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Why are remote Western Australians installing renewable energy technologies in stand-alone power supply systems?

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Abstract

As people living in remote areas rely on SPS systems for their electricity and water needs, they hold a practical and non-idealistic perspective towards using renewable energy technologies. This research explores pastoral owner-operators' personal experience and opinion of stand-alone power supply (SPS) systems over 30 years in remote pastoral regions Western Australia (WA). This research was undertaken qualitatively in terms of remote Australians experience of energy service delivery and SPS system performance to obtain personal opinions of remote pastoral people who rely on SPS systems to provide basic needs. This research concluded that the impressive growth in total renewable energy capacity in remote off-grid SPS systems in WA is primarily due to subsidies that aim to fuel-switch to renewable energy sources. Despite this, other major reasons for the increases in renewable energy capacity are escalating conventional fuel costs, difficulties in attracting qualified service contractors, increasing desire for quiet, 24-hour energy services, and a range of unique situations. Despite the increased use of renewable energy technologies, this research reinforced previous research conclusions that consistently found both the conventional and renewable energy service sector wanting in remote areas. Three areas needing attention to sustain the growth in renewable capacity are: technical SPS system integration, service infrastructure, and technical reliability.

Keywords

RAPS, SPS, renewable, pastoral, Western Australia.

1. Introduction

Pastoralism is a key primary industry predominantly concerned with the grazing of animals in marginally productive regions. The pastoral industry occupies 45% of WA's natural ecological system that is presently described as "rangeland". The WA rangelands themselves represent around 87% of the total state area in mostly arid and semi-arid regions [1];[2]. Most pastoral leases are held by families or pastoral companies and are principally concerned with raising cattle and sheep for meat and wool [1]. Indigenous groups, mining companies or conservation groups also hold a small minority of leases. During the research there were a total of 527 pastoral leases in WA, covering 474 pastoral stations [2]. The research tool was based on the Centre for Appropriate Technologies (CAT) & Australian Cooperative Centre for Renewable Energy (ACRE) 2000 survey of WA pastoralists and was sent to all WA pastoral leases.

Remote pastoralists are often many hundreds of kilometres away from electricity network infrastructure and predominantly provide their own energy services. Internationally, the small systems that provide electricity services in remote off-grid areas are known as stand-alone power supply (SPS) systems, although in Australia they are more commonly called remote area power supply (RAPS) systems. The historical dominance of fossil fuel based generation in off-grid RAPS/SPS systems has been due to the availability and low cost of diesel fuels. Recent increases in diesel fuel costs and technological developments are attracting more people towards renewable technologies for supplying their energy needs in remote areas. Pastoralists have purchased renewable energy technologies for practical reasons, such as reducing the number of times they travel several hundred kilometres to check and refuel stock water supply equipment on the property. Pastoralists provide a commercial niche for many new renewable technologies while unit prices are high. Researches on early adopters of technologies provide valuable technical performance and reliability information in addition to personalised qualitative opinion useful for further market development. This research updates and clarifies why remote Western Australians have chosen to include or exclude particular technologies in their SPS systems over the last 30 years.

2. Recurring issues in WA pastoral renewable energy research

In 1981, the Solar Energy Research Institute of Western Australia (SERIWA) prepared a study entitled “ Potential for Photovoltaic Applications on Remote Pastoral Leases in Western Australia”, which was later revised in 1984 [3]. The researchers sent questionnaires to all 483 pastoral stations in operation at the time and received a response rate of 48%. The research found 32% of respondent household RAPS systems were direct current (DC) and the remaining 68% operated alternating current (AC) systems. In terms of primary fuels, 84% used diesel fuel to power the generator, 14% used petrol and two percent used unspecified fuels in their RAPS system. At the time there was little knowledge of photovoltaics. Only 22% of respondents were aware of the technology, 95% of them wanted to know more, and 83% were interested in taking part in further photovoltaic studies [3].

A 1994 study by Watt and McGill entitled “Opportunities for Distributors to Supply RAPS” researched remote households that chose expensive grid extensions and compared them with those that had chosen RAPS systems. Two surveys were completed, an initial 1987 survey, and the final survey in 1992. The study concluded that RAPS system owners had fewer power outages and fewer problems with quality of supply than fringe of grid respondents. The satisfaction if users with renewable energy components in RAPS systems had increased over the five years between the two surveys [4].

In 1991, Harman, et al. conducted the first study specifically focused on non-technical barriers to using renewable energy in SPS systems. The study included the perspectives of manufacturers, householders and a survey of pastoralists in WA. The study found that appealing to environmental concerns was unlikely to be effective in increasing the use of renewable energy technologies. The use of wind and solar technology was seen as costly, unfamiliar, and lacked good after-sales support at the time [5]. The report by Harman, et al. also reviewed previous research concerning institutional barriers to the introduction of larger-scale renewable technology undertaken by Blakers, Diesendorf, and the Appropriate Technology Development Group from 1985 to 1987. The reviews concluded that the main barriers to renewable energy technology uptake were: the reluctance of electricity utilities to offer fair buy-back rates for privately-owned wind-generated electricity supplied to their grids; a failure of governments to recognise the environmental advantages of renewable

energy, and; a failure to internalise environmental impacts [5]. While these particular barriers are not especially relevant to pastoralists, remote Australians do rely on the services that larger-scale renewable energy industries make more accessible and cost effective.

In 2000, the Centre for Appropriate Technology (CAT) & Australian Cooperative Research Centre for Renewable Energy (ACRE) published a major market survey on renewable energy RAPS systems in Australia. It remains as the most extensive field market surveys on RAPS systems undertaken in the country. The survey involved visiting 134 separate remote sites with over 350 separate electricity and water pumping systems. The owners of RAPS systems with renewable energy technologies were interviewed to determine their thoughts, their systems performance, maintenance needs and its costs. In addition to these interviews, a total of 260 completed surveys were received from a mail-out of 1,270 forms nationwide [4]. The CAT/ACRE research targeted pastoralists, indigenous communities and tourist sites and the results of the survey uncovered a wide variety of fascinating issues. Consistent with previous studies, pastoralists in general viewed the high capital cost of renewable systems as the biggest disadvantage, with the lack of reliable operation another important factor [4]. Unfortunately, the study found many areas where the renewable industry continued to fall short. Lack of system maintenance, training and information was commonly reported, as was insufficient levels of after sales service. The research found that some people resented being used as “guinea pigs” in demonstration systems. Overall, the CAT/ACRE survey found a wide range of perceptions about renewable energy, and researchers were surprised to find more opposition to renewable energy technologies than they expected. Interestingly many renewable energy industry perceptions of their own performance, seemed to be at odds with the view of their consumers overall [4].

Systems incorporating renewable energy technologies for electricity production were installed on approximately 21% of respondent properties and were generally a combination of solar-diesel, wind-diesel or solar-wind-diesel hybrid systems. Several respondents in WA complained of poor service from SPS system installers and the renewable energy service industry generally. This was in addition to the lack of local expertise and information on maintaining and repairing renewable energy systems. This lack of local knowledge was a major problem as the distances between

properties and service centres meant the time and cost of waiting for qualified professionals to be on-site was prohibitive. Telephone interviews with pastoralists who had renewable energy technologies were asked about their principle motivation for obtaining the technologies. