Session Two:

Implementing Sustainable Energy Services in Remote Indigenous Communities

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Summary
The Centre for Appropriate Technology (CAT) has managed the highly successful Bushlight Indigenous community renewable energy project since it’s inception in 2002. To date, Bushlight has installed more than 120 high quality, reliable remote area power supply systems in remote aboriginal communities across northern and central Australia.

In our experience, the long term sustainability of remote area power supply systems is dependant on three key factors:

- Effective engagement, consultation and communication with community residents
- Appropriate technical design of the renewable energy system, including a thorough assessment of the life cycle cost of various supply options
- The availability of a comprehensive support network to ensure that any operational issues are attended to quickly and effectively

This paper describes these three critical factors in detail and suggests ways in which engineers and project managers can incorporate consideration of these issues into future remote area power supply projects.
Background

The Centre for Appropriate Technology (CAT) is a leading Indigenous science and technology organisation based in Alice Springs in Centre Australia. For nearly 30 years, CAT has been assisting Indigenous communities to pursue sustainable livelihoods in regional and remote Australia through the application of appropriate technologies. CAT is a not-for-profit organisation incorporated under the Associations Act in the Northern Territory. It has approximately 100 staff located in offices in Alice Springs, Cairns, Darwin, Kununurra and Derby.

Since its inception in 2002, CAT has managed the highly successful Bushlight renewable energy project. Bushlight is jointly funded by the Australian government through the Department of Families, Housing, Community Services and Indigenous Affairs (FaHCSIA) and the Department of the Environment, Water, Heritage and the Arts (DEWHA). More than $40m fund has been invested in the project over the last 6 ½ years.

Bushlight’s aim is to “Improve livelihood opportunities for people in small remote Indigenous communities through the provision of sustainable (consistent, affordable, reliable) renewable energy services”

Since 2002 Bushlight has worked with more than 100 communities and installed more than 120 Renewable Energy (RE) systems across central and northern Australia.

In 2006, Bushlight was awarded Engineers Australia Northern Division and National Engineering Excellence Awards in recognition of the engineering outcomes of the project as well as the significant impact of the project on the lives of Australians living in the most remote parts of the country.

In 2008, the Australian government, through the Asia Pacific Partnership on Clean Development and Climate provided funding for CAT to implement the Bushlight Community Energy Planning Model in several remote villages in India in conjunction with a group of Indian based partners. This project is currently underway.

Bushlight

Despite the great promise of the underlying technology, prior to the inception of the Bushlight Project the implementation of RE systems in remote Indigenous communities had met with mixed and often poor results. Situations such as those shown in the images below were relatively commonplace. A comprehensive market survey of communities revealed that the majority of residents were not satisfied with the performance of their renewable energy systems, and that only two thirds of systems installed were actually found to be operational at the time of the survey.
Examples of failed RE systems and components

Research by the Australian Cooperative Research Centre for Renewable Energy (ACRE) and CAT into the cause of this consumer dissatisfaction and poor technical/engineering outcomes revealed a complex web of factors contributing to the situation including:

- Lack of consultation with residents during the project planning phase
- Lack of training provided to users
- Inappropriate RE system design requirements and specifications
- Lack of a formal standard for RE system design
- Procurement policies focused on purchasing the cheapest possible solutions
- Scarcity of recurrent funding to pay for maintenance services
- Lack of a suitably trained support network to provide ongoing support and maintenance services post the installation of the system

Bushlight sought to specifically address these and other factors contributing to poor outcomes for renewable energy installations in Indigenous communities.

In order to achieve consistent, positive outcomes in all communities Bushlight works with, the Project developed a model of engagement referred to as the Bushlight Community Energy Planning Model. This model has 3 key components:
1. Effective engagement, consultation and communication with community residents

Community development principles universally accepted around the world indicate community resident’s value and take greater ownership over infrastructure that they understand and that provides recognisable benefit to them. The provision of a reliable electricity supply would certainly be considered by most as providing a recognisable benefit to community residents, but to what extent do residents generally understand the issues associated with the generation and use of this valuable and high cost resource? Communicating these concepts and making decisions in a cross cultural environment further exacerbates the difficulty of ensuring the residents of a community receiving a renewable energy system fully understand its capabilities and limitations.

Bushlight has developed a comprehensive community engagement process supported by a wide range of educational and training resources. These resources are specifically designed for use in cross cultural environments where literacy and numeracy levels are highly variable. A suite of icons (some of which are shown below) have been developed to assist in establishing a common understanding of basic energy concepts with residents, from which point more complex discussions and decisions can be explored.

