B5 Energy

Guiding principles

Access and equity: Indigenous communities often experience difficulties in maintaining reliable and adequate access to energy services, especially electricity, because of issues relating to:

- small populations and the relative costs of maintaining a reliable energy system
- distance from existing grid, regional centres, fuel supplies and maintenance services
- climate (which can affect the accessibility of communities in some seasons, and the ability to maintain reliable electricity supplies).

Health and safety: Energy supplies, especially electricity, can pose potentially life-threatening hazards. Community residents should be made aware of the dangers and how to avoid them. The installation of electrical infrastructure must comply with relevant standards, legislation regulations and the advice of technical professionals. Qualified professionals should be engaged at all levels of infrastructure design, installation, operation and maintenance. Basic training should be provided to residents in how to safely access and use electricity.

Environmental health: To ensure a basic level of health and hygiene, communities require a reliable supply of electricity for lighting, cooling, refrigeration, heating, water pumping, communications, clothes washing, entertainment and a range of other domestic and enterprise-related activities.

Appropriateness: Decision making about appropriate energy options should take account of the cost, affordability, quality (design and installation) and reliability of the proposed system; the amount of power that will be available and the ability of the community to operate and maintain a power system.

Affordability: The cost of electricity infrastructure design, installation, operation and maintenance is much higher in remote areas than in metropolitan areas. The cost of electricity supply to the consumer is therefore much higher in remote areas; for example, $2 per kilowatt hour (for the full life-cycle cost of electricity generation), compared to about 14 cents per kilowatt hour in town.

Sustainable livelihoods: Community enterprises usually involve energy consumption and therefore increase the demand for energy. To ensure an energy system has the capacity to meet these needs, it is important to carefully assess the community's goals, and the likelihood of these being realised.

Systems overview

In this guide, ‘energy supply infrastructure’ refers to the hardware used to produce and distribute electrical energy in a community. It does not include infrastructure related to the supply of other forms of energy.

Remote Indigenous communities typically have one of the following types of electricity supply system:

- *Grid connection*
  - Grid power is generated in a large centralised power station and distributed over a network of transmission and/or distribution lines to remote communities. Individual houses are supplied by a local distribution network.
- *Fossil fuel generator systems*
  - Generator systems, also called gen-sets, involve an engine coupled to an electrical alternator. The engine runs on a liquid fuel, most commonly diesel, followed by LPG (liquefied petroleum gas) and petrol. Generator systems can connect directly into a house or a local distribution network.
- *Stand-alone power systems (SP systems)*
  - Renewable energy (RE) systems draw energy from the sun, wind or water and store it in a battery bank from where it is distributed to consumers as required. Solar photovoltaic (PV) is the most common form used in Australia today. RE systems can connect directly into a house or a local distribution network.
  - Hybrid systems involve coupling an RE system with a generator, with contributions from both required to meet the daily energy needs of a community. Electricity is distributed to consumers from the batteries, which are charged by both the RE component and the generator. Hybrid systems can connect directly into a house or a local distribution network.

A well-designed SP system with associated energy efficiency measures and management of demand (EE and DSM — see Useful terms) is likely to be more reliable and provide better quality power than most community generator/fossil fuel systems, though grid power is preferred if available. The reliability of off-grid supplies is largely determined by fuel supply for generators.

Current service delivery arrangements

Typical electricity supply arrangements for different sized communities are as follows:

- **Main towns** are supplied by grid power, with each house having either a standard power meter or a prepaid ‘card’ meter.
- **Major communities** have reticulated grid power or large SP systems, with each house having either a standard power meter or, more commonly, a prepaid ‘card’ meter. Responsibility for the provision of electricity sits with a utility or a private contractor. A qualified essential services operator (ESO) is employed in the community to operate and maintain the power station.
- **Minor communities** generally rely on generators and SP systems (RE or hybrid). These communities usually do not have household metering systems, although some use prepaid ‘card’ meters. Some also use energy limiting devices.

Table B5.1 gives further details of electricity supply arrangements in major and minor communities.

Table B5.1: Responsibilities and arrangements for electricity supply in major and minor communities

<table>
<tr><th>State/ territory</th><th>Major communities</th><th>Minor communities</th></tr>
<tr><td>NT</td><td>Power and Water provides services. Construction works and some operation and planned maintenance tasks may be subcontracted to a local provider. Local participation is through the recruitment and training of community-based ESOs where this can be sustained.</td><td rowspan="3">Responsibility for electricity supply usually sits with the Australian Government.
Local councils or Indigenous community-controlled organisations (ORAs or ORCs) typically provide services. The Centre for Appropriate Technology also provides regional support to some outstations through the Bushlight renewable energy provisioning and maintenance project.</td></tr>
<tr><td>Qld</td><td>Ergon Energy generates and distributes electricity to 34 remote Indigenous communities throughout Queensland. Ergon employs and trains local part-time power station attendants either directly or through local councils at many locations.</td></tr>
<tr><td>WA</td><td>The Remote Area Essential Services Program delivers services. The WA Government funds a contracted program manager by tender to manage three regional service providers. Horizon Power, a state-owned corporation, is responsible for generating or procuring, distributing and selling electricity to five large remote Indigenous communities in regional WA through the private Aboriginal and Remote Communities Power Supply Project.</td></tr>
</table>

(continued)

State/ territory	Major communities	Minor communities
NSW	Typically local government authorities operate and maintain essential services. All settlements in far west NSW receive power supply via the interstate, interconnected grid managed by Country Energy.	Communities are grid-connected at least to the land trust boundary and often to each household within the trust.
SA	The SA Government program manages two separate providers, the private contractor Cavill Power Products for electrical generation, and the SA utility ETSA for electrical distribution. Local participation is through the recruitment and training of community-based ESOs where this can be sustained.	ORAs or ORCs typically provide services.

ESO = essential services officer; ORA = outstation resource agency; ORC = outstation resource centre

Relevant Australian guidelines and standards

Most electricity distribution companies have their own construction standards and operating guidelines for grid supply. Refer to the local utility for details.

Table B5.2 shows relevant Australian standards for generators, stand-alone power systems and energy audits.

Table B5.2: Australian standards for energy systems

Standard (year)	Topic
Generators	
AS/NZS 3010:2005	Electrical installations — generating sets
AS 2790–1989	Electricity generating sets — transportable (up to 25 kW)
AS 1940–2004	The storage and handling of flammable and combustible liquids
AS/NZS 3000:2007	Electrical installations (known as the 'Australian/New Zealand Wiring Rules')
Stand-alone power systems — 100% renewable energy[a]	
AS 4509.1–1999	Stand-alone power systems — safety requirements
AS 4509.2–2002	Stand-alone power systems — system design guidelines
AS 4509.3–1999	Stand-alone power systems — installation and maintenance
AS 4086.1–1993	Secondary batteries for use with stand-alone power systems — general requirements
AS 4086.2–1997	Secondary batteries for use with stand-alone power systems — installation and maintenance
AS 2676.2–1992	Guide to the installation, maintenance, testing and replacement of secondary batteries in buildings — sealed cells
AS/NZS 5033:2005	Installation of photovoltaic (PV) arrays
AS/NZS 3000:2007	Electrical installations (known as the 'Australian/New Zealand Wiring Rules')
AS/NZS 3008.1.1:1998	Electrical installations — selection of cables — cables for alternating voltages up to and including 0.6/1 kV — typical Australian installation conditions
AS 1768–2003	Lightning protection
AS/NZS 1170.0:2002	Structural design actions — general principles
AS/NZS 1170.1:2002	Structural design actions — permanent, imposed and other actions
AS/NZS 1170.2:2002	Structural design actions — wind actions
Stand-alone power systems — hybrids[b]	
AS/NZS 3010:2005	Electrical installations — generating sets
AS 4594.1–1999	Internal combustion engines — performance
AS 1359.101–1997	Rotating electrical machines — general requirements — rating and performance
AS 1319–1994	Safety signs for the occupational environment
AS 1940–2004	The storage and handling of flammable and combustible liquids

(continued)

Standard (year)	Topic
AS 1692–2006	Steel tanks for flammable and combustible liquids
AS 2149–2003	Starter batteries — lead acid
AS 4044–1992	Battery chargers for stationary batteries
Energy audit	
AS 2725–1984	Guidelines for reporting energy use as part of an energy audit

AS = Australian Standard; NZS = New Zealand Standard

a Current government rebates schemes require all RE systems to be designed and installed by persons accredited by the Clean Energy Council of Australia.

b Renewable energy and generator standards also apply to hybrid systems.

