some prompts were provided as suggestions for the interviewers. Respondents included a poster to illustrate the cost of running various household appliances, an in-house display, more information, radio ads, stickers for power points, information on the carbon tax and climate change, an option to have part of their pay deducted for power cards and educating children so they can talk to parents.

The things that were stopping households from using less energy were too many people in the house, other people don't listen, medical devices need power, and the house gets too hot and they need the air-conditioner. Respondents were mixed on what they wanted to know. A quarter of the households indicated they did not need more information about their energy usage, while 42 per cent wanted more information about their energy usage and how to use it more efficiently.

## 1.4 Energy Use and Behaviour

Home energy use questions focussed on the use of refrigerators, televisions, stoves, air-conditioners and hot water systems. Respondents were asked to name the appliance they thought used the most energy, and 19.1 per cent of residents did not know, 21.4 per cent said the air-conditioner and 16.7 per cent said the hot water heater. Other responses included the television, refrigerator, washing machine, electric jug, fans, phones charging and electric frying pan.

The most common household appliances were televisions and stoves; 95.2 per cent of households have a TV, 95.2 per cent have a stove and 88.1 per cent have a refrigerator. Almost half the households (47.5 per cent) have two televisions and 12.5 per cent have three or more. Respondents use their television after school (7.7 per cent), for movies or games (7.7 per cent), to watch sports (10.3 per cent), at night (28.2 per cent), and all day (46.1 per cent). Most respondents purchased their television at the local shop (61.1 per cent), while others got theirs from the tip (16.7 per cent), a larger community or Darwin (8.3 per cent) or a second hand shop (5.6 per cent). Other televisions were from friends, a prize or a digital television from the government.

Households indicated they had a refrigerator, but 9.5 per cent of respondents did not have a working refrigerator or freezer. Stoves were problematic, with 35 per cent indicating the stove was broken; the most common problem was a broken element. Households with broken stoves are using electric fry pans to cook, and 93 per cent of households use a fire at least occasionally.

Households indicated they had a hot water heater, and the most common hot water heater was solar (72.5 per cent), heat pumps (15 per cent) and electric (12.5 per cent). A quarter of the homes had a hot water booster as part of the solar hot water system, but half the households with a booster didn't use it because it was broken or they were not interested.

Respondents indicated that it is hard to keep their house cool, especially during the wet season (December to March) and in the months leading up to the wet season, known as the build-up. Only 35.7 per cent of residents said their house stays cool. Households had a variety of methods to try to keep houses and residents cool. The top ways to cool the house were fans (47.6 per cent), going outside (35.7 per cent), opening windows (23.8 per cent), turning on the air-conditioning (21.4 per cent), having a shower (14.3 per cent), mopping floors (9.5 per cent), sprinklers on the lawn or house (4.8 per cent), cleaning the fans (2.4 per cent) or going for a swim (2.4 per cent). Responses total more than 100 per cent because respondents could list multiple reasons.

All the households had ceiling fans, with an average of 4.7 per household. Only a third of houses had a portable fan and 59.5 per cent had air- conditioning. Households use the air-conditioning more during the build-up and wet season; only 26.7 per cent of households with an air-conditioner use it all year.

## 1.5 Interest in The Project Trials

The first question in this section asked whether people would be interested in having a trial in-house display installed in their home. The majority of respondents did not provide an answer (66.7 per cent), 4.7 per cent said no and 30.9 per cent said yes.

The next question asked respondents whether they thought a program like Manymak might help their household and community save power and money. It was meant to be an open-ended question and would be used to compare attitudes at the end of the program. Most households (92.7 per cent) thought a program like Manymak would help their household, but few respondents offered a specific reason. Two respondents indicated they were sick and could not afford to run out of energy, while others mentioned they thought the program would help them save money. Three respondents thought a program like Manymak would provide more information to help them make decisions on their energy usage. Others mentioned that they need information so they can educate their family, and one respondent replied that they had a new house and need to know how to use energy. Most respondents (95 per cent) thought Manymak would be good for their community; the reasons given were that the community needed to learn a better way of doing things, and they needed more information to make good decisions about energy usage.

## 1.6 Store Survey Results

The initial surveys of stores were conducted in three stores as detailed in the methodology section. The key findings of the survey were:

- The inventories of stock have not been included for evaluation in this report due to insufficient detail on appliances rated output (Watts) to draw robust conclusions.
- The survey revealed that the stores stock energy-related products based on price, availability and consumer demand. One of the main limiting factors identified by stores in stocking energy-efficient appliances in general is the limited range of affordable energy-efficient appliances available from the wholesale suppliers. The items being stocked are selected in reflection of the low-income of community customers. Energy efficiency was not generally a priority consideration when selecting stock for the community stores unless through a specific purchase request.
- The best-selling items identified were televisions, large (9.5 kg) washing machines, electric frypans, refrigerators/freezers, kettles and toasters. Many of these items were also listed as the most commonly out of stock items, clearly identifying a high demand. Only one store had identified a demand for 'solar powered' appliances. They had sold out of solar powered portable refrigerators and were looking to stock a wider range of solar powered items.

# Appendix C: Knowledge, Attitudes And Behaviours Survey

## 1 KAB survey

A knowledge, attitudes and behaviours (KAB) survey was conducted in Milingimbi in July 2014.

The frequency of responses to each question in the survey was examined. This analysis revealed that:

- Of the 73 per cent of households that answered this question, 86 per cent indicated they were willing to participate in the project.
- 85 per cent of households had signed the privacy notice.
- 53 per cent of households claimed they believe the project will help their household.
- 31 per cent of households were interested in the BEEBox.
- On average, householders reported that 5.3 adults and 5.8 children resided in the household the previous night.

Respondents were asked to indicate which of the following events affect the consumption of energy and hence the depletion of power cards. The following table presents the percentage of respondents who indicated they were aware of the various sources of energy consumption or savings.

| Source of energy consumption or savings | % reporting |
|---|---|
| Broken appliances | 2% |
| Hot weather | 4% |
| Lots of people in the house | 53% |
| Closing windows and doors when using air-con | 81% |
| Cooking on a fire or sitting outside | 8% |
| Turning off appliances when not using them | 6% |
| Using a fan instead of air-con | 2% |

Respondents indicated when a power card was last inserted in the meter. The percentage of respondents who offered each answer appears in the next table. In at least 70 per cent of instances, the power card was installed during the last week.

| Time since power card last installed | % reporting |
|---|---|
| < 3 days | 37% |
| 3-7 days | 33% |
| > 7 days | 20% |
| Not certain | 3% |
| No response | 7% |

There is no project implementation data for the last two questions, so no comparison could be made between before and after project implementation.

The final questions related to whether individuals believed the *Dharray Manymakkung Pawaw ga Gapuw* project helped their household, and the number of people who slept in the house the previous night. Ninety-one per cent of individuals indicated the project was helpful. The average number of people who slept in the house the night before was 8.5, with a standard deviation of 4.3.