![Examples of icons developed by Bushlight to assist in the discussion of energy concepts](image)

These icons are used consistently throughout the community engagement process to maintain uniformity and familiarity. Other supportive resources such as RE system operation and troubleshooting manuals and service level agreements are written in an uncomplicated style using plain English and extensive use of illustrations and images.
A well developed and executed community engagement strategy will result in well informed residents who understand and accept the capabilities and limitation of the renewable energy system being installed. Residents will have confidence to manage their energy services and the renewable energy system itself effectively, efficiently and within its operational limits. Community members will have a high degree of psychological ownership over the infrastructure and will be highly motivated to ensure it’s correct operation and maintenance. They’ll also have the skills to carry out basic troubleshooting and the ability to confidently interact with external service providers should the need arise.

The engineering profession is often involved in the provision of RE systems in remote locations – be they indigenous communities or mainstream applications such as mining, tourism or cattle enterprises. Consultation with the ‘client’ is normal practice for all engineering projects, and in the case of government funded infrastructure in remote communities, the principle client is typically the funding agency. The principle stakeholder in the ongoing sustainability of the asset, however, is without doubt the residents of the recipient community. Assuming that it is not in the interests of either the funders or the implementing organisation to be associated with the delivery of unsustainable infrastructure, it is incumbent on both parties to ensure that an appropriate level of community consultation is undertaken. In the specific case of consulting with Indigenous community residents, it should be recognised that specialist communication skills and processes may be required to enable residents to fully participate in and understand the required decision making process. Key decisions that should be made by residents in consultation with implementing and funding agencies include:

1. Whether or not a renewable energy system will meet the current and foreseeable future energy needs of residents,
2. The capacity and physical limitations of the renewable energy system,
3. The location of the RE system and related electricity distribution infrastructure within the community,
4. Agreement on the level of ongoing contributions by residents towards energy provision costs and the mechanism for making these payments.

2. Appropriate technical design of the renewable energy systems

The first step in the design of an appropriate RE system for any particular site should always be a thorough life cycle cost analysis of the available power supply options taking into account: the RE resources available; the community’s identified energy needs; the capital costs of the various options; the investment parameters and horizon of the key stakeholders (funders and residents); fuel costs; maintenance and service arrangements and costs; and equipment replacement costs.

The chart below shows an example of this calculation for a typical 4 house community, 200 km’s from the nearest service centre, with a delivered fuel cost of $1.60. In this case, a grid connection is not one of the options considered. In this particular case it can be seen that that the life cycle cost of a PV system providing 24 hour power is less than half that of providing a similar supply with diesel generation over a 10 year period.

A cash flow analysis of the same site shows that the PV system has a payback period of less than 3 years compared to 24 hour diesel generation, and similar costs over 10 years to an 8 hour per day diesel power supply option.
Life Cycle Cost analysis should be carried out in accordance with AS/NZS 4536: 1999 or other relevant standards.

An important component of the life cycle costs calculation is the estimation of the capital cost of the various options. Obtaining or calculating these estimates is critical to carrying out an accurate life cycle cost analysis.

Although the life cycle cost of the various supply options is an important factor in determining the most appropriate power supply system to be installed, other non-financial factors may also be relevant. These include:

- Level and type of skills and capabilities within the community and local support network to maintain and sustain the system
- The expressed preferences and concerns of community residents
- Availability of capital to support the project (a high capital solution may be the most attractive over the full life cycle of the equipment but if the required capital is not available this may simply not be an option).

Once a power supply option has been identified and agreed as the most appropriate one for a given circumstance, it’s critical that the renewable energy equipment be designed, manufactured and installed to standards appropriate for the environmental conditions prevailing at the site. Typically in northern and/or central Australia this would involve designing the equipment to withstand dust, insect infestation, high and low humidity, ambient temperatures in the range of -5°C to +45°C.

Sizing and specification of the key components of the RE system must be carried out in accordance with AS 4509 by a system designer holding Clean Energy Council accreditation for RE system design. A list of accredited designers is available form the Clean Energy Council website. [www.cleanenergycouncil.org.au](http://www.cleanenergycouncil.org.au)

Installation and maintenance requirements for RE systems are also covered in AS4509 however in Bushlight’s experience additional specific details and specifications are required to ensure the long term reliability and sustainability of RE systems in remote Indigenous communities. Information and examples of Bushlight standard’s for RE system installation and maintenance, including commissioning checklists, are available from the Bushlight website or by contacting the Bushlight team at CAT’s Alice Springs.
office. The Bushlight website also contains a list of specific components (Solar Modules, Batteries, Inverters etc.) that have been pre-approved for use in Bushlight RE systems. These components have been found to meet Bushlight’s specific requirements and specifications and in some cases have been independently tested under laboratory conditions to confirm their performance under the environmental conditional prevailing in central and northern Australia.