Involving the community

The design, management and maintenance of energy systems in Indigenous communities should be informed by people's expectations of their involvement in their energy system and their capacity to be involved.

In **major communities** with larger energy systems, residents' involvement will mostly be limited to reporting faults.

In **minor communities**, residents' involvement is more likely to include operating the system and performing some level of maintenance.

In all communities it is important that residents know how to use the system in a safe and responsible manner.

Managing energy use

The high cost of electricity supply to remote communities means that every household needs to manage their energy use so that:

- their consumption does not exceed their capacity to pay for the energy used
- the community's total consumption does not exceed the overall capacity of the system or the service provider's fuel budget.

Poor management will lead to high operating and maintenance costs or reduced availability of power, at either the household or community level. In some situations, an existing energy system may not need to be upgraded or replaced if appropriate energy management practices (such as DSM) are implemented.

EE and DSM measures can increase available electricity without increasing the supply and are the key means by which communities can manage their energy consumption. Examples include:

- turning off lights and fans when a room is unoccupied
- switching from incandescent to fluorescent lights
- closing doors and windows when using air conditioners and heating
- fixing broken windows and doors, and fitting them with seals
- improving building insulation and establishing trees or shade structures around buildings to reduce cooling needs
- increasing the efficiency with which energy is used by appliances; for example, by
  - swapping old appliances for new, energy efficient ('5-star') appliances
  - selecting appliances appropriate to the local climate
  - fuel switching (for example, changing from electric to gas stoves)
- managing the time of energy use to reduce peak loads (load scheduling)
- using other load management measures such as timers on lights and fans.

EE and DSM measures can:

- reduce operating costs, including consumer costs
- increase the reliability of an energy system
- increase system life
- reduce greenhouse gas emissions (for generator and grid systems)
- be a cheaper and easier option than upgrading energy infrastructure
- provide residents with greater control over their energy expenditure, particularly if accompanied by an education and awareness program.

Installation of the following hardware to improve EE and DSM requires wiring modifications for installation:

- circuit and appliance timers
- one-shot boosters for solar hot water systems
- circuit splitting and low-ampere circuit breakers
- daily enable button
- daylight (photo-electric) switches
- segregated circuits.

More complex hardware can also be used to manage energy use, such as systems that track household (or building) energy use and limit supply on all or some circuits once a predetermined threshold has been reached. Clipsal C-BUS energy management units and the Centre for Appropriate Technology's EMU (energy management unit) are examples of such systems.

Ensure that:

- consumer agreement is reached before implementing EE and DSM measures
- training to implement these measures is provided
- visitors are aware of what EE and DSM measures are in place and how to use them.

Consider:

- *Literacy and education*
  - improving uptake of measures by linking the energy consumption of different appliances to the running cost
  - using demonstration kits of DSM fittings as education and awareness tools
  - fixing stickers and putting up posters to remind people to turn off lights, fans and other appliances when not in use
  - using pictorial resources (such as posters) that clearly relate energy consumption to household expenditure.
- *Affordability*
  - making energy efficient appliances and fittings locally available and affordable
  - charging more for electricity, as a way of encouraging people to change their energy use behaviour
  - assessing the amount of extra work (and cost) that will be involved to maintain the proposed measures.

Safety

Household electricity (240 volts AC) can kill on contact. Community residents should therefore be informed about the safe and responsible use of electricity. Liquid fuel storage areas or battery banks (such as those used in RE systems) are also hazards and need to be managed appropriately.

Ensure that residents know:

- how to identify and avoid potential hazards (through education, training, warning signs and restriction of access)
- when they should contact a licensed electrician, and how to identify and report faulty or damaged household wiring
- how to identify and when to replace faulty appliances
- how to store fuel safely and securely and comply with appropriate standards.

Education should cover issues such as not tampering with house wiring, and not stealing fuel or batteries from generators.

Appraising community requirements

When planning to install a new community electricity supply system or upgrade or augment an old one, the following issues should be addressed.

Ensure that:

- project workers and the community have an accurate picture of current and future energy use patterns, including associated cost-recovery mechanisms.

Consider:

- whether EE and DSM measures may be all or part of the solution.

An overall assessment is essential to making a decision about the appropriate size, functions, costs and future capacity of the system. A wide range of information about the community is required, including an estimate of total electrical energy demand. The main issues that need to be considered are described below.

Determine the community's energy requirements

Consider the following issues:

- *Community information*
  - population profile and demographics (permanent and mobile populations including seasonal variations, number of infants, children, teenagers, adults and the elderly)
  - size, location and access, including distance to goods and services (including the electricity grid)
  - employment, enterprise and education levels, including people's capacity to pay for electricity and potential to contribute to the operation and maintenance of an electricity supply system
  - support structures for existing community infrastructure operation and maintenance
  - community plans and aspirations for the future, particularly as they relate to future electrical energy demands
  - community population increase or decrease: realistic estimates of the future size of a community are needed to design an appropriate solution; high growth requires expansion capacity to be built in, while low or negative growth allow tighter designs.

- *Current status of energy infrastructure*
  - current electricity supply arrangements: ownership, capacity, usage patterns, reliability and community satisfaction
  - existing distribution networks: depending on quality and safety laws, existing networks can be extended or upgraded, at significantly lower cost than a new installation
  - the condition of the existing infrastructure: depending on quality and safety laws, existing infrastructure can be incorporated into the new or upgraded system, which can significantly reduce capital costs
  - current running costs (check logbooks and system financial records; review fuel and meter records)
  - cost-recovery arrangements, including the use of meters or prepaid 'card' meters, the metered cost of electricity, or type and details of other arrangements used (such as monthly user contribution)
  - current arrangements for service and maintenance needs of the system (see system operating and maintenance manuals), including the service regime and funding
  - system configuration and design, including original intent of the system and capacity for upgrade (see system operating and maintenance manual and/or system design paperwork if available).
- *Energy service needs*
  - number, size, location, design and construction of houses and other buildings in the community, and their usage patterns
  - refrigeration and space heating and cooling requirements in the buildings (in relation to the climate of the area)
  - other infrastructure in the community, such as police station, schools, clinic, store, workshop, service station, water supply, communications, sewerage system
  - commercial activities and related electrical equipment, including any existing or planned tourism ventures
  - type and number of hot-water systems in the community
  - existing energy management/control measures, such as timer buttons on lights, one-shot hot-water system electric boosters
  - critical services that require uninterrupted 24-hour power (such as medical equipment)
  - current or prevailing energy use habits within the community.

Quantify the community’s energy needs

It is standard practice for an energy audit to be carried out to assess a community’s energy needs. Every energy-using item needs to be considered: coolrooms, water treatment and reverse osmosis, cooling and heating, lighting, computers and information technology equipment, wastewater, pressure pumps, cooking, etc (see Healy 2007). This process is described in AS 2725–1984 *Guidelines for reporting energy use as part of an energy audit*.

Ensure that:

- community members are thoroughly involved in the audit process, so that appliance use patterns, and current and future energy needs are assessed accurately.

It is often impractical to undertake a detailed energy audit in larger communities. Instead, sample energy audits of individual homes can be used (for an example, see Table B5.3). AS/NZS 3000:2007— *Electrical installations* provides guidelines for energy demand assessment. A professional experienced with such assessments should be involved in any such process.