# 2 Compared responses before and after implementation

Respondents then indicated how long power cards tend to last. The following table displays the percentage of respondents who indicated the power cards last fewer than three days, three to seven days or more than seven days. In approximately 80 per cent of households, the cards last less than one week. These percentages did not change significantly over time.

| Duration of credit for power | % who indicated how long power cards last | |
|---|---|---|
| | Before implementation | After implementation |
| < 3 days | 45% | 51% |
| 3-7 days | 36% | 31% |
| > 7 days | 21% | 16% |
| No answer | 2% | 2% |

Respondents were asked to indicate how often households lose access to power because the power card is depleted. The values in the table below did not change significantly over time.

| Frequency of disconnection | % who indicated how often power is depleted | |
|---|---|---|
| | Before implementation | After implementation |
| At least once a week | 26% | 20% |
| Less than once a week | 11% | 10% |
| Not certain | 0% | 10% |
| Never | 61% | 59% |

Next, respondents were asked how long they wait to purchase another power card if a previous card is depleted. The next table presents the responses. Again, responses did not change significantly over time.

| Delay between power cards | % who indicated delay before another power card is purchased | |
|---|---|---|
| | Before the implementation | After the implementation |
| Within a day | 21% | 20% |
| 2 - 7 days | 11% | 8% |
| Once I am paid | 60% | 61% |

# 3 Relationship between questions before and after project implementation

Relationships between the questions were explored. Prior to the commencement of the project, the majority (73 per cent) of respondents who answered the question indicated that they were willing to participate. However, only about half of the respondents believed that the project would benefit their household and fewer than one third of respondents were interested in the BEEBox. The latter result confirms the low initial interest in the BEEBox found in the barrier survey.

On average, about 11 people resided in the households the night before they were surveyed. After implementation, the majority of respondents indicated the project was helpful. On average, fewer people than in the pre-project survey slept at the house the night before (8.5 people). This variation could be due to more Yolŋu living in Milingimbi at the time of the first survey due to ceremonies and cultural commitments.

The KAB data from Milingimbi does not show a significant project influence on Yolŋu households' perceptions of using power more efficiently. There were no significant changes before and after the project implemention whether through longer-lasting power cards, households experiencing a reduction in power disconnections or more frequent purchase of power cards. This is particularly surprising given that the project was implemented for the longest period in Milingimbi. Milingimbi was also the first community in which the project was implemented. Because of that, many aspects of the project, particularly the community education and engagement components, were not as well-developed in Milingimbi as in other communities.

Several interesting relationships between pre-project answers emerged from the statistical exploration. Firstly, households that experience more power disconnections also experience longer power disconnections, confirming that it is difficult for Yolŋu to purchase the next power cards. Secondly, households with more people purchase more expensive power cards. While power tends to last longer in these households, power disconnections tend to be longer too. Thirdly, households that experience more power disconnections were more willing to participate in this project but were not as interested in a BEEBox. This relationship could be due to households not perceiving the BEEBox as a device that would assist them in reducing their disconnection frequency or duration.

Only two key relationships emerged from the statistical analysis of post- project surveys. Compared to the other participants, the respondents who perceived the project as unhelpful were more likely to purchase a new power card only once they were paid.

# Appendix D: CDU Qualitative Research Summary

*This appendix is authored by the Charles Darwin University research team who delivered the qualitative research component of the project.*

*It presents a summary of the findings from the qualitative research interview process as described in the methodology section. These findings were developed independently from the quantitative data analysis. A selection of translated quotations from the interviews have been placed throughout the discussion section and have not been repeated here.*

# 1 Introduction

The qualitative findings of the evaluation of the Manymak LIEEP project provide descriptive insights into and understanding of how Yolŋu experience, interpret, and use power and pre-payment meters, and the barriers to and enablers of Yolŋu making efficient use of power and water (project objective 1). More than 100 semi-structured interviews with Yolŋu also illuminate the wider issues associated with chronic overcrowding in the Indigenous communities of east Arnhem Land. The qualitative findings explore how the project addressed these barriers and facilitated Yolŋu using power and water more efficiently, and the perspective of the Yolŋu energy efficiency workers (YEEWs) and residents on the engagement strategies and technologies deployed by the project (project objective 2). Most importantly, the qualitative findings explore why particular aspects worked or otherwise. Finally, the qualitative findings provide guidance on how projects like this one could be improved in the future (project objective 4).

In this appendix, we provide the findings relevant to objectives 1 and 2. Section 1 discusses how Yolŋu perceive the barriers and enablers to more efficient power and water usage, and section 2 evaluates the overall Manymak project from the perspective of Yolŋu, through the eyes of YEEWs and householders.

When reading the findings, it is important to understand that statements represent Yolŋu subjective perspectives of reality. It is not the objective quality of the environment but the way people subjectively perceive and interpret their environment that influences how people act and interact. How Yolŋu perceive and interpret their environment shapes how they use power and water and influences how they interact with non-Indigenous people.

The stories shared during more than 100 interviews across the communities are remarkably consistent. The uniformity of the stories suggests that Yolŋu in all six communities share a similar history, experiences, interpretations, and usage of power and water. This consistency may also be a result of communities being geographically concentrated in a relatively small area, with many Yolŋu moving freely between communities. Additionally, the uniformity in the telling of stories points to structure and process underpinning the sharing of important information in Yolŋu communities.

Quotes give voice to the YEEWs who contributed to the project and to the Yolŋu who received the project. Given that the majority of the interviews were conducted in local Yolŋu languages, most quotes are interpretations by the Yolŋu interpreter. Due to the limited time available between collecting and analysis of the interviews, in order to meet the timeframes of the LIEEP program, there was sufficient time only to check the findings with the lead Yolŋu co-researcher and the Yolŋu interpreter but not with the local Yolŋu co-researchers. Consequently, the findings are not yet approved by the participating Yolŋu communities.

The Yolŋu story of barriers and enablers of efficient use of energy, power and water usage, and pre-payment meters

This section presents findings that address objective 1 of the project. This starts with identifying and clarifying the barriers and enablers of efficient use of energy in Yolŋu communities, then moving into providing insights into how Yolŋu use power and water. This section concludes with providing pathways forward that Yolŋu perceive would increase energy efficiency and improve the quality of their lives.

The findings presented in this section emerged from systematic thematic analysis of the pre-project and evaluation interviews. The analysis was facilitated by participant observations conducted by the principal researcher over 10 weeks of field work in all six communities.

The findings are presented in the form of a chronological story of Yolŋu experiences with, and interpretations and perceptions of, power and water that emerged from the analysis. Throughout this narrative, insights are provided into how historical and current experiences, interpretations and perceptions influence present day Yolŋu understanding and use of power and water, and their interactions with Balanda. While some of these experiences and perceptions facilitate using power and water wisely (enablers), others hinder appropriate power and water usage (barriers).

This narrative shows that barriers have emerged over time through the interactions between Yolŋu and Balanda and that they are influenced by the natural, built, spiritual, cultural, economic and political environment.

Over millennia prior to European settlement, fire and water were sacred as they were critical for survival. Yolŋu saw themselves as being related to and part of fire and water; fire and water were related to and are part of Yolŋu. Fire and water fulfilled many vital physical, cultural and spiritual functions in the life of Yolŋu. Over tens of thousands of years, Yolŋu built up extensive knowledge of fire and water, reflected in comprehensive systems and laws. Fire, water and shelter were free. From the perspective of Yolŋu people today, their ancestors lived in harmony with the environment, including fire and water, and they were free, healthy and strong.