Most RE systems designed for installation in remote locations have some degree of data logging capacity to enable service personnel to check or monitor the performance of the system and to troubleshoot system faults. The process for collecting and analysing this data, and the frequency at which this is done should be considered during the system design process. Bushlight RE systems are designed to hold a minimum of 12 months of system operational data on site as the technical service internal for these systems is 1 year (i.e. a technical service person is scheduled to visit each site every 12 months).

Where a single RE system is intended to supply multiple residents within a community, a method of ensuring equitable energy use amongst residents is required to ensure that no one user can discharge the main system battery and cause power to be disconnected to all residents (something that would obviously cause disharmony within the community). Bushlight uses individual Energy Management Units (EMUs) installed in each house to limit household daily energy consumption to a pre-agreed level. If a household exceeds it’s allocated daily energy budget, supply to non-essential loads within the house is disconnected. Household energy budgets within all houses are reset (and disconnected houses reconnected) at midday each day.

Where energy efficient appliances are factored into the load calculations for RE systems, consideration needs to be given to the process residents would follow to replace these with like appliances if they fail or come to the end of their life.

The appropriate design of the renewable energy system hardware is a component of the overall implementation of a renewable energy project that the engineering profession could be expected to be most comfortable and familiar with. The complexity in the process is predominantly around designing systems to meet highly variable loads as levels of occupancy, seasonal temperature variations and access to household appliances can cause overall community loads to vary significantly from day to day and throughout the year. In principle, the RE systems needs to be sized to meet the highest expected load under the lowest expected RE resource conditions in order to provide a reliable supply of electricity to the community.. In practice this would lead to unjustifiably large (and expensive) systems, so compromises and judgement calls need to be made. Bushlight’s use of the household Energy Management Units alleviates this problem significantly by fixing the total possible load within the community to the sum of the individual household energy budgets programmed into the EMUs. Hybrid RE system, incorporating a diesel generator backup have greater flexibility to meet highly variable loads, however the additional issues associated with maintaining generating sets (and their ongoing fuel supply) need to be taken into consideration during the design phase.
3. Implementation of a comprehensive support and maintenance strategy

Renewable energy systems consist of numerous components, each with their own maintenance requirements and service life. With appropriate maintenance and periodic component replacement, RE systems can be expected to perform reliably for at least 20 and up to 30 years. An important aspect of the design of RE systems is the preparation of maintenance schedules and checklists that will ensure this potential life is reached in practice. The table below show the typical life span of the key components of RE systems.

<table>
<thead>
<tr>
<th>Component</th>
<th>Typical life</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Batteries – flooded cells</td>
<td>5 – 7 years</td>
<td>Assume good quality batteries installed in appropriate enclosures</td>
</tr>
<tr>
<td>Batteries – sealed cells</td>
<td>8 – 10 years</td>
<td></td>
</tr>
<tr>
<td>Inverters and other electronic components</td>
<td>12 – 15 years</td>
<td></td>
</tr>
<tr>
<td>Solar Modules</td>
<td>25 years</td>
<td>Output typically degrades by 20% over this period</td>
</tr>
<tr>
<td>Switchboards, equipment cabinets</td>
<td>25 years</td>
<td>Recommend cabinets are made from aluminium to prevent corrosion</td>
</tr>
<tr>
<td>Sheds, fencing etc.</td>
<td>25 years</td>
<td></td>
</tr>
</tbody>
</table>

**Table 1. Typical RE system component lifetimes**

Long term maintenance arrangements need to take these component replacement requirements into account so as to ensure the ongoing performance of the RE system.

Component replacement is, however, only one aspect of the maintenance and support strategy required to ensure RE systems remain operational over their full design life. The efficient and effective provision of scheduled and unscheduled maintenance services is a critical issue. Within the context of remote indigenous communities, Bushlight developed and implemented a three tiered maintenance and support strategy. In our experience, this model can be implemented or adapted to suit most situations.

**Level 1**

This involves providing appropriate training to as many community members as possible (preferably all community members) in basic system operation, troubleshooting and maintenance. Training is provided around the time of system installation and is a combination of hands-on demonstrations and reviewing of written manuals. System operation tasks include turning the RE system on and off and reading and interpreting meters. Basic trouble shooting training includes resetting safety switches and circuit breakers, replacing light bulbs, and monitoring the status of indicator lights on the main RE system. Community level system maintenance tasks include keeping the RE system and solar modules free of obstructions, grass and shade from trees, and periodically washing dust of solar arrays. A plain English, highly illustrated operator manual is provided to community members as part of their training.
Communities have a tendency to nominate one or two people within the community to receive ‘local operator’ training. This often suits project managers and system installers due to the usual financial and time constraints which apply to projects delivered in remote locations. Bushlight’s experience is that if the whole community is involved in the engagement process, and the broader community genuinely has ownership over the project there will be a greater level of interest amongst community members in receiving training. Agreeing to participate in the community level training is also a commitment that residents make during the community consultation period. In general, the more community members that receive the Level 1 training, the greater the chance that if problems do arise with the power supply within the community they can be resolved without the need to involve costly external services providers.

