NEW DEVELOPMENTS IN SOLAR POWERED SERVICES
FOR REMOTE ABORIGINAL COMMUNITIES

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INTRODUCTION

One of the most significant developments in the life of the aboriginal people of Australia in recent times is the movement away from large centres of population to homeland centres or outstations [1]. The small communities resulting from this movement generally require some basic services such as water and small amounts of electrical power. The use of conventional approaches to supply essential services in such homeland communities is inappropriate, if not impossible, because of the remoteness of these locations.

This paper describes the most recent developments of a transportable solar power supply system called the Solar Pack for such remote communities, which could also be used in any other similar situation.

This development has involved the Department of Aboriginal Affairs, local community advisors and the aboriginal people themselves, and is being directed by the Murdoch University Energy Research Institute (MUERI) (formerly the Solar Energy Research Institute of Western Australia).

BACKGROUND

The Solar Pack has been reported extensively in several papers [2] [3]. The first Solar Pack was installed in March 1985 and has operated satisfactorily with no maintenance since that time. Seventeen of these units have been installed in Western Australia, the Northern Territory and South Australia. A brief description of the Solar Pack will help those not acquainted with it.
The Solar Pack is designed to provide the high priority needs of a small community with a system that is simple, reliable, durable and transportable.

The standard Solar Pack provides refrigeration, lighting, power for radio communications and a 240V ac power outlet for appliances such as television/video, power tools and car battery charging facilities, all in a centralised unit.

Solar panels on the roof of an insulated shipping container provide power for a large battery bank and the appliances inside the unit. This power supply is silent and has no moving parts, thus ensuring low maintenance and high reliability. A controller protects the system from over charge and over discharge and ensures that essential services such as radio communications are always available.

Optional facilities have now been added to the Solar Pack, such as water pumping, coolroom, evaporative cooler and tyre inflating facilities. These are described in this paper.

**DESIGN APPROACH**

The design approach for the Solar Pack system has been characterised by three main criteria. The Solar Pack unit is designed to provide the basic services required by a small remote community. The units must be reliable because of the very remote locations in which they can be deployed and they should be transportable because of the transient nature of these communities.

The focus on basic services differs markedly from the conventional approach to providing power in these remote communities, where a diesel generator set is installed. This power supply system often becomes undersized in a short period of time as appliances are obtained by the individual members of the community, or conversely, oversized because a significant portion of the community moves away from the location. Note that the main difference is that the Solar Pack is providing services such as water, communications, refrigeration, power, etc, as distinct from the diesel generator which provides power only.
The problem of load management for the system is addressed by designing the major part of the system to operate on direct current (dc) power. A small inverter is supplied for production of conventional alternating current (ac) to power a TV set or portable power tools. Also, the control unit has a hierarchy of loads and should the battery voltage be falling too low, the loads are gradually disconnected in a sequence which ensures that the most critical loads are connected for the longest time. Therefore, the system has a degree of self-protection against overloading while essential services such as the radio are permanently supplied with power.

DEPLOYMENT OF SOLAR PACKS

The Solar Pack, fully loaded and operational, weighs approximately 6 tonnes and will fit on a truck with a tray 7 metres long and a standard width of 2.4 metres. The container is lifted with four manually operated jacks allowing the truck to drive underneath. The jacks are loaded onto the truck and used to off-load the unit on site. The jacks are then returned to home base.

All items of equipment, such as batteries, refrigerators, inverters, etc, are bolted to the container structure. Support channels and light poles are also fixed so that there is no movement in transit. The refrigerators are generally filled with food and operate during the journey.

In transit, the Solar Pack has been subjected to very rough roads during which the array was always in the extended operating position. In all installations there has been no damage to any of the equipment during transit or on location.

The container and array extend to a height under 4.5 metres when mounted on the truck; this allows it to travel without restrictions in the metropolitan area and country roads.

On arrival the container is aligned so that the arrays face north, lowered with the jacks and mounted on two traverse steel rails which are then bolted to the container sides to ensure stability in high wind speeds.
If required, external cabling can be run underground from the container to free standing lights, etc.

**OPERATIONAL EXPERIENCE**

Because of the remoteness of the units the basic design philosophy has been to design for minimum maintenance and minimum instruction to users.

In general, the acceptance and performance of the Solar Pack has been very good. The only maintenance required is to top up the batteries with distilled water once a month, and the main instruction required is to make the user understand the automatic 'load management' system.