Table B5.3: Example of a household energy audit

Appliance	Model	Age (years)	Quantity	Power rating (W)	Surge power (VA)	Average (hours/day)		Average load (kWh/day)		Annual average (kWh/day)
						Summer or wet	Winter or dry	Summer or wet	Winter or dry	
Fridge	Fisher&Paykel E373	New	1	81	910	12.0	10.0	0.97	0.78	0.87
Chest freezer	Westinghouse FD212	New	1	105	700	12.0	10.0	1.25	1.01	1.13
Kitchen CFL		New	1	18		4.2	4.8	0.08	0.09	0.08
Living room CFL		New	1	18		5.2	6.0	0.09	0.11	0.10
Street light, fluorescent		Unknown	1	18		10.5	12.1	0.19	0.22	0.20
Kitchen ceiling fan			1	65		2.0	0.3	0.13	0.02	0.08
Living room ceiling fan			1	65		8.0	1.3	0.52	0.09	0.30
Television		Unknown	1	130		7.0	7.0	0.91	0.91	0.91
DVD		Unknown	1	30		4.0	4.0	0.12	0.12	0.12
Television		Unknown	1	5		2.0	2.0	0.01	0.01	0.01
Washing machine	Top loader	Unknown	1	500	3500	1.5	1.5	0.75	0.75	0.75
Total			**11**	**1035**	**5110**	**68.4**	**59.0**	**5.02**	**4.11**	**4.55**

CFL = compact fluorescent light bulb; kWh = kilowatt hours; VA = volt-amperes; W = watts

When quantifying the electrical needs of a community:

Ensure that the following parameters are assessed

- total daily kilowatt hour load — total volume of electrical energy required in a day
- total maximum demand (in kilowatts) — total of all peak instantaneous loads
- after-diversity maximum demand — total maximum demand after a diversity factor (see Useful terms) is applied.

The diversity factor assesses load-usage patterns and load management in the community. It is needed to prevent oversizing the system. This is particularly relevant to systems that include a generator. Peak or maximum loads can be quite brief in small communities, and minimum loads can be much lower than these peaks. There is no standard way of estimating ‘after-diversity maximum demand’.

Once a community’s electrical energy demands have been quantified, costs and a range of other factors that may influence future demand should be considered in order to make an informed decision about the most appropriate supply solution (see ‘Assess costs’ and ‘Assess other issues’, below). Much of the relevant information will have been collected during the assessment process.

Assess costs

Consider the following issues:

- *Local policies*
  - Contact your local government representative or Indigenous Coordination Centre (ICC) to find out what the current energy policies are in your state or territory, and how they affect your community for issues such as rebates, renewable energy and cost recovery.
- *Capital costs*
  - What level of capital (specific purpose, one-off) funding is available? The level of capital funding available will influence the supply solution ultimately chosen. Generally a community-scale generator will be the option with the lowest capital cost. Capital funding is only one aspect of the total cost picture (which is only fully revealed by a life-cycle cost analysis).
  - What are the sources of funding, and what is the purpose? Energy supply infrastructure funding is usually provided by government grants. Funding may be tied to specific projects (for example, renewable energy grants).
  - Are rebates available? Generally, rebates are available for RE systems.

- *Operating (recurrent) costs*
  - How will the operating costs be met? Operating costs include fuel, maintenance, breakdown and replacement costs. Access to recurrent funding in some form is essential. Grants and ongoing funding arrangements may be available.
  - What are the sources and purpose of funding? Energy supply infrastructure recurrent funding is usually provided by government.
  - What level of recurrent funding is available? The level of funding is critical to the sustainability of the energy system, but depends on policy and may vary from state to state and over time.
  - What is the duration of the funding commitment? Ensure that recurrent funding is available for the expected lifespan of the system.
  - Are rebates available? Rebates may be available for diesel.
- *Cost recovery*
  - What cost-recovery mechanisms are currently in place? Cost-recovery mechanisms are one way to meet operating costs and may include rates, levies and tariffs. See utilities, and local and state/territory governments for relevant policies.
- *Life-cycle cost assessment*
  - What does a full life-cycle cost assessment show about the relative costs associated with the various options available? The ideal option is the one that costs least over the working life of the system while delivering the required level of service. Figure B5.1 shows further information about life-cycle costing.

Life-cycle costing of an energy supply system

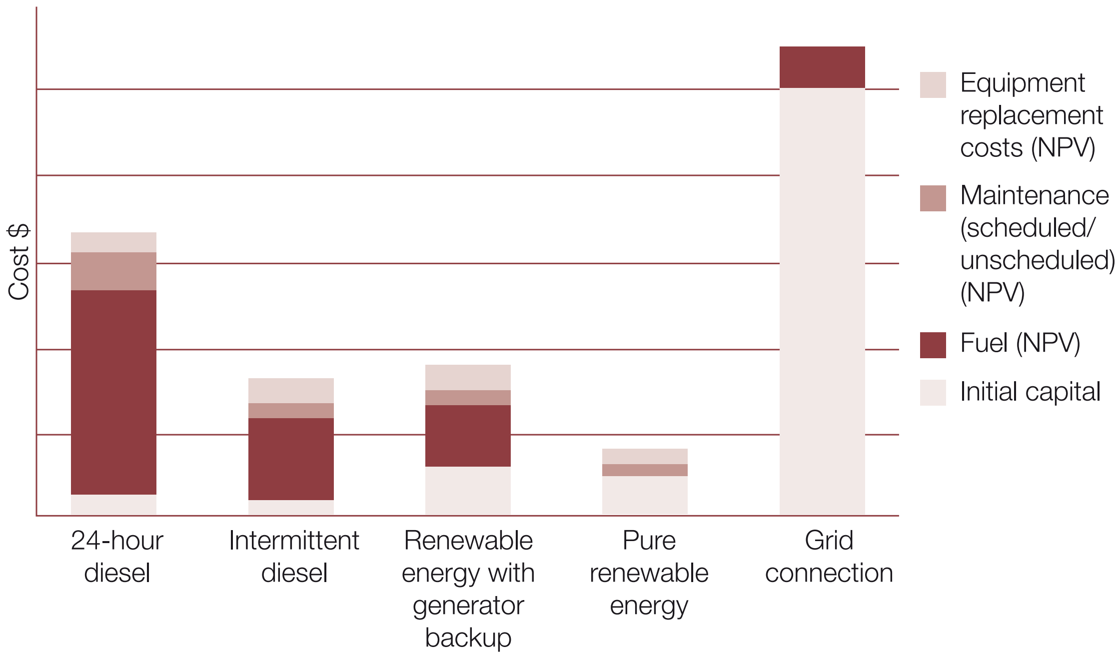
Life-cycle costing (LCC) analysis provides a valuable assessment tool when considering the long-term financial implications of a variety of potential supply solutions. LCC analyses are usually applied over 10 or 20 years. They account for the capital and recurrent costs associated with a system in net present value (NPV) terms, allowing for easy comparison between options.

It is recommended that an LCC analysis always be undertaken when considering upgrading or replacing a community energy system. An LCC analysis should be carried out after the process of appraisal and before making a final decision as to the appropriate supply solution.

Figure B5.1 is an example of a comparison of life-cycle cost for various supply options for a remote community. In this example, pure renewable energy (RE) is the cheapest solution and grid connection the most expensive solution, because significant amounts of new distribution cabling (poles and wires) must be deployed. In other circumstances, where the grid is already in place locally, grid connection capital costs for new customers are minimal and grid connection is the cheapest solution.

(continued)

Figure B5.1: Life-cycle cost comparison of energy supply systems



NPV = net present value
Source: Centre for Appropriate Technology, 2009

Assess other issues

Consider:

- *Servicing, support and access*
  - How easy is it to access maintenance service networks and resources? All systems require regular maintenance. Adequate maintenance resources need to be available.
  - What technical skills are available locally and are they likely to be retained? Maintenance duties can be carried out more effectively and at less cost if such skills are locally available. Suitable accreditation, qualifications and licences may be required for many of these tasks.
  - How far is the community from an existing grid, regional centres, fuel supplies and maintenance services? There are extra costs and difficulties associated with delivery of reliable energy services to more remote communities.
  - Does accessibility to fuel, maintenance and transport vary with the seasons? Communities with poor seasonal access present special challenges (for example, larger fuel storage to cater for wet season inaccessibility; higher levels of inbuilt redundancy to cover longer maintenance response times).

- *Climate and geography*
  - What are the community's climatic conditions? Tropical regions tend to require higher levels of space cooling, particularly fans. An extended wet season reduces the availability of solar energy. Soil type and presence of rock may also affect the type of distribution system that can be installed in a particular area.
  - Are there specific environmental considerations (such as cyclone or tsunami risk, marine environments, extreme temperatures)? All structures must meet appropriate wind loading standards and codes. Marine environments can be particularly harsh on equipment and materials, so may necessitate resistant construction; likewise, areas with extreme temperature variations. System design and siting need to minimise potential damage from flooding.
  - Will there be seasonal load variations? Different climates have different seasonal load variations and these affect the maximum and peak demands the system needs to be designed for. Oversizing is wasteful and may also lead to reduced generator life; load diversity factors need to be properly applied.
- *Environment*
  - Are there noise, exhaust, fuel supply, vibration or visual issues? Every supply solution attracts different costs and benefits in terms of environmental impact. A community's attitude towards these needs to be assessed. For example, liquid fuel systems require large areas for safe storage and containment. Generators produce noise, exhaust and vibration; diesel generators produce more than LPG generators. Large solar systems involve large PV arrays; these may attract tourism.
  - How much greenhouse gas will be emitted? RE systems do not produce greenhouse gases; diesel produces a lot; LPG produces less than diesel. Greenhouse gas abatement is now widely viewed as desirable. Also, costs associated with liquid fuels continue to increase.
- *Land tenure*
  - What type of land tenure does the community have? The ability to establish new infrastructure will depend on community type and the degree of access to the land on which they are settled.
- *Cultural issues*
  - Are there any sacred sites on the land involved? Inappropriate development on culturally significant land will be unacceptable to community members. Up-front consultation can avoid costly changes later.
  - What are the residents' attitudes towards energy supply options? People's attitudes towards different technologies and fuels vary. It is best to first consult with people about proposed changes so that agreement can be reached and any required support program planned for and implemented.

- Will access to the site be restricted (at times) by ceremonial activities? Every system type requires regular scheduled maintenance and, if there is a failure, unscheduled access. Restricted access can mean extended down time or potential capital costs associated with replacement of parts as a result of poor maintenance. Siting and design of systems need to take account of such considerations.

- *Emerging technologies*
  - What emerging energy supply technologies need to be considered? Many emerging energy supply technologies boast improved efficiency, capacity, reduced capital and/or recurrent costs and improved reliability. The use of any new technology that has not been thoroughly and exhaustively tested in appropriate environmental conditions is not recommended for installation in a remote Indigenous community.

Choosing appropriate solutions

The following sections discuss different energy supply options (grid, fossil fuel generator, stand-alone power systems; see Table B5.4) in terms of:

- system capacity
- initial cost
- recurrent cost
- power system relative to recurrent costs
- reliability
- quality of supply
- growth capacity
- design life
- environmental impact
- greenhouse gas impacts.

Table B5.4: Advantages and disadvantages of different energy supply options

	Number of remote communities with this supply option[a]	Advantages	Disadvantages
Grid	274	Quiet, easy to manage solution for community providing reliable 24-hour power. Residents generally access equalised tariffs (ie electricity costs are subsidised by the government) so cost to residents is low.	High capital cost — only cost-effective with large consumer base so only applicable to large communities close to an established grid. Power can be unreliable at the end of a long line. Exposes government to additional, effectively uncapped, customer service obligation liabilities.
Fossil fuel generator (diesel, LPG, petrol)	555	Relatively easy to maintain and cheap to replace.	Can be noisy if not installed in sound-proof room. Exhaust gases smell and pollute local environment. Requires reliable fuel supply. Safe and adequate fuel storage costly for large systems. Safe storage of fuels can be an issue in smaller communities. If system size is well matched to load, there is limited capacity for load growth; if it isn't, system operates inefficiently.
Stand-alone power system: 100% renewable energy design	105	Quiet; no outlay on fuels; can operate in isolated locations for long periods. Lower life-cycle cost than other options in smaller communities.	High capital cost and limited capacity to power heavy loads. Batteries must be disposed of appropriately.
Stand-alone power system: hybrid design	107	Greater flexibility in meeting peak loads more efficiently than either renewable energy or fossil fuel alone. Lower life-cycle cost than diesel generation in small to medium-sized applications.	Increased component count. Increased system complexity. All issues relating to generator systems.

LPG = liquefied petroleum gas

a Remote communities that have this supply option according to the Australian Bureau of Statistics publication *Housing and Infrastructure in Aboriginal and Torres Strait Islander Communities* (2006)

Ensure that:

- a program of EE and DSM is seriously considered before making decisions about upgrading or replacing an energy system
- the final decision is made with input from someone knowledgeable and experienced with all the available options
- further consultation with the community occurs to help determine whether the system needs to be a hybrid system or a pure renewable energy system with a generator available to run certain loads and as backup.

Case study 11 — Upgrading a power system

The resource agency (RA) for a community in the central desert region of the Northern Territory agreed to upgrade the community's current, unreliable power system. As a first step they spoke to Power and Water Corporation, who informed them that there was little likelihood of the community being connected to the grid as it was too small and too remote. This left them with the option of either a generator system or stand-alone power system. The RA was concerned that a new, possibly larger, generator system would lead to a steep increase in running costs, particularly with the increasing cost of fuel, and was worried that at some time in the near future they might not be able to afford to provide 24-hour per day power. Having seen similar-sized communities with renewable energy power systems, the RA decided to discuss the option of an renewable energy system replacing the current diesel generator. The discussions included the need for residents to manage their energy use if the renewable energy system was installed. People agreed with the idea.

The RA then began to look in detail at the financial implications of the new system. A significant rebate on renewable energy systems was discovered. In order to better understand what was involved, a consultant was brought on board and asked for a financial comparison between a pure renewable energy system, a hybrid system and a diesel generator system.

Using data from the current system's operation logbooks, and information collected during an energy auditing process, the consultant was able to determine a rough load schedule and design for each option, from which two 10-year life-cycle costings were developed, one inclusive of initial capital and the other exclusive. These showed quite clearly that a renewable energy system would have very low running costs compared to a generator system, although it would have a high capital cost. The RA soon realised, however, that a renewable energy system needed regular and skilled maintenance, which the RA could not provide given the skill sets of its current staff. Furthermore, the consultant advised that a number of loads in the community could not be run from a pure renewable energy system and would need a generator to power them.

(continued)

As a result, the RA had to:

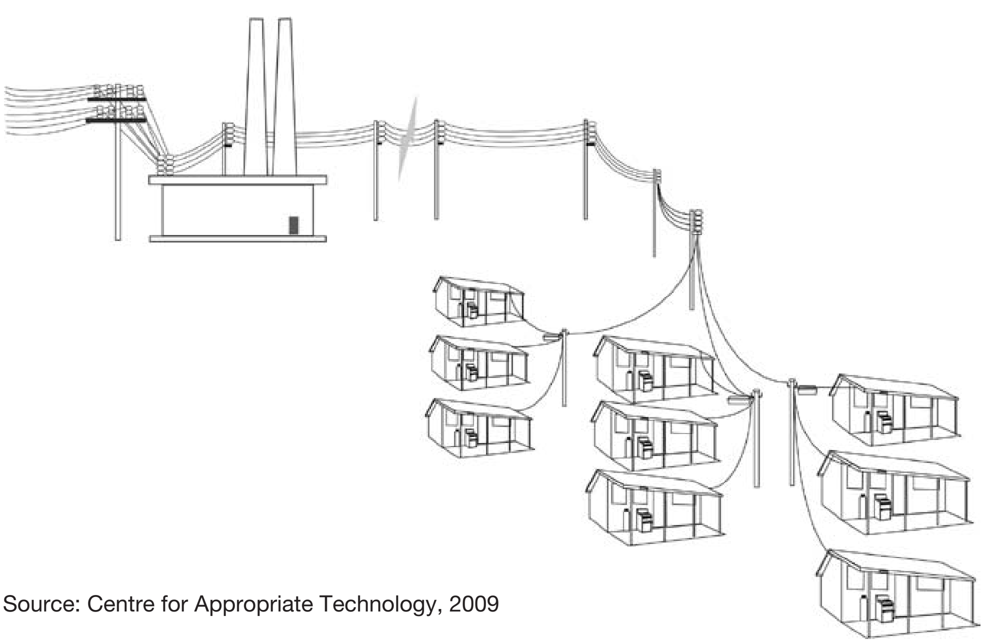
- *determine if the required capital funding could be accessed to pay for a stand-alone renewable energy power system*
- *determine what technical capacity was needed to maintain such a system adequately and whether current staff could be up-skilled, or if there was a service and maintenance program already in place that could be tapped into, or both*
- *consult with the community further to help determine whether the system needed to be a hybrid system or a pure renewable energy system with a generator available to run certain loads and as backup.*

Subsequent research revealed there were schemes in place from which to access the necessary capital funding. An essential services officer was identified who was happy to be trained to help support a renewable energy system. The consultant was re-employed for a more thorough assessment of the costs and benefits of the various options, and a hybrid stand-alone power system was chosen. The final design involved close negotiation with residents about daily energy demands and demand-side management measures. As a result, when the system was installed, the generator needed to run (on average) for only an hour or two every day.

Grid supply

Connection to grid supply involves the design and construction of a high-voltage transmission and distribution line connecting an established utility-owned and operated grid to a community (Figure B5.2).

Figure B5.2: Grid or external power station electricity supply



Source: Centre for Appropriate Technology, 2009

One or more high/low-voltage transformers (substations) are installed, depending on the size of the community.

- **System capacity**: limited by the capacity of the distribution lines and transformer(s) and the upstream capacity of the generation and transmission system.
- **Initial cost**: largely a function of the distance and terrain between the community and existing grid connection point; upstream costs may also need to be taken into account.
- **Recurrent cost factors**: maintenance of the line and substations — related to the type of construction and the distance and terrain between the community and the power station, and size of load.
- **Power system relative recurrent costs**: generally low.
- **Reliability**: typically better than local fossil fuel–based generation.
- **Quality of supply**: generally good.
- **Growth capacity**: good, as long as there is additional capacity available within the network.
- **Design life**: 40 years.
- **Environmental impact**: usually fairly low — lines will require clearing underneath.
- **Greenhouse gas impacts**: medium to high, depending on the generation technology supplying the grid.

A grid system may be used to connect a number of smaller communities to a larger community power station. An example is the Urapuntja Outstation in the Northern Territory where 16 outstations are connected by 150 kilometres of power lines back to a central power station located at Arlparra Store, requiring only one power station to be built and operated.

Local distribution networks are generally three-phase, with either single or three-phase service wires to individual consumers. Motors and many industrial appliances often require three-phase power for operation.

Most utilities do not allow (or at least discourage) new extensions from existing grids and do not generally fund grid extensions. Ownership regimes vary but usually the distribution utility owns and operates the power line, while another retail company sells the power to the community or customers. The viability of a grid extension is dependent on several factors:

- access arrangements, including rights over the land the line traverses; most electricity distribution companies will require secure access or tenure over the line route such as through formal agreements or easements)
- line ownership and service arrangements
- distance
- load of the community
- construction type (overhead or underground)

- reliability and response times required
- funding availability.

Appropriate design and installation

The design and installation of grid connection systems is generally undertaken by the electricity distribution company or a suitably qualified person. It is possible (and fairly common) to include the design of the grid extension (including surveying the line route) as the first phase of the construction contract.

Ensure that:

- ongoing funding arrangements for the operation and maintenance of the line are established and documented prior to installation
- cultural issues, sacred sites and heritage sites are considered as part of the design process
- cost-recovery arrangements for the power consumed are determined before installation; most grid connected supplies are metered by an electricity retailer, with the customer charged through credit meters or prepayment systems (for example, card meters).

Maintenance

Most grid connections are operated and maintained by an electricity distribution company because it requires specialist skills and safety procedures not generally found outside the industry. Local involvement may be limited to maintenance of the line corridor, such as grading and vegetation removal. Therefore, no specific skills are needed by the community.

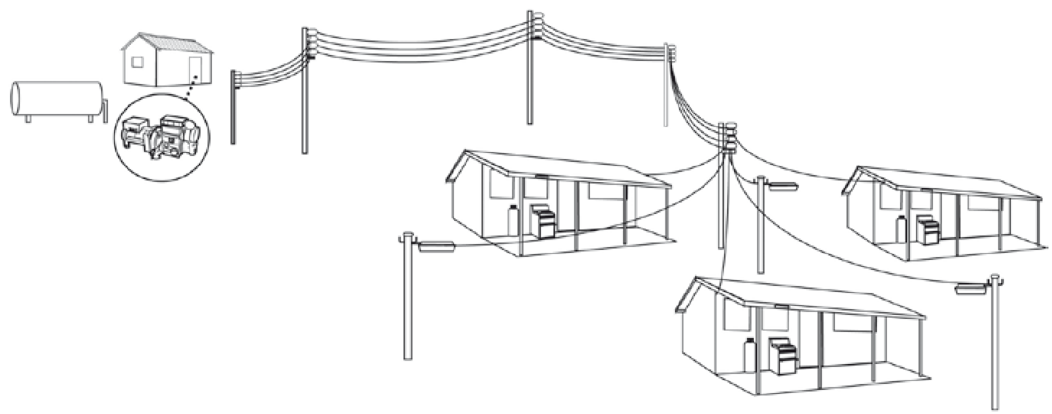
Ensure that:

- contractual obligations of the electricity distribution company regarding scheduled and unscheduled (that is, breakdown or power failure) service provision are well documented and understood
- contact details of the relevant utility representative are readily available
- all damage and faults are reported immediately.

Generators

Generator systems, also called ‘gen-sets’, consist of an engine coupled to an electrical alternator. Different engines run on different liquid fuels, the most common being diesel, followed by petrol and LPG. Generators can run independently or together (using an automatic control system that synchronises their operation so that they are switched on and off-line as required). Generator systems can connect directly into a house or a local distribution network (Figure B5.3).

Figure B5.3: Community generator electricity supply



Source: Centre for Appropriate Technology, 2009

- **Capacity**: generator size, number and configuration can be scaled to meet community needs; only petrol generators are small.
- **Initial cost**: low.
- **Recurrent cost factors**: fuel as well as maintenance consumables and periodic generator replacement.
- **Power system relative recurrent costs**: high.
- **Reliability**: good, if system is well designed, operated and maintained.
- **Quality of supply**: typically poor.
- **Growth capacity**: if sized correctly, then growth capacity is limited, as oversizing leads to lower running efficiency and may also lead to shorter generator life; however, can be upgraded or augmented with another generator at relatively low cost.
- **Design life**: 3–5 years for generator running 24 hours per day every day, longer for intermittently run generators (such as backup generators). Petrol generators are designed for intermittent use only. Diesel engine life is typically 30 000 hours; petrol engine life is less than 10 000 hours.
- **Environmental impac**t: high — fuel or oil required to be transported and stored.
- **Greenhouse gas impacts**: high.

Appropriate design and installation

Ensure that:

- generators have the capacity to meet the known design loads over their operational life and are correctly sized to supply the baseload and the after-diversity maximum demand (see Useful terms) efficiently; this can often mean that more than one generator (as well as control gear) is required
- arrangements are in place for regular provision and storage of fuel; determine who will be responsible for organising and paying for fuel supplies and what their capacity is to maintain and deliver fuel supplies to the community throughout the year and on an ongoing basis
- fuel storage depots meet relevant standards (such as AS 1940–2004; see Table B5.2) with appropriate safety measures in place (for example, all relevant safety signage is provided where appropriate)
- fuel storage capacity is sufficient to cover periods of poor or no access to the community
- fuel infrastructure is lockable, bunded and metered
- fuel-level gauges are fitted
- adequate measures (such as fencing, locked sheds) are in place to restrict access to generating equipment and fuel supplies to qualified staff only
- starter batteries are secured to avoid unauthorised removal.