**Level 2**

Communities often have arrangements in place with local service providers to provide basic building and infrastructure maintenance and municipal services. Bushlight identifies those people or organisations that would normally provide ‘first line response’ to infrastructure problems within the community and provides an intermediate level of RE system support and maintenance training. These are the people who are likely to be the closest and most readily available to respond to problems with the RE system that can not be rectified by community members themselves. This training involves managing issues such as minor battery terminal corrosion, minor cable or appliance faults, incorrect system operation (overuse or misuse) shading on arrays from large trees and generator maintenance issues. By training and supporting an ‘intermediate level’ of technical support, the need to call in high level technical service providers, at what is typically significant expense, can be avoided in the majority of situations. Over the last 6 years, Bushlight has provided this intermediate level training to more than 100 resource agency and service provider staff. The Bushlight training resources for the intermediate level service providers are available on the Bushlight website.

**Level 3**

All renewable energy systems require regular inspections and maintenance by appropriately trained and qualified technical service providers. In the case of Bushlight RE systems, component selections and quality standards are such that the service interval for this maintenance is set at 12 months. Technical service providers should be engaged on an ongoing basis to provide both scheduled maintenance and also be available to respond to unscheduled or breakdown maintenance issues. The types of issues attended to by this level of the maintenance and support network include: battery maintenance; checking of solar array outputs; system operational data retrieval and review; checking tightness of terminals; and inspecting electrical compartments and components. The most common unscheduled maintenance activities include: vehicles coming into contact with poles or pillar boxes; damage to house or distribution wiring; and individual component failure. By ensuring that the nominated technical service providers have training in any specific equipment installed on site, have access to drawings, circuit diagrams and where appropriate spare parts, and are familiar with the access and community contact protocols, the time and cost of responding to unscheduled maintenance events can be minimised.

Identifying or establishing support networks to provide ongoing maintenance and support services for RE systems installed in remote communities is often not within the scope of RE system supply contracts, but clearly it is essential to the long term sustainability of the installed infrastructure and the community power supply.
Whilst identifying a technical service provider capable of undertaking future maintenance and support activities is important, if this is the only response mechanism established to deal with day to day power supply issues within communities it will be a very high cost solution which places the viability and sustainability of the system at risk. Having only one trained person with a community, or a single external service provider who can respond to maintenance issues ultimately leads to increased outages and operational costs.

Bushlight maintenance staff based in Alice Springs manage technical service contracts across all regions of central and northern Australia and will usually be able to provide advice as to where suitable contractors are located throughout these regions as well as which agencies and service providers have been provided with intermediate training by the Bushlight Project.

Conclusions

In Bushlight’s experience the implementation of renewable energy systems in remote communities can be greatly enhanced by focusing on the three critical success factors discussed in this paper – community consultation and engagement, appropriate system design, and comprehensive maintenance and support arrangements.

Specific issues to be considered include:

- ensuring all sections of the community are involved in the consultation/engagement process
- community residents have involvement in and ownership over key decisions relating to the type and capacity of the power supply system to be installed
- The decision as to the most appropriate power supply system is based on a thorough understanding of the life cycle cost of the various options, and takes into account non-financial considerations as appropriate
- RE systems are designed to operate in the environment in which they will be installed and are designed in accordance with the relevant Australian Standards
- Component replacement and RE system maintenance requirements are identified during the design phase and well documented
- A multi level (or ‘multi option’) support strategy is in place to ensure maintenance and support services are readily available if/when they are required.

Funding agencies, program managers and project designers and should recognise that all of these elements need to be built into RE projects in order to achieve outcomes that are sustainable in the long term. If should also be appreciated that some of the skills required to successfully implement RE systems in remote communities may come from outside of the mainstream engineering profession, and allowance for this should be made when designing and implementing projects.

The Bushlight team with the Centre for Appropriate Technology has extensive experience in the design, specification, manufacture, project management, installation, commissioning, maintenance and support of RE systems in Indigenous communities (in particular solar PV systems) and is very happy to provide advice, assistance or services to other organisations or companies working in this field.