The latter is necessary as in occasions of low solar radiation the system will disconnect non-essential loads such as the TV or the lights. This is done to prevent the batteries from being excessively discharged. The disconnection of the TV in the middle of a good film is disappointing to anyone, and it instantly generates initiative within the more dexterous members of the community to interfere with the controls and in some cases quite successfully flattening the batteries. Generally after this, though, the community learns that the controller will recover all services within one or two sunny days. Interfering with the controls has happened in two communities out of seventeen. It is hoped that the latest modification to the controller will prevent this.

Other minor problems with a commercial battery charger for vehicles has prompted the design of a simpler and more reliable unit which will be incorporated in future units.

From the viewpoint of the institutions supplying the Solar Packs the advantages in using this system may be summarised as:

1. Safety, the system operates on 24V dc
2. Relatively maintenance free
3. No fuel costs and reduced maintenance costs when compared to a diesel or petrol generator
4. Relatively vandal proof and secure when locked up
Maintains food and acts as a store when the community goes 'walkabout'.

Capable of movement should the group relocate.

Batteries incapable of operating in conventional vehicles.

The disadvantages are basically related to the limited amount of 240V ac power available. This last issue is approached under 'Latest Developments'.

Although not yet investigated, there seems to be an acknowledgement that the Solar Pack is enhancing the health standard of the community through the availability of refrigeration which is prolonging the shelf life of bush tucker and enabling the storage of staple foods which compliments the diet.

### Latest Developments

Exposure to the remote homelands communities and discussions with the people living in those communities has revealed several other services which could be potentially supplied by the Solar Pack. Therefore development of new options for the Solar Pack is continuing.

**Water Pumping**

The first of these additional services is water pumping. The requirement is for a basic survival water supply and hence the general rules of thumb often applied in such a situation (eg, 400 litres per person per day) do not apply. A survey of pumps was made and some of these were tested. A simple air lift pump powered by a dc compressor has been selected to provide such a small water supply requirement and has operated reliably on its own in outback applications.

The requirements for pumping equipment follow the general design principles of the Solar Pack; ie, little or no maintenance, simple installation, ease of repair. The attractive characteristics of this pump are that the pump body which goes in the bore hole is all plastic, with no moving parts, and it has a flexible plastic column or delivery pipe which makes it very easy to install. Being all plastic means that there is no corrosion and no moving parts means no wear.
The pumps can tolerate sand and silt and can run dry with no damage. The only moving parts are in the compressor which is mounted above ground on the container roof.

**Cooling**

As mentioned earlier, some Solar Packs have been used as community stores with the provision of refrigeration enabling the preserving of perishable commodities. This has catered for specific foods such as break, milk, meat, etc; however, bulkier foods such as vegetables, fruit, etc, require more space but not very low temperatures.

With the ambient temperatures experienced in some parts of Central Australia (45°C to 50°C) these vegetables will last only a couple of days. If the temperatures could be dropped to those similar to a cool cellar; ie, 15°C to 25°C, these foods could be stored for several weeks, sufficient to cope with intermittent deliveries.

Two types of cooling systems were developed, one for dry arid regions and one for wet subtropical areas.

The dry arid region can make use of an evaporative cooler and utilises the insulated container as a store. The evaporative cooler, dc powered, is thermostatically controlled and its speed varies according to the amount of heat to be removed therefore utilising a minimum amount of energy. Tests indicate that with outside ambient temperatures of 40°C inside temperatures were kept at 25°C and the energy used was 500 Wh/day or the equivalent output of three solar panels. This is a remarkably efficient use of solar energy. Moisture is also introduced in the air, keeping the vegetables and fruit fresh.

The high relative humidity in the wet regions of Australia precludes the use of evaporative cooling and the more energy intensive process of vapour compression is the next best choice. Air conditioning and refrigeration are the two single biggest power users in towns in the north west of Australia. A 3m³ coolroom using dc powered vapour compression systems was developed. The coolroom is mounted inside the insulated container. Calculated energy demands indicate a requirement of 3 to 5 kWhrs/day.
This means that all of the array of a standard Solar Pack would have to be dedicated to it, a larger array installed for existing Solar Packs or an auxiliary source of power is necessary. This energy level, although higher than the evaporative cooler, is significantly lower compared to conventional coolrooms as it eliminates the walk-in spaces, it is permanently shaded and it is housed inside the insulated container itself.

**AUXILIARY POWER**

Several options have been looked into and three have been adopted; wind power, petrol generator set and diesel generator set.