Consider:

- life-cycle cost of fossil fuel power generation compared with alternatives (that is, renewable energy)
- whether single or three-phase distribution lines are required (this is usually a function of distance and the size and type of loads)
- the level of automation required for reliable operation
- the possibility of installing at least two gen-sets in smaller systems where the water pump relies on the generator
- the location of the power generation and reticulation equipment in relation to
    - community housing, to minimise the environmental and social impacts from noise and localised air pollution
    - sacred and heritage sites
    - the effects of extreme climatic events such as flooding and cyclones
- the impact of corrosive environmental conditions on equipment, such as those caused by dryland salinity and marine environments
- potential effects of fuel storage in water catchment areas that supply drinking water

- greenhouse gas emissions
- the design life of proposed generators and funding arrangements for replacement costs
- using a separate charging mechanism for starter batteries if the gen-sets are not going to be operated 24 hours a day every day, or do not have battery chargers fitted (small trickle-charge PV systems tend to be a reliable option).

Maintenance

Large generator systems (>50 kilovolt ampere and multi-generator systems) require trained personnel, such as a dedicated ESO supported by an essential service provider, to operate and maintain them. A small generator can be maintained and operated by someone with basic knowledge of engine mechanics. Smaller, single unit systems tend to be maintained by a mix of community residents, ESOs and resource agency staff, depending on the community. Generators need regular servicing (every 300 hours).

As part of cyclic maintenance:

- record all meter readings, including fuel use, on a daily or weekly basis in system logbooks
- check oil and fuel levels on a daily basis
- change oil, fuel and air filters after every 300 hours of operation (or as per engine manufacturer's specifications)
- have scheduled engine overhauls and annual maintenance checks carried out by a qualified service mechanic.

Ensure that:

- system logbooks are provided
- essential replacement parts for the generator and control systems are always available on site (for example, filters, oil, control boards)
- an appropriate process for disposing of used oil and filters is established and maintained (see Chapter B4 Waste).

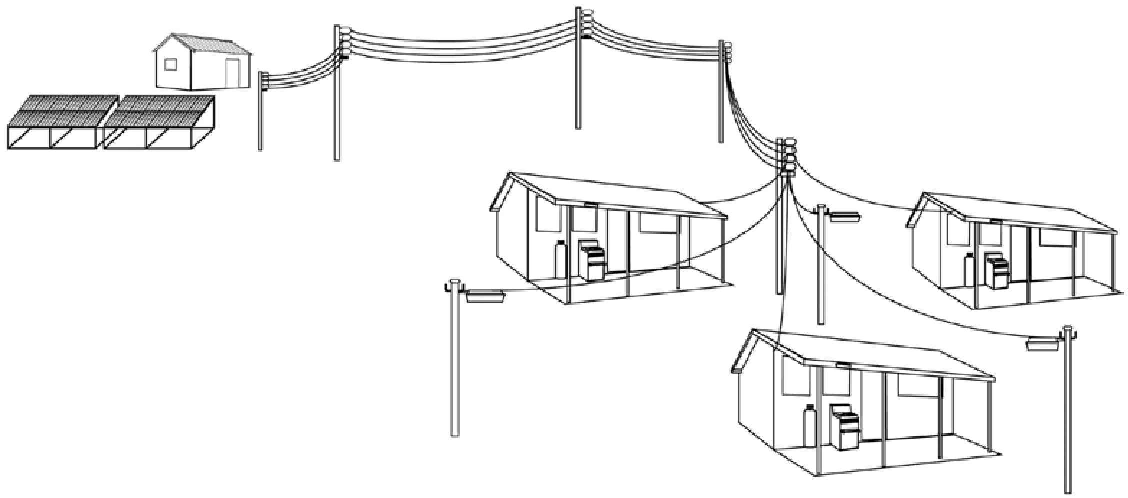
Consider:

- availability of personnel with the skills and training required to deliver the appropriate level of scheduled and unscheduled maintenance
- funding for relevant training
- funding for recurrent costs, including the provision of regular fuel supply and maintaining fuel supply networks
- cost-recovery arrangements and funding for purchase of fuel.

Stand-alone power systems — 100% renewable energy

Remote area RE systems draw energy from the sun, wind or water and store it in a battery bank from which it is distributed to consumers as required (Figure B5.4).

Figure B5.4: Stand-alone renewable energy system electricity supply



Source: Centre for Appropriate Technology, 2009

All of the energy required to meet the normal day-to-day requirements of the community are drawn from RE sources in 100% RE systems. Solar PV is the most common RE source used in remote Indigenous communities. Solar PV systems consist of solar panels that convert sunlight into low-voltage direct current (DC) electricity, a battery bank and an inverter for changing the low-voltage DC power into 240-volt alternating current (AC) electricity. Wind power is another form of RE and operates in a similar manner to solar PV; however, it provides DC electricity from wind turbines and requires the relevant control hardware.

Smaller systems that do not use an inverter must use DC-only appliances, which are expensive and can be difficult to access. Many RE systems either have built-in backup generators or the capacity to have a backup generator; however, this refers to manual generator use and not automatic (see Stand-alone power systems — hybrids, below, for RE systems with automatic generator use). RE systems can connect directly into a house or a local distribution network.

- **Capacity**: small to medium.
- **Initial cost**: high.
- **Recurrent cost factors**: periodic replacement of batteries and balance-of-system components (see Useful terms).
- **Power system relative recurrent costs**: low.

- **Reliability**: very good if system is well designed, operated and maintained.
- **Quality of supply**: high.
- **Growth capacity**: moderate — expansion capacity can be built into systems.
- **Design life**: overall system design life 20 years (battery replacement required every 5–10 years).
- **Environmental impact**: low.
- **Greenhouse gas impacts**: low.

Appropriate design and installation

Ensure that:

- system design, installation and maintenance is carried out in accordance with AS 4509 — *Stand-alone power systems* Parts 1, 2 and 3 (see Table B5.2)
- the community is involved in energy budgeting to ensure loads and usage patterns are accurately assessed
- the community is consulted about the location of the solar panel array and infrastructure
- battery size is large enough to provide sufficient autonomy during cloudy periods to prevent the need for regular generator backup; allow for 2 days autonomy in desert regions and 3 days in tropics as a minimum, and (if possible) design the system to operate normally through one in 10-year low solar insolation levels
- design and installation work is only carried out by Clean Energy Council (CEC) accredited RE system designers and installers
- a qualified electrician carries out all AC installation work and any RE installation work over 120 volts DC and provides a certificate of compliance with AS/NZS 3000 — *Electrical installations* (see Table B5.2).
- system commissioning is carried out by experienced personnel, using CEC checklists
- protection from system overuse is built in — either through inverter set-points or energy limiting hardware or both; load shedding can be part of this
- all relevant safety signs are provided (system voltage, access restrictions, spark hazard signs)
- where flooded cell batteries are installed, an emergency eyewash station is supplied along with appropriate signs
- adequate measures (such as fencing, locked sheds) are in place to restrict access to electrical equipment and batteries to qualified staff only
- solar panels are not shaded; even a small amount of shading can have a significant impact on energy generation
- solar panel arrays have a minimum slope of 10 degrees to facilitate dust removal and self-cleaning

- arrays are accessible for cleaning and maintenance
- all array cabling is in UV-stabilised conduit and preferably concealed from direct sunlight
- training is delivered to consumers in use of the system, including energy management and system limitations
- training in basic maintenance and fault finding is delivered to local system operators
- all operating and maintenance manuals are present on-site, and system operations, including start-up and shut-down procedures, are clearly described and visible next to the relevant equipment
- all electronic components are adequately rated and tested to withstand the environmental conditions in which the system will be operating
- there is adequate ventilation for heat removal from electronic components and enclosures
- electrical equipment is protected from adverse environmental conditions (such as moisture) and insect ingress
- battery and equipment shelters have passive solar design and adequate insulation (air conditioners are not desirable for keeping equipment cool because of their high energy consumption, and reliability and maintenance issues)
- all electrical enclosures have two-digit ingress protection (IP) ratings appropriate to the installation circumstances; IP ratings describe
    - first digit: the maximum size of objects, dust, insects, etc that can enter a sealed area (the higher the rating, the smaller the size of objects excluded; a minimum rating of five ‘dust protected’ is generally recommended)
    - second digit: the degree of protection against water ingress (the higher the rating, the better the protection: a minimum rating of six ‘powerful water jets projected against the enclosure from any direction shall have no harmful effects’ is generally recommended).

Consider the following issues:

- The environmental conditions in which the equipment will be operating. System physical design should be robust enough to withstand dust, insects and water, and withstand high temperatures and wide temperature variations.
- Use of valve-regulated (sealed) gel batteries over flooded cell batteries will minimise maintenance requirements.
- The impact of dust on the system can be minimised by siting solar panel arrays away from roads and landfill.
- The system needs to be protected from lightning.
- A backup generator with battery charger may be needed for charging batteries at times of extremely low solar input or unusually high loads.

- If there are high levels of mobility in the community, the system should be designed to meet the needs of the community infrastructure (such as house size), not the current population.
- Savings can be made by implementing DSM measures — each kilowatt hour per day saved off the design load of a 100% RE system can save up to $7500 of the capital cost of the system. Examples of common DSM measures include
    - circuit or appliance timers
    - identifying loads that can be deferred until batteries are fully charged (such as washing machines)
    - replacing appliances with more efficient ones.
- When powering multiple houses from one RE system, it is necessary to ensure that one house cannot abuse the energy supply and disadvantage others. An energy meter that allocates/enforces the daily budget is one means of achieving this.
- Wind turbines can have lower capital cost than solar PV, but have increased maintenance requirements and technical complexity. Reliable wind data are less readily available than solar data.
- Use user-friendly labels and meters on key equipment, such as main control panels, to provide easily accessible information about battery state of charge and system operation.
- Insect infestations can be deterred by placing naphthalene flakes or a similar product inside equipment enclosures.
- Weed growth around and under the solar array and associated infrastructure can be eliminated by using weed matting and aggregate cover.
- Damage from stock, or vandalism, can be prevented by fencing around solar arrays, and battery and equipment sheds or enclosures.
- Use of modularised, standardised, factory-tested enclosures can assist installation and facilitate fault finding — especially with multiple, similar installations.

Maintenance

As part of cyclic maintenance:

- establish a maintenance regime with clearly defined roles and responsibilities for ensuring long-term reliability of RE systems; for example
  - community maintenance tasks: keeping system clean, basic fault finding — checking circuit breakers, reporting faults
  - essential service provider tasks (trade qualification not required): regular thorough system checks including battery voltage levels and recording of system meter readings, as well as responding to faults reported by the community
  - trade maintenance tasks (scheduled) — maintenance and repair check on an RE system by qualified personnel
  - trade maintenance tasks (unscheduled) — maintenance and repair response to faults unable to be resolved at non-trade level.

Ensure that:

- funding arrangements for ongoing maintenance of an RE system are established before installation (including the cost of replacement of batteries); for example, government, service provider and community contributions
- appropriate training in operation and maintenance of RE systems is provided to
  - community members
  - non-trade RE system maintenance service providers (such as local government council)
  - trade RE system maintenance service providers (such as a subcontracted CEC-accredited electrician)
- maintenance specifications are clearly detailed in maintenance checklists and manuals, which are provided on-site and to relevant organisations and personnel
- user manuals for community members/consumers are appropriate to their level of literacy and education.

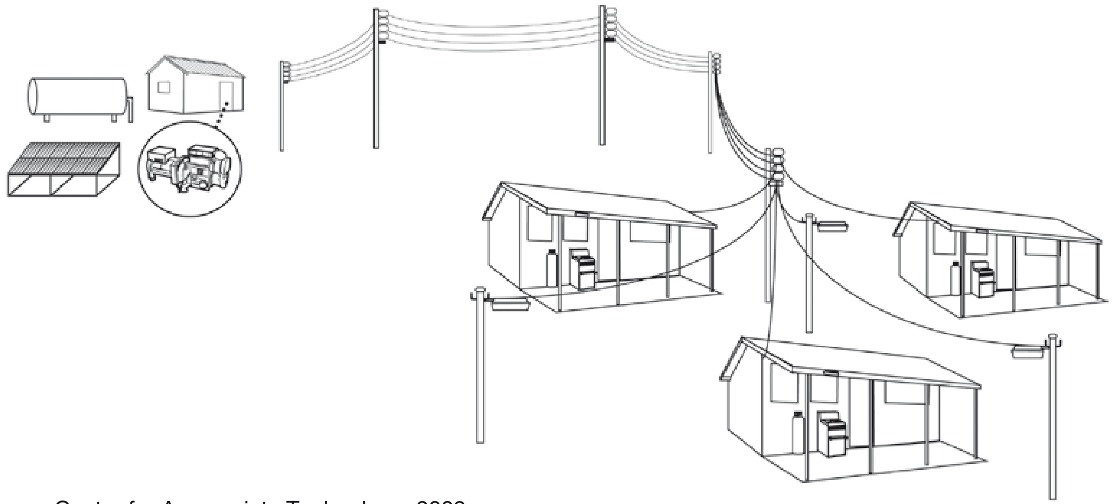
Consider:

- implementing approaches to building the skills of local people in operating and maintaining the RE system.

Stand-alone power systems — hybrids

Hybrid systems couple an RE system with a generator and use contributions from both to meet the daily energy needs of a community (Figure B5.5).

Figure B5.5: Stand-alone community hybrid system electricity supply



Source: Centre for Appropriate Technology, 2009

Both the RE component and the generator charge the batteries from which electricity is distributed to consumers. Hybrid systems commonly have the ability to run all loads off the generator if required. The level of contribution from each component can be varied, depending on a variety of financial considerations as well as expected load variations. Hybrid systems can connect directly into a house or a local distribution network.

- **Capacity**: system is scaled to community needs with the RE component meeting the baseload requirement and the generator covering the rest.
- **Initial cost**: medium to high depending on the design of the system (higher RE component will increase capital cost).
- **Recurrent cost factors**: fuel, maintenance and consumables, and periodic replacement for generator and batteries; this is a function of the design of the system, specifically the percentage of generator contribution (the higher the generator contribution the higher the recurrent cost).
- **Power system relative recurrent costs**: medium.
- **Reliability**: good if system is well designed, operated and maintained.
- **Quality of supply**: generally quite high.
- **Growth capacity**: able to meet a wide range of loads if designed appropriately.
- **Design life**: generally as for generator and RE systems; however, generator design life depends on its level of contribution (less run-time means longer life).
- **Environmental impact**: low.
- **Greenhouse gas impacts**: low.

All attributes of RE systems and generator systems apply for hybrid systems, including the areas below.

Appropriate design and installation

Ensure that:

- only CEC-accredited designers and installers carry out such work
- commissioning is by experienced personnel, using CEC checklists
- the generator maintenance regime is given the same high priority as it would if it were the only source of energy, because reliability of the generator component is critical
- fuel infrastructure is lockable, bunded and metered
- fuel level gauges are visible from a distance.

Consider the following issues:

- It is good design to ensure that load shedding occurs if the generator fails to start when called by the inverter.
- Running a number of life-cycle cost analyses to account for different contribution levels from the solar and generator components will ensure that the most economic mix is achieved for the funding available (both capital and recurrent).
- A purpose-built passive-solar shed for housing the infrastructure is preferable to shipping containers.
- It is preferable to include a new gen-set and fuel infrastructure as part of the installation unless the existing generator is in very good condition and is able to synchronise with the inverter.

Maintenance

As part of cyclic maintenance:

- record all meter readings for both the generator and RE system on a daily or weekly basis in system logbooks
- run an annual maintenance check of all generators by a qualified service mechanic, and of the RE system by a qualified electrician.

Ensure that:

- system logbooks are provided
- essential replacement parts for the generator, generator control systems and RE system are always available on site.

Consider:

- availability of personnel with the skills and training required to deliver the appropriate level of scheduled and unscheduled maintenance to each component of the hybrid system
- cost-recovery arrangements and funding for the purchase of fuel and replacement of batteries.

Case study 12 — Managing energy use

A remote community relied on a diesel generator system for their power. Operated and maintained by an essential services officer (ESO) employed by the local council, the system had been failing regularly, particularly in the evening, leaving the residents without power for several hours at a time while the ESO travelled out to the community. This was a major problem, as one of the older residents required reliable power for a respirator and had to move back to town for safety. The residents began asking the council to fix the problem.

At first glance it seemed that the system was simply not large enough to meet the community's loads and needed an upgrade to a larger generator. This was reinforced by the fact that the system had begun to shut down more often after another family moved into the community and occupied an empty house.

The council was worried about the system's reliability and the increased fuel consumption and costs, but was unsure what to do. They called in a consultant with a thorough understanding of the options available to fix the problem. The consultant looked at all of the system performance data available and conducted energy audits on every house, which included speaking to residents about appliance use and their impressions of the electricity supply.

The major findings were:

- *The peak, or maximum, loads of the community were quite high and the minimum loads relatively low. This was attributed to widespread and heavy air conditioner use during the afternoons and evenings in the build-up and wet season.*
- *Where the peak demand exceeded the capacity of the power system, system protection caused the power to be cut entirely. These peaks appeared to be the result of numerous air conditioners and electric stoves being used at the same time.*
- *The generator itself was in relatively good condition, having had regular maintenance, but needed to be replaced in another year or so when it would be at the end of its service life.*

(continued)

The consultant made the following major recommendations:

- *Maintain the current generator, but implement a demand-side management (DSM) regime to handle how and when electricity is used in the community. (Increasing the generator size would lead to poor loading on the new generator, compromising its sustainability and resulting in higher fuel costs.)*
- *Promote the use of gas by providing new gas stoves, removing electric ovens, facilitating the delivery of gas bottles and providing training in the use of gas stoves. Residents indicated that they were open to this idea as long as refills were readily available, and training and support were provided.*
- *Renovate houses to provide seals on all doors and windows in rooms with air conditioners; and replace air conditioners fitted in areas open to the outside with overhead fans. This would require negotiation with residents, which would fit naturally within a broader education program about energy use in the community and DSM.*
- *Consider installing a load controller for the generator that is capable of shedding certain loads during demand surges, instead of simply cutting all power.*
- *Engage a consultant later in the year to evaluate the best solution for replacement of the current generator at the end of its life, making sure the future energy needs of the community are fully explored and taken into account. Options would include like-for-like replacement or a hybrid system.*

Taking this advice, the council spent around $15 000 on appliance replacements, renovations and training. System performance data from the months after this work showed peak loads to be significantly lower than previously, with no power drop-outs at all. This allowed the respirator-dependent resident to move back into the community.

Useful terms

After-diversity maximum demand	The demand capacity or load capacity that a power system is designed for, after taking into account the fact that not all maximum or peak (appliance) loads will be present at the same time.
Alternating current (AC)	An electric current that reverses direction (polarity) 100 times per second. All common household and industrial appliances use AC electricity.
Alternator	A device generating AC electrical power.
Ampere or amp	The unit of electric current.
AS	Australian Standards
Autonomy	Number of days the fully charged battery bank of an RE system can provide the energy requirements of a community without any energy input from the normal source (solar PV panels, wind generator, etc) due to dense cloud or lack of wind.
Balance-of-system (BOS)	The components of a photovoltaic power plant other than the photovoltaic panels themselves. This includes all electronic components like cables, switches and, most prominently, the DC/AC inverter and storage batteries. Supporting structures for the array, if any, are also part of the BOS. For economic analyses, the cost of land for a free-standing power plant is sometimes included as part of the BOS.
Baseload	The power available in an electrical system to meet minimum expected requirements at a given time.
Bunding	An earth wall or an outer tank around fuel infrastructure (tanks, pipes, etc) to contain spills or leaks.
CFL	compact fluorescent light bulb
Clean Energy Council (CEC)	The accrediting organisation for RE system designers and installers.
Daylight (photo-electric) switch	A device that senses the level of ambient light and switches a light or other circuit on or off accordingly as an energy efficiency measure.
Direct current (DC)	Electric current in which electrons flow in one direction only. Opposite of alternating current (AC). This is the form of output for solar panels and batteries, and must be converted to AC for use in most appliances.

Diversity factor	The ratio of the sum of the individual non-coincident maximum demands of various loads on the system (the total theoretical maximum demand), to the after-diversity maximum demand of the complete system. The diversity factor is usually greater than 1, since it is unlikely that all of the maximum or peak loads will occur at the same time.
EE and DSM	energy efficiency and demand-side management. These related measures are based on modifying behavioural patterns of energy use and providing tools to achieve this. They include putting timers on lights and fans and turning off lights, air conditioning and fans when not needed; modifying energy infrastructure to use energy more efficiently, including swapping old appliances for new energy efficient ('5-star') appliances; and modifying other infrastructure to reduce the need for energy consumption (eg insulating buildings).
ESO	essential services officer
Grid power	Electrical power provided by a system where the power source or power station is outside the community and connected to it by a transmission/distribution network of poles and wires.
kilowatt (kW)	Kilowatt, 1000 watts of real power (see Watt). The consumption of a 2-bar radiator or electric kettle is roughly equivalent to 1 kW.
kilowatt hour (kWh)	The use of 1000 watts for one hour; the unit of electricity used for billing.
LCC	life-cycle costing
Load	The electrical load that is placed on a power source such as a solar PV cell or generator by appliances. Larger loads imply greater current flow and greater power and energy consumption. Some loads cause greater current flow but relatively lower power consumption. These are referred to as low power factor loads (eg certain kinds of electric motor).
LPG	liquefied petroleum gas
NPV	net present value
PV	photovoltaic
RE	Renewable energy: in the context of this chapter, RE refers to any power system using technology that is powered by renewable energy, including solar PV systems, wind turbines and microhydro power systems. In Australia, the most widely used RE technology is solar PV, due to the high levels of solar radiation prevalent in most remote northern areas.

Redundancy	Backup power supply options in case the main power system fails. Usually this refers to a generator. As such, any backup generator needs the same level of maintenance and support (eg reliable fuel supply) as the main power system. Redundancy is particularly important where critical services such as water supply and medical equipment rely on uninterrupted supply.
Solar PV	Solar photovoltaic: general term describing an interconnected system of photovoltaic modules that convert sunlight into electrical energy (DC voltage and DC current).
SP	stand-alone power
SP systems	Stand-alone power systems: includes renewable energy (RE) systems that draw energy from the sun, wind or water and store it in a battery bank, and hybrid systems that couple an RE system with a generator, with contributions from both required to meet the daily energy needs of a community.
Three phase	Refers to a high-capacity electric power system having at least three conductors. Generation utilities generate three-phase power and transmit it to load centres where it may be consumed at three phase or single phase.
Utility	Distribution (or transmission) utility: an organisation supplying and maintaining the distribution network (the poles and wires or 'grid') between a large generating plant or power station and in some cases a very high voltage transmission system, and the customer premises.
	Generation utility: an organisation supplying and maintaining large power generation plant or power stations.
Volt (V)	The unit of electric potential difference, or force.
Watt (W)	The unit of electric power. With AC measurements, effective power (measured in watts) equals the product of voltage (volts), current (amps) and power factor.

Further reading

ABS (Australian Bureau of Statistics) (2006). *Community Housing and Infrastructure Needs Survey 2006, Housing and Infrastructure in Aboriginal and Torres Strait Islander Communities,* Cat. No. 4710.0, ABS, Canberra.

Checklists and other materials are available from the Clean Energy Council www.cleanenergycouncil.org.au

Healy Engineering (2007). *Sustainable Power Systems — Holistic Concepts for Isolated Power Systems*, Healy Engineering, Perth.

Ove Arup and Partners, Smith and Hooke Architects, Healey Engineering, d'ENVIRON Health and Morton Consulting Services (2000). *Code of Practice for Housing and Environmental Infrastructure Development in Aboriginal Communities in Western Australia*, Western Australia Department of Indigenous Affairs, Perth.