European colonisation and settlement changed everything. The missionaries in particular imposed profound changes without asking or explaining, creating both dependence and confusion. They enticed Yolŋu to forego their nomadic lifestyle in harmony with nature and their rom, and to settle in one place, to live in houses, and to use the power and water provided through generators and taps. Yolŋu become increasingly disconnected from their environment, including fire and water, and became increasingly dependent on the missionaries for power and water. At first, power and water were given free to Yolŋu, but later Yolŋu had to pay for both. The missionaries did not, or not effectively, explain the deeper stories of why they wanted Yolŋu to live in settlements and provided houses, power and water and how it all works. Yolŋu did build and maintain their own houses and grew food, and the extent to which they continued to live traditional lifestyles gave Yolŋu some freedom.

After the demise of the missions, the government assumed control and imposed Western systems, including provision of power and water. This further increased Yolŋu disconnection from the environment and themselves, and further undermined their freedom and independence. Frequent changes to systems and laws without adequate explanation, deepened Yolŋu disconnection from ancestral rom while making it difficult to master the Balanda rom, creating uncertainty and confusion, and making life hard for Yolŋu. That state of affairs also applies to power and water. The resulting lack of knowledge of how power and water works and how to use both effectively makes it difficult for Yolŋu to do the right thing and use power and water wisely.

Yolŋu also resent that suddenly they have to pay for power and water, which they had always previously known as free resources. Living disconnected from the environment and being able to access power and water easily eroded Yolŋu valuing and respecting power and water and using both wisely.

Overcrowding, unemployment and low school attendance contribute to Yolŋu using more power and water and using power and water inefficiently. Yolŋu feeling oppressed and experiencing inequalities creates mistrust of and resistance to Western law. Children using a lot of power and water and not listening to adults also contributes to power and water being wasted. Interactions between these barriers make it difficult for Yolŋu to keep the power going, which makes life more difficult. Many Yolŋu would love to go back to the old ways, however they realise that they cannot.

The introduction of Balanda power and water systems into Yolŋu lives disrupted their traditional use of fire and water. They had to come to grips with a system that was foreign to them and that was delivered in a manner they found difficult to understand. The historical interactions outlined above—both between Yolŋu and Balanda, and between Yolŋu and fire/power and water—created the backdrop to Yolŋu perceptions of power and water use in the six communities before the Manymak project.

In short, the combination of these barriers means that many Yolŋu lack understanding of where power and water come from, and how to use both efficiently. Many Yolŋu are not aware of the link between power usage and costs. Accordingly, they have many appliances turned on at one time and leave them on for prolonged periods, whether they use them or not. However, many Yolŋu retain skills in traditional ways of using power/fire and water and in some cases prefer them. Working out ways to work with rather than against Yolŋu traditional knowledge could be one option to increase energy efficiency and empower people.

Contextual barriers outside Yolŋu control considerably increase power and water consumption. Overcrowding diffuses responsibility for using power and water wisely and for contributing to paying the costs. Community stores sell only low-efficiency energy and water appliances and equipment that leads to inefficient power and water usage (e.g., spotlights, children's pools) and increases power and water consumption. These stores are the only way for Yolŋu to purchase appliances in remote communities. The design of houses that are unsuitable for the tropical climate and their density and location means that Yolŋu have to use fans and air-conditioners, often in inefficient ways, and use water to maintain thermal comfort. Insufficient street lighting and high incidences of violence and theft forces Yolŋu to use security spotlights. The community stores selling energy inefficient spotlights without sensors increases power usage. Moreover, Balanda infrastructure such as the shire council, police, clinic, hospital and school combined are using considerable power—much more than Indigenous households. Yolŋu use a range of conventional and creative strategies to stay connected to power or to substitute for electricity, including their kinship system and use of fire and hunting. While these are generally successful and periods of being without power are generally rare, they find it difficult and stressful to get the next power card and to pay for power.

The Yolŋu story about their own relationship to and use of power and water, and barriers to and enablers of Yolŋu using power and water wisely, weaves together their experiences, perceptions and interpretations of how they used fire and water in the past and their rom, of Balanda and their rom, their interactions with them, and the systems they introduced. Further, many barriers to Yolŋu using power and water are outside of their control. Hence, changing how Yolŋu use power and water requires changing perceptions and interpretations of Yolŋu and Balanda as well as changing the environment Yolŋu live in. The specific individual and contextual barriers and enablers are elaborated in the discussion under objective 2.

# 2 Project evaluation from the perspective of Yolŋu

### *Yolŋu energy efficiency workers*

The project was able to identify and employ a sufficient number of capable Yolŋu in each community using a combination of written and oral communication methods in English and Yolŋu languages. In particular, it proved effective to conduct information sessions in language, having Yolŋu energy eficiency workers (YEEWs) already employed in other communities sharing their knowledge about the project and employing interpreters.

Involving community elders to a higher degree in identifying and selecting community members increased the acceptance and ownership of the project, ensured that the most suitable community members from the perspective of the community were involved with the project and helped to restore the authority of elders in communities. Preparing information sessions better together with the community, employing a cross-cultural facilitator and having YEEWs sharing their personal perspectives may have increased the effectiveness of the information sessions. The induction process was critical in creating a solid foundation for working together and was more effective when conducted in Yolŋu languages by ARDS educators. The part-time employment was appropriate as it gave educators flexibility to take care of other business in their lives. However, flexibility to work in the afternoons, evenings and weekends may have ensured that more people were at home with time to contribute. The option to work longer hours may have facilitated talking in more depth to people, thus improving the quality of the education and educating more people.

Educators were motivated to do the job because they saw the job as a meaningful opportunity to help their communities and themselves. They could see the education filling a critical knowledge gap in their communities that would make life for their fellow community members easier. They also wanted to learn more about power and water. The project team repeatedly visiting the communities for several days at a time for several months and letting the educators lead while supporting them facilitated building trusting relationships, gave credibility and authority to the education and enhanced the status of the project. Balanda staff experienced in working with Indigenous communities, being adopted into the kinship system, had some understanding of the Yolŋu rom and able to speak Yolŋu languages to some degree enhanced trust and credibility. The YEEWs greatly appreciated the support provided.

Yolŋu and Balanda working together with the Yolŋu leading the project in their communities and with the Balanda supporting the Yolŋu throughout this process was the key to the success of this project. The project team supporting supervisors to empower their teams was effective and appropriate. Yolŋu and Balanda supervisors supervising together was perceived as best by the YEEWs, as each have distinct advantages and limitations. Balanda supervisors handing over the responsibility to the Yolŋu and supporting them to build confidence was effective. Respect, flexibility, honesty, openness, humility, curiosity and patience emerged as key attitudes required to work effectively with Yolŋu. A cross-cultural induction at the start of their employment and cross-cultural mentoring throughout the project would increase the effectivness of Balanda supervisors.

The team approach was another critical key to the success of the project. Employing a team of Yolŋu in each community was culturally respectful and appropriate, as teams match the collectivist Yolŋu society. Teams gave Yolŋu flexibility to fulfill their cultural obligations while enabling project milestones to be fullfilled. Teams enabled the YEEWs to support and encourage each other. Deliberately creating diverse teams increased the reach, acceptance, and participation of community members, and the quality of the education. The teams from all six communities meeting at the culmination of the project was highly effective as it increased learning, understanding and support.

Organising exchanges between the YEEW teams at the commencement of the project and throughout the project might have enhanced the sense of having a purpose larger than just one community, the sense of team work across communities and the overall effectiveness and quality of the project. Project-specific T-shirts and badges helped the formation of strong team identities, and increased visibility and credibility of the teams in the communities. The YEEW felt well supported by the various consortium organisations, but there was confusion among the YEEWs about the different organisations and people involved and their roles, pointing to the importance of spending time to work out together the organisational structure of projects. The high recruitment, participation and retention rate accomplished by the project team indicates that the engagement strategies used were effective overall.