Windpower of course should be considered where wind regimes are high, such as near the coast or on top of hills. The wind option would have to be carefully selected to match the times when solar energy is insufficient to carry the load. Two small wind generators, 270 Watts and 50 Watts, have been connected to a Solar Pack as an experiment.

A 1 kW petrol driven dc generator has been built. It is manually started and will stop when it runs out of fuel, approximately two to three hours, thus bringing the batteries up to two thirds of its charge capacity. It has an inherent battery charge controller which will disconnect the charge if the battery has reached its fully charged state.

A 2 kW diesel driven dc generator has also been built. This unit is fully automatic with electric start. The generator is permanently connected to the batteries and if it reaches a state of charge between one half and two thirds discharged, it will automatically start. It will not stop until the batteries are again fully charged. After nine charge cycles the generator enters into the equalisation mode which slightly gases the battery to equalise the voltage level of each battery cell and thus eliminate any sulphation.
MINI PACK

A physically smaller version of the Solar Pack, but of equal power, has been developed to cater for regions where standard ten tonne trucks cannot go and only four wheel drive utilities may reach.

This unit is 2.4 metres long, 1.5 metres wide and 2.2 metres tall. It is fully wired and assembled but the solar arrays are folded and bolted to the side and roof of the Mini Pack. On arrival to site these arrays are unfolded and bolted in place. The whole unit weighs under one tonne.

Other options which can be relatively easily incorporated into the Solar Pack are a compressed air facility for inflating tyres and a satellite receiving dish with the associated control for reception of satellite TV programmes.

SYSTEM COSTS AND ECONOMICS

The current cost (November 1987) of the basic Solar Pack unit which consists of an 840W photovoltaic array, two refrigerator units, one internal light, one external light, a 450VA inverter, one 5A 12V battery charger, a 12V radio outlet and shelf and the associated battery, controller, switchboard, etc, is $A38,000.

In terms of the economics of the system only the power supply plant should be considered as the rest of the system should remain the same.

Assuming that the battery will require replacement after five years and the balance of the system after twenty years (with no residual capital value) then the annual running costs of the system would be approximately $1.15/kWh. This assumes an average energy delivery of 5 kWh/day and an interest rate on borrowed capital of 12%.

The existing variable load (180W average) is not compatible with conventional diesel driven generation equipment. The smallest practical diesel generator size would be around 2 kW and hence would only be loaded to 10% of rated load for much of the time.
A generator set operating under these conditions would exhibit extremely poor fuel efficiency (less than 1 kWh/litre for diesel) and correspondingly poor reliability.

A better alternative is the use of a petrol (gasoline) driven battery charger in conjunction with the existing battery bank. This would result in a cost of approximately $1.40/kWh. Clearly, the use of photovoltaics is the most economic solution.

The use of photovoltaics produces an immediate economic advantage compared to the petrol based system. This economic advantage will become more significant as the real cost of petrol increases in the future.

The purchase of this type of equipment, as distinct from a diesel generator set, is that it requires a higher up-front cost followed by little or no recurrent costs. The purchase of a diesel generator set requires a less substantial up-front payment but considerably higher on-costs such as fuel, oil and maintenance plus the inconvenience of frequent breakdowns which creates hardship to those using the system and an organisational effort to those who have to arrange for repairs. The Solar Pack systems have irrefutably proven that these solar systems are inherently more reliable. Should a problem ever occur, it is not a catastrophic one as it is with diesel generators.

If this activity is costed into the original assessment when considering options, it makes the decision making process a fairer one. Institutions or organisations funding these services have to look at budgeting in a different manner to cater for the higher up-front costs of such systems.

CONCLUSIONS

A photovoltaic power supply system has been developed and deployed at numerous sites in central and north-west Australia.
The system provides reliable dc power for communication, refrigeration and lighting equipment and limited ac power for hand tools, television and video equipment. The energy supply can be enhanced by using auxiliary dc generators.

The system is easily transported and can withstand rugged road conditions without apparent damage to any of the equipment. The solid container can withstand cyclonic weather conditions and could prove a temporary shelter when these occur.

The system requires minimal maintenance and should significantly enhance the quality of life for remote communities. The system is silent in operation.

Feedback from the communities indicates that the Solar Pack unit is an 'appropriate' technical solution to the problem of providing basic services to small remote communities. The Solar Pack seems to be enhancing the health levels and the independence of the communities.

Institutions and organisations considering power options should bear in mind the much lower operational costs and the reduced number of breakdowns that these solar systems provide which in turn means greater stability for the communities, less organisational problems when arranging for repairs and different budgeting methods to cater for higher up-front costs.

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REFERENCES