The YEEWs being educated by Yolŋu and Balanda ARDS educators in Yolŋu languages was another key to the success of this project as it considerably increased engagement in and understanding of the power and water education. The content of the education was developed based on the CAT experience with power and water usage in central Australian Indigenous communities but not together with the Indigenous communities in Arnhem Land in which the project was conducted.

While the education was a great start and useful, the YEEWs believe that the education was largely missing the deep, true and full stories about reasons and need for the project and using power and water. Yolŋu are highly motivated to learn the deeper stories so that they can truly understand the stories themselves and share their education stories from the heart. The effectiveness of the education was limited by insufficiently linking them to the Yolŋu rom and the land/country, and insufficiently educating in depth about budgeting. The poster kit, power station visits and role plays definitely assisted understanding. However, developing education resources together with the educators and using more experiential and action learning education could have improved the effectiveness of the education.

In general, the BEEBox was complicated and difficult to understand for most people, resulting in the education taking longer, incorrect information being passed on to communities, and neglecting other education elements that might have had a bigger impact on reducing power consumption. Overall, the education was too short for YEEWs to fully understand. Thus, some educators understood while other educators were confused. While some YEEWs educated their kin and household, others found it difficult to pass on the education to their own kin and households. Learning about power and water gave the educators a sense of accomplishment and inspired them to continue working.

YEEWs believe that the household visits were well received and created a clearer understanding on a topic that they are interested in, but that had not been explained to them previously. Giving complete stories to Yolŋu and stories that benefit the community was critical for creating trust and for Yolŋu participating in the project. The YEEWs conducted the household visits in teams. Educating Yolŋu to Yolŋu in local Yolŋu languages was culturally appropriate and effective. From the perspective of the educators, YEEWs being related, trusted and respected in their communities helped in approaching community members and overcoming lack of interest at the start of the project. Being educated in their own language made Yolŋu more comfortable talking with the YEEWs, addressed the language barriers that exist, especially in younger generations, and facilitated bridging the considerable differences between the Yolŋu and Balanda worldviews and rom. Yolŋu educating Yolŋu also enables repeated and long-term education, and education as part of their everyday lives as the YEEWs live in the communities. Educating in their local Yolŋu languages gave the YEEWs a sense of accomplishment and pride.

The reach of the education was limited by its focus on principal tenants due to project regulations (the LIEEP privacy notice being signed). This approach meant that often YEEWs had to come back to houses several times, creating additional work and putting YEEWs under time pressure to nevertheless fulfil project milestones. While the education stories being Balanda stories added credibility to the stories the educators were sharing, YEEWs did not identify with nor own these stories. That made it more difficult for them to understand the stories and share them effectively.

The educators tried to increase understanding by using methaphors linking back to their rom and showing the impact of the BEEBox. In addition to the education stories, the YEEWs assisted households with the reporting of damages and leaks, and to address power card challenges.

The repeated passing on of the education stories, time pressure, focus on numercial milestones and lack of quality checks compromised the quality of the education in the communities. Too much and too complex paperwork combined with time pressure resulted in YEEWs sometimes skipping completing the paper work. Principal tenants often got tired of being asked the same questions and found some questions asked in the project surveys invasive. Both together reduced the validity of the survey data. It takes time to develop the education stories together with Yolŋu communities, which then need to be repeated several times to bridge the vast cultural divides. However, the short-term nature of this project meant that there was insufficient time for many Yolŋu to understand the education.

The educators felt privileged, proud and happy about having been chosen to work for this project and to conduct the project because it was meaningful and they were able to help their communities by educating Yolŋu in Yolŋu languages. They felt proud of what they accomplished and they gained confidence to learn and work.

YEEWs were very grateful for and valued the education they were given. The YEEWs felt that they learned valuable new knowledge and skills regarding power and water, working with Balanda and educating Yolŋu. The educators feel strongly reponsible for fulfiling future educator roles in their communities. The power and water education they were given and working for this project has made the YEEWs aware of how power and water works and how much power they are using on a daily basis. The degree of understanding varied widely: some educators understood the stories well while others are still confused. The educators became more conscious of their own household and more likely to monitor how they use power and water and to use power and water more wisely. It is too soon to evaluate whether the project led to enduring behaviour changes for YEEWs and their households, but to date the impact on reducing energy use appears modest.

From the perspective of the YEEWs across the six communities, some Yolŋu understood the education and the BEEBox but many still do not understand. Nevertheless, YEEWs believe that the education and the BEEBox resulted in Yolŋu using power more wisely. The educators reported that Yolŋu in general appreciated the retrofits. While the YEEWs found that some Yolŋu were welcoming and wanted to know about the education, other Yolŋu did not want to know about the education. However, according to the educators, more Yolŋu are becoming more interested in finding out about using power and water more wisely, and more Yolŋu are using power and water wisely.

### *Households*

The households were visited by the YEEWs up to four times. The power and water knowledge is new for Yolŋu. The majority of householders were grateful for and appreciated the education provided by the project. They found the education useful and helpful, and they appreciated Balanda working with their kin to help Yolŋu to use power and water wisely. Yolŋu being educated to educate Yolŋu and Yolŋu educating Yolŋu in their own language was highly appreciated by Yolŋu and effective. It critically empowered Yolŋu and built trust, credibility and understanding of the Balanda knowledge system. The poster kit supported Yolŋu in understanding the education.

The education focussed on the financial aspects of using power to motivate Yolŋu to use power and water wisely. However, principal tenants found the new knowledge challenging to understand. Other factors that may have led to principal tenants not understanding the education might also include: the education not being sufficiently linked to the Yolŋu rom, or placing insufficient emphasis on budgeting, or being compressed into a too-short timeframe. The focus on the BEEBox may have meant that less time was spent on other education about how Yolŋu could reduce their power usage. Some principal tenants understood the education but others remain confused. Commonly, only the principal tenants got educated but they typically did not pass on the education to other householders, limiting the reach of the education. Further education is needed, preferably involving other residents of households in addition to the principal tenant. All of these householders' experiences and perspectives are consistent with the YEEW perspective.

While it was confusing for some, the BEEBox and the accompanying education from the YEEWs facilitated many Yolŋu using power more wisely. The BEEBox helps Yolŋu to monitor how much power they are using and to know when they use too much power and what appliances use most power. The BEEBox reminds or prompts them to turn off appliances. While some principal tenants passively accepted the BEEBox, others actively sought the device. Some principal tenants declined the installation of the BEEBox because it was unfamiliar to them or they distrusted the motivation behind the BEEBox. Concern around the BEEBox causing a house fire, using power itself and leading to power overload were other justifications for not agreeing to the BEEBox installation.

As with the education, typically only the principal tenants made the decison and learnt about the BEEBox, and they commonly did not pass on the BEEBox story to the householders. Consequently, while some Yolŋu interviewed understood the purpose of the BEEBox and how it works, others did not. While most householders understand the color indicator system, there seems to be a lack of understanding that the BEEBox measures power consumption against a pre-determined budget. A wide variety of misunderstandings and incorrect stories about the BEEBox circulated across all communities and contributed to people rejecting, ignoring or switching off the BEEBox.

Perceptions of the effectiveness of the BEEBox in the communities appear to be generally mixed. Many Yolŋu believe that the BEEBox is really useful and helpful, is saving power and makes the power cards last longer. Generally, the BEEBox is perceived as addressing the meter box issues of being installed outside the house and not indicating when they run out of power. Many householders who have a BEEBox nevertheless check the meter box so they know how much credit they have remaining. Other Yolŋu are sceptical of the usefulness of BEEBox and do not believe that the device helps in saving power.

Not all households were offered a BEEBox, and this created perceptions of inequality in the communities. Those householders who did not receive a BEEBox do not understand why they were not offered a BEEBox, in contrast to their neighbours and acquaintances. The removal of some BEEBoxes created upset and people resorted to old ways of using power unwisely. Some households that do not have a BEEBox find it difficult to save power and believe they cannot save power without a BEEBox. The vast majority of householders were concerned about the maintenance of the BEEBox and who would pay if the BEEBox breaks and needs to be repaired.

Similar to the YEEWS, while retrofits were a specific section in the discussion points that co-researchers used to guide interviews, participants did not often refer to retrofits. When they did, they talked most about the solar hot water system and stove timer. They generally appreciated these devices and believed that they helped in saving power. While the quantitative data indicates that, stove timers excepted, the retrofits did not significantly reduce power, the qualitative data suggests that they did enhance quality of life. For instance, participants living in households that did not have a hot water system installed before reported that people living in this household now can have a hot shower or a hot bath in their own house rather than having cold shower or going to the house of a relative to have a hot shower.

Many principal tenants and householders believe that the education they received provided much-needed knowledge, helped them to better understand the power system and helped them to use less power and save money. Most householders stated that the power and water stories improved their understanding and that they now know how to look after power and water wisely. Many householders understood the connection between using appliances and how long the power card lasts, and they now know which electrical devices use more power.

Many Yolŋu changed their daily power practices. They are monitoring how they use power, use devices less often, are being more diligent about switching off devices after using them or when leaving the house and communicating with other householders about how to save power. These changes have been reinforced due to the benefits of having power cards lasting longer. Many participants pointed out that they nevertheless also still use traditional hunting and cooking practices using fire outdoors to save power. Other residents are contributing towards the cost of the power card, addressing a key challenge for principal householders. However, some participants indicated that they are not using power differently than before the project.

The situation with respect to water echoes that for electricity. Many Yolŋu are making a conscious effort to act upon the knowledge that they were given during the education sessions. They are now monitoring and timing their water usage, turning off taps and showers, reporting leaky taps and supervising and disciplining children to use water more wisely.

# 3 A well-needed and useful project but too short—long-term projects are necessary to create lasting changes

In brief, while the project was well-needed and useful, it was too short to afford comprehensive and long-lasting behaviour change. Many Yolŋu did not receive sufficient education. Some of the YEEWs and many of the community members who did get the education do not yet fully understand. Yolŋu want and need more education to better understand power and water supply and to use power and water more wisely. Some Yolŋu are forgetting the power and water stories and are going back to how they used power and water before the project.

To have the whole community understand the education and hence be able to use power and water wisely requires longer-term projects. For many Yolŋu, English is their third or fourth language, and Western knowledge is difficult to understand. They have been living in houses with power and water being supplied through technology only for relatively few decades since the missionary times. Most people have grown up predominantly experiencing Indigenous knowledge systems. Indigenous languages do not support the understanding of Western knowledges. Knowledge is passed orally. Application of 'conventional' community education approaches is problematic due to Yolŋu spending a lot of their time keeping their traditional knowledge alive, moving between communities, and spending extended periods of time in their homelands. The general community sentiment about the project being too short and long-term projects being needed was strongly echoed by the YEEWs, who found themselves in a difficult situation because from their perspective, the project finished prematurely.

### *The untimely and unwelcome end to the project for YEEWs*

The employment of Yolŋu energy efficiency workers (YEEWs) to deliver community education programs in language in their own communities was a key innovation of the Manymak project that was fundamental to it achieving the impact that it did in such a short time. However, as YEEWs were employed out of project funds, it was always the case that their positions would cease at the end of the project. 'Real jobs' requiring Indigenous language skills are rare in remote Indigenous communities, so the creation of more than 90 YEEW positions was extremely welcome from a Yolŋu perspective. The educators were earning money and do not want to rely only on Centrelink payments. Conversely, the loss of these jobs at the end of the project caused significant disappointment for YEEWs in particular.

During the interview process, the YEEWs Forum, and discussion groups held towards the end of the project, the YEEWs strongly expressed their pain, sadness, anger and disappointment that their jobs were ending. The trust and pride that the project had successfully built up was eroded. Some YEEWs feel they are letting their communities down. They identified with being educators and experienced pride, satisfaction and fulfilment of making a difference to their communities. As many Yolŋu still do not understand or have not received the education yet, the educators feel that their job is far from finished. They feel that if they are no longer working, their communities will not get the education and help report damages or leakages that help them to save money and have an easier life. Understandably, they want to be re-employed permanently, but some are continuing to educate people voluntarily.

### *Summary project evaluation from the Yolŋu perspective*

In conclusion, from the Yolŋu perspective, the Manymak Energy Efficiency Project with Indigenous communities in east Arnhem Land was important and beneficial to the community. The project addressed critical needs and knowledge gaps of the communities. Importantly, Yolŋu see this project as the first project in which Balanda and Yolŋu have worked together, Balanda supporting Yolŋu to take the lead and Yolŋu educating Yolŋu about Balanda systems of knowledge. This collaboration empowered Yolŋu and facilitated trust, credibility and understanding. The power and water education the YEEWs and householders were given has helped them to better understand power and water supply, consumption and pricing. Many Yolŋu changed their daily power practices: they use power and water more wisely and are saving money. The YEEWs and householders expressed their appreciation and gratitude for this project being conducted in their communities.

The most critical keys to the effectiveness of the project were the following culturally appropriate, respectful and responsive approaches:

- Yolŋu and Balanda working together with the Yolŋu leading the project (in community delivery) and with the Balanda supporting the Yolŋu throughout this process
- YEEWs working as a team
- YEEWs being educated in Yolŋu languages
- Yolŋu educating Yolŋu in local Yolŋu languages.

The effectiveness of the project could have been most critically improved by:

- Yolŋu and Balanda developing the project together before applying for funding

- developing education resources together. with the educators using more traditional experiential education approaches linked to the Yolŋu rom and land/country
- educating in depth about budgeting
- educating the entire household and children at school
- educating the household in the afternoons, evenings and/or weekends
- taking sufficient time for the education, with possibly a lower proportion of time spent on specific devices
- addressing aspects of the environment that influence how Yolŋu use power and water (e.g., house design and township planning, overcrowding)
- conducting the project over a longer term
- creating longer-term positions for YEEWs on an on-going basis.

While the project was well-needed and useful, it was too short for Yolŋu to fully understand to afford comprehensive and long-lasting behaviour change and to educate all community members. The YEEWs strongly expressed their disappointment that the project was ending. The overwhelming preference in these six Yolŋu communities is for this work and its associated jobs to be ongoing, not a short-term ‘once-off’ project.

# APPENDIX E: ORIGINAL FUNDING AGREEMENT DESCRIPTION OF ACTIVITY AND BUDGET

## *The description of the Activity in the Funding Agreement is:*

The Recipient will deliver the Manymak (Good) Power Use! Project, which will trial and demonstrate an approach to energy efficiency by targeting 620 low-income households in participating east Arnhem Indigenous communities. The Activity will assist participants by reducing expenditure on energy, increasing thermal comfort and allowing participants to make informed decisions around energy consumption.

The Activity must be further described in a Project Plan submitted to the Department and approved by the Department.

## *The Activity components as per the Project Plan were:*

a) Identifying barriers to efficient use of energy by low-income Indigenous households in Galiwin'ku, Gapuwiyak, Milingimbi, Yirrkala, Gunyangara and Ramingining by partnering with local Indigenous people in the design and delivery of household and community stores surveys, audits, ambassador training and dissemination of educational information including community workshops.

b) Developing best-practise engagement and technology approaches to address identified barriers to energy efficiency, including:

- retrofitting 550 participants' households with energy saving devices based on survey results
- installing data loggers to all 550 participant households and an additional 70 households used as a control group:
- installing an in-house display in 250 participant households
- developing promotional material in local languages and action-based checklists targeting behaviour based energy efficiency measures
- introducing an energy efficiency rewards scheme in selected communities.

c) Evaluating measurable household energy efficiency improvement in participants' households. Individual components will be evaluated separately.

d) Delivering a best-practice model for achieving improved energy efficiency that benefits participants' households, addressing the following barriers:

- information failure
- capital constraints
- remoteness/accessibility
- split incentives.

The Recipient will analyse the survey results as well as energy billing data to determine the effectiveness of the energy efficiency components of the Activity, compared to a control group.

### *Appendix E: Project Budget from Funding Agreement:*

| **Expenditure Item** | **LIEEP Funding** | **Activity Generated Income** | **Other Contribution (cash)** | **Other Contribution (in-kind)** | **SUB-TOTALS (ex GST)** |
|---|---|---|---|---|---|
| Barrier survey | $60,000 | | | | $60,000 |
| Store survey | $29,000 | | | | $29,000 |
| Development marketing and communications materials | $150,000 | | | | $150,000 |
| Resource development of ambassador training kit and householder education materials | $140,000 | | | | $140,000 |
| Ambassador recruitment and training | $337,500 | | | | $337,500 |
| Ambassador employment, HH engagement and education, including energy surveys | $1,892,800 | | | | $1,892,800 |
| Program office mentoring (on the ground) | $390,000 | | | | $390,000 |
| Retrofit program | $2,981,000 | | | | $2,981,000 |
| In-house display devices | $330,000 | | | | $330,000 |
| Electricity consumption data-logging | $250,000 | | | | $250,000 |
| Data management; IT resources | $162,500 | | | | $162,500 |
| Rewards scheme | $250,000 | | | | $250,000 |
| Travel expenses; flights and vehicle | $240,000 | | | | $240,000 |
| Advisory board management | $87,500 | | | | $87,500 |
| Project staff | $2,100,000 | | | | $2,100,000 |
| IES water smart metering | | | $600,000 | | $600,000 |
| IES independent evaluation | | | $100,000 | | $100,000 |
| IES media and marketing | | | | $175,000 | $175,000 |
| IES specialist consultation advice and review | | | | $250,000 | $250,000 |
| IES travel expenses | | | | $87,500 | $87,500 |
| IES project office | | | | $350,000 | $350,000 |
| IES project inception | | | | $37,500 | $37,500 |
| Charles Darwin University | | | | $269,464 | $269,464 |
| Dept Housing; Community Housing Officers | | | | $400,000 | $400,000 |
| EASC on-ground mentoring | | | | $400,000 | $400,000 |
| Bushlight | | | | $169,000 | $169,000 |
| PWC / Alice Solar City Consortium data management | | | | $300,000 | $300,000 |
| **TOTALS (ex GST)** | **$9,400,300** | **-** | **$700,000** | **$2,438,464** | **$12,538,764** |

# Appendix F: Cost-benefit Analysis Details

The total costs of the project are provided in the budget discussion.

They are attributed to the four levels of the cost benefit analysis methodology according to the following allocations.

## 1 Allocation of Ambassador Program Costs

Allocation of the costs of employing YEEWs is the most complex part of the cost-benefit analysis due to the way activities and costs were tracked.

The YEEW labour hours spent on training and administration are estimated to account for 25 per cent of all employment, with household visits making up 75 per cent.

The household visits are allocated to the relevant discussion topics (house visits often involving two or more topics). This approach assumes that each topic used the same amount of labour time.

| Interaction category | Sum of TOTAL | % of household visit time | % of total hours of employment |
|---|---|---|---|
| BEEBox | 815 | 21% | 15.8% |
| Energy | 572 | 14% | 10.5% |
| Recruitment | 1211 | 31% | 23.3% |
| Research | 202 | 5% | 3.8% |
| Stove timer | 482 | 12% | 9.0% |
| Water | 666 | 17% | 12.8% |
| Training and dmin | - | - | 25% |
| **Grand Total** | **3948** | 100% | 100% |

Next, the costs of the ambassador program are broken down by relevant activities. Note that these costs include commitments as at March 2016.

| Ambassadors program costs breakdown | LIEEP spend | In-kind spend |
|---|---|---|
| Contracts - employee costs | $1,228,404.15 | - |
| Contracts - office, ICT, vehicle costs | $478,959.38 | - |
| Training contracts | $234,221 | - |
| Other costs | $260,837.46 | - |
| **Ambassadors total** | **$2,202,422.00** | **$344,989** |

Allocation of retrofit costs is based on the average of the contract costs for each batch of installations. Additional overhead costs for the retrofits activity are divided proportionally among retrofits. Ambassador costs directly attributable to recruitment and support of individual technology trials are also attributed specifically to those trials, with the remainder apportioned as per the table. All costs associated with the project data collection, research and evaluation are attributed to Level 4.

The resulting allocation of full project costs is presented on the following page.

| **Project budget activity** | **Sub activity for cost-benefit analysis** | **#Participants** | **Level 1** | **Lvl 2%** | **Level 2 specific** | **Level 2 shared** | **Level 3 - LIEEP** | **Level 3 - In-kind** | **Level 4 - LIEEP** | **Level 4 - in-kind** |
|---|---|---|---|---|---|---|---|---|---|---|
| Project team | | | | | | 1,379,288 | 100,000 | 1,618,721 | 600,000 | |
| Travel costs | | | | | | 531,425 | | 5,382 | | |
| Consortium governance | | | | | | | | | 79,000 | 189,795 |
| Marketing and communication | | | | | | 80,000 | | 50,153 | 114669 | |
| Development of resources | energy education and training kit | | 119,464 | | | | | 29,490 | | |
| Incentive scheme | | | | | | 219,897 | | 227 | | |
| Ambassadors | training and admin | | | 25.0% | | 541,322 | $739,797 | 344,989 | | |
| Ambassadors | research | | | 3.8% | | | | | $46,065.16 | |
| Ambassadors | recruiting houses | | | 23.3% | | 285,604 | | | | |
| Ambassadors | BEEBox | | | 15.8% | 193,474 | | | | | |
| Ambassadors | stove timers | | | 9.0% | 110,556 | | | | | |
| Ambassadors | energy education | 564 | 128,982 | 10.5% | | | | | | |
| Ambassadors | water education | 463 | 156,622 | 12.8% | | | | | | |
| BEEBox | | 252 | 624,979 | | | | | 4,556 | | |
| Retrofits | indirect costs | | | | | | | 102,117 | | |
| Retrofits | 302J | 114 | 1,170,334 | 50% | 178542 | | | | | |
| Retrofits | HP | 87 | 674,434 | 29% | 102889 | | | | | |
| Retrofits | ceiling insulation | 47 | 283,329 | 12% | 43224 | | | | | |
| Retrofits | stove timer | 209 | 190,399 | 8% | 29047 | | | | | |
| Energy data loggers | | 663 | | | | | | | 542,085 | |
| Water meters | | | | | | | | | | 445,300 |
| Surveys | collection of interview data -barrier surveys | 42 | | | | | | 3,316 | 14,467 | |
| Surveys | collection of interview data - co-researchers | 100 | | | | | | | 224,000 | |
| Surveys | other costs | | | | | | | | 42,533 | |
| Data management | | | | | | | | | 151,043 | 86,552 |
| Evaluation | | | | | | | | | | 142,769 |
| **Total** | | | **3,348,543** | | **657,732** | **3,037,536** | **839,797** | **2,158,951** | **1,813,862** | **864,416** |

The resultant costs are then summarised against the direct trial activities. The estimated total kWh saving represents double that observed in the community level savings, but this tallies well assuming that the project's activities were only fully functional for half of that year and that double the savings would have been achieved had all trials been in place for the full calendar year.

| **Trial** | **#** | **Unit** | **Level 1 direct total cost $** | **Level 1 Cost - per unit $** | **Level 2 cost – specific $** | **level 2 cost – shared $** | **Level 3 cost $** | **Level 4 cost $** | **Presumed Functional Life (years)**[99] | **Cost of "Business as Usual"* ($ per unit)** | **Level 1 total cost net of BaU $** | **Estimated annual kWh saving total** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BEEBox | 252 | installs | 624,979 | *2,480* | 193,474 | 566,932 | 559,692 | 499,879 | 5 | - | 624,979 | 55,188 |
| 302J | 114 | installs | 1,170,334 | *10,266* | 178,542 | 1,061,635 | 1,048,079 | 936,073 | 15 | 3,800 | 737,134 | 71,985 |
| HP | 87 | installs | 674,434 | *7,752* | 102,889 | 611,794 | 603,982 | 539,435 | 10 | 2,533 | 454,034 | 90,184 |
| Ceiling insulation | 47 | installs | 283,329 | *6,028* | 43,224 | 257,014 | 253,732 | 226,616 | 20 | | 283,329 | 34,310 |
| Stove timer | 209 | installs | 190,399 | *911* | 139,603 | 172,715 | 170,510 | 152,288 | 5 | | 190,399 | 102,985 |
| Energy education | 564 | houses | 230,527 | *409* | | 209,116 | 206,446 | 184,383 | 3 | | 230,527 | - |
| Water education | 463 | houses | 174,541 | *377* | | 158,330 | 156,308 | 139,604 | 3 | | 174,541 | - |
| **Total** | | | **3,348,544** | | **657,732** | **3,037,536** | **2,998,748** | **2,678,278** | | | **2,694,944** | **354,652**[100] |

[99] Obtained from CAT report prepared for the project: "LIEEP HWS Life Cycle Cost Analysis Report", adjusted based on subsequent advice for heat pump longevity. BaU represents the case of installing a standard ground mounted electric hot water system.

[100] This figure was previously 456MWh based on stove timer savings of 3 kWh per unit; subsequent analysis identified a lower estimate for this activity

# APPENDIX G: PROJECT TIMELINE

| Date | Activity / Progress |
|---|---|
| **February 2012** | • LIEEP guidelines released |
| **March 2012** | • EOI submitted |
| **October 2012** | • Detailed business case submitted |
| **December 2012** | • Notification of successful application |
| **May 2013** | • Milestone 1: funding agreement signed<br>• Project director appointed |
| **June / July 2013** | • Appointment of remaining project team members<br>• Scoping for retrofit program |
| **August 2013** | • Milestone 2 submitted: project and other plans |
| **September 2013** | • Barrier survey, ambassador program and education program designed<br>• Retrofit QS estimates sought<br>• Community visits completed to identify types of houses and inform retrofit program<br>• Galiwin'ku – first scoping meeting with key stakeholders to introduce the project and identify houses for retrofits |
| **October 2013** | • Barrier and store surveys completed<br>• Yirrkala: 19 x houses complete barrier survey |
| **November 2013** | • Initial scoping visits for household retrofits completed<br>• Gapuwiyak: project introduced to the community |
| **December 2013** | • Gunyangara and Yirrkala: initial consultation in community to advise on the data logger installations<br>• Department of Housing retrofits discussion paper produced |
| **January 2014** | • Ramingining: community engagement officer visits community seeking feedback from key stakeholders on the design of the project<br>• Galiwin'ku - Barrier survey and energy store survey completed |
| **February 2014** | • Milestone 4: retrofits and incentive scheme program designed and commencement of installation data loggers<br>• Eco switches and Coolbros purchased for assessment<br>• Milingimbi / Galiwin'ku: ARDS conducts community consultation visits to inform design of employment and education<br>• Gapuwiyak: community engagement officer community consultation<br>• Ramingining: installation of data loggers |
| **March 2014** | • Milestone 5: employment engagement commenced, poster kit developed, education program and incentive scheme designed<br>• 620 x data logger installations across all six communities completed<br>• Milingimbi: EARC engaged as host employer, recruitment of YEEWs commenced |
| **April 2014** | • Milingimbi: employment of YEEWS and delivery of training by community |

| Date | Activity / Progress |
|---|---|
| | engagement officer and interpreter<br>• Department of Housing commence detailed retrofit scoping against agreed priority retrofit list |
| **May 2014** | • Milingimbi YEEWs training commences and 46 households approached;<br>• database designed<br>• Consortium agreement executed<br>• Milestone 6 successfully completed |
| **July 2014** | • LIEEP project launch celebration held at Milingimbi<br>• Milingimbi: completion of privacy notices and knowledge, attitude and behaviour survey (KAB) for households<br>• New CDU researcher assigned to project |
| **August 2014** | • Dept. of Infrastructure service level agreement signed for delivery of first round of major retrofits<br>• Gunyangara and Yirrkala: community engagement officers' community consultation in preparation for project<br>• 6 pilot stove timers installed in Gunyangara |
| **September 2014** | • Milestone 7: progress update submitted<br>• Finalised project-specific LIEEP privacy notice; created plain English version translated to Yolŋu Matha audio for use by YEEWs<br>• Galiwin'ku: EARC engaged as host employer, recruitment and employment of 17 x YEEWs Galiwin'ku YEEWS advise 52 x houses of upcoming retrofits<br>• Gunyangara: additional data loggers installed; retrofits installed: 3 x roof insulation, 8 x solar hot water systems and 6 x stove timers<br>• Yirrkala: retrofits installed; 5 ceiling insulation, 3 heat pump HWS and 12 solar hot water systems.<br>• Milingimbi: 97 x houses approached to participate |
| **October 2014** | • Research and evaluation workshop number 1 (reviewed and adjusted research and evaluation approach)<br>• Yirrkala: consultation with community elders around project<br>• Galiwin'ku: energy efficiency training for YEEWs by Community Engagement Officer with local interpreter commences<br>• Gapuwiyak: visit to prepare for retrofits<br>• First BEEBoxes received |
| **November 2014** | • Milingimbi: First BEEBoxes installed; CDU researchers trial a direct research visit<br>• Retrofit installation commenced in Milingimbi, Galiwin'ku, Yirrkala, Gunyangara and Gapuwiyak |
| **December 2014** | • Milestone 8 successfully completed<br>• Milingimbi: final houses approached to participate, finalised installation of 59 BEEBoxes, 78 stove timers and 39 hot water systems (32 x heat pump and 7 x solar)<br>• Galiwin'ku: 39 BEEBoxes installed, training delivered by community engagement officer, advised 52 x houses of retrofits<br>• Yirrkala and Gunyangara: consultation with community elders about the project |

| Date | Activity / Progress |
| --- | --- |
| | • Yirrkala: EARC engaged as host employer |
| **January 2015** | • Research and evaluation workshop number 2 (introduced Yolŋu Co-Research approach)<br>• Contract awarded to ARDS for provision of training to YEEWs<br>• Ramingining: retrofit scoping commences<br>• Yirrkala: procurement of hose organisation. Co-researchers recruited, training<br>• Milingimbi: EARC employment induction and recruitment of replacement YEEWs<br>• Gunyangara: procurement of hose organisation Mangarr / Gumatj Association. Co-researchers recruited, training |
| **February 2015** | • Yirrkala and Gunyangara: recruitment and employment of YEEWs finalised. Co-researchers conducted pre-project interviews with household<br>• Gunyangara: co-researchers conducted pre-project interviews with household<br>• Gapuwiyak: procurement of host organisation completed with contract awarded to EARC<br>• 19 February: Cyclone Lam sweeps through east Arnhem Land, devastating communities, damaging infrastructure and impacting project delivery. Seventy houses in Galiwin’ku that were included in the project were damaged and required residents to vacate (approximately 10 per cent of project houses) |
| **March 2015** | • Gapuwiyak: recruitment and employment of YEEWs<br>• Ramingining: recruitment of ambassador program<br>• Yirrkala and Gunyangara: first energy efficiency training delivered by ARDS, household visits<br>• Gapuwiyak: recruitment and employment of YEEWs<br>• Gunyangara: 4 x weeks of energy efficiency training and installation of 1 x BEEBox<br>• 21 March: Cyclone Nathan passes over east Arnhem Land<br>• Galiwin’ku: additional BEEBox training and follow up household visits following cyclones Lam and Nathan<br>• Milestone 9: progress report submitted |
| **April 2015** | • Ramingining: CoreStaff engaged as host employer<br>• Yirrkala and Gunyangara: energy efficiency household visits commence. Co-researchers conduct household interviews<br>• Gapuwiyak: energy efficiency training. Recruited and trained co-researchers and conducted pre-project interviews with households.<br>• Milingimbi: recommence work after the devastation of cyclone Lam and Nathan with ARDS delivering water efficiency training |
| **May 2015** | • Milestone 10: progress report<br>• Galiwin’ku: new YEEWs employed and training. Retrofit installation; 80 BEEBox and 19 stove timers<br>• Milingimbi: Energy Efficiency workshop, first 100 water efficiency household education, 6 x hot water systems installed, BEEBox and stove timer ant treatment applied and retrofit of dedicated power points for BEEBox display units<br>• Gunyangara: 25 x household visits approach to participate and 9 x BEEBox follow up visits<br>• Gapuwiyak: 102 x household visits and BEEBox installations |

| Date | Activity / Progress |
| --- | --- |
| | • Ramingining: employment of YEEWs |
| **June 2015** | • Galiwin'ku: water conservation training<br>• Yirrkala: BEEBox training<br>• Gunyangara: 10 x BEEBox and 19 x stove timers installed<br>• Ramingining: induction and energy efficiency training. Co-researchers recruited, trained and conducted household interviews.<br>• Gapuwiyak: YEEWs present energy efficiency school on energy efficiency and complete second household visit |
| **July 2015** | • Research and Evaluation Workshop number 3 (discussion of research and evaluation framework and development of final report plan)<br>• Gunyangara: water conservation training<br>• Garma Festival: information stall with YEEWs from Yirrkala and Gunyangara assisting<br>• Gapuwiyak: YEEWs present on energy efficiency at the school and commence BEEBox installation<br>• Ramingining: 5 BEEBox installations and first household visits |
| **August 2015** | • Yirrkala: water conservation training. Co-researcher fieldwork to clarified of researcher and YEEW roles and develop evaluation interview discussion points.<br>• Gapuwiyak: 35 BEEBoxes installed<br>• Ramingining: thermal comfort and tracking study commences and 21 BEEBox installed. |
| **September 2015** | • Milestone 11: progress report<br>• Filming of project video in Gapuwiyak and Yirrkala<br>• Newcastle LIEEP Forum: supervisor from Galiwin'ku presented along with a co-researcher<br>• Commenced community engagement in communities for incentive scheme<br>• Galiwin'ku: BEEBox visits, 69 x stove timers installed and water conservation training and household visits<br>• Gunyangara: final household visits and project completion<br>• Yirrkala: 39 BEEBoxes installed<br>• Gapuwiyak: additional YEEWs employed to introduce more females to the team, filmed project video, follow up BEEBox visits and water conservation training<br>• Ramingining: BEEBox and energy efficiency top up training |
| **October 2015** | • House visits continue in communities<br>• Gulkula Forum held with YEEWs and co-researchers<br>• Communities approached about incentive scheme<br>• Galiwin'ku: 55 stove timers installed<br>• Yirrkala: 83 x houses approached to participate, 39 x BEEBox installation and 41 stove timers installed<br>• Gunyangara: 9 stove timers installed. Co-researcher training and evaluation and participant interviews<br>• Gapuwiyak: retrofits installed; 16 solar hot water systems and 7 houses received ceiling insulation. Co-researcher training and conducted evaluation and |

| Date | Activity / Progress |
| --- | --- |
| | participation interviews<br>• Ramingining: YEEWs present at school and to RJCP workers on energy efficiency. 12 houses receive ceiling insulation. Thermal comfort and tracking study and co-researcher training and household interviews |
| **November 2015** | • Milingimbi: final house visits including 35 KAB surveys and project close with a lunch and certificate of appreciation ceremony held in community<br>• Galiwin'ku: tap timer and hose nozzle 'give –away' conducted as joint PWC and LIEEP project activity. Recruited and training co-researchers and conducted household interviews.<br>• Ramingining: water conservation training, house visits and retrofit program completed with a total of 35 solar hot water systems installed. conducted household post-project interviews<br>• Gapuwiyak: continue with water household visits |
| **December 2015** | • YEEWs complete final household visits before employment ended<br>• project completion barbecues and certificate presentation to YEEWs held in each community<br>• Yirrkala: 11 x ceiling insulation completed, follow up BEEBox visit and 70 x houses educated on water conservation<br>• Ramingining: 35 x solar hot water systems installed<br>• Galiwin'ku: continues household visits, follow up visits on installed tap timers and hose nozzles, final privacy notices collected, assisted co-researchers on household interviews.<br>• Gapuwiyak: final house visits and pack up office<br>• Milestone 12 successfully completed, all project targets met or exceeded |
| **January 2016** | • Commence detailed work on the project final report<br>• Design and procurement of community incentive scheme underway |
| **February 2016** | • Preliminary qualitative and quantitative evaluation findings |
| **March 2016** | • Milestone 13: Submission of first draft of the final report to the Australian Government |

East Arnhem Regional Council

Centre for Appropriate Technology Limited

indigenous essential services Pty Ltd

NORTHERN TERRITORY GOVERNMENT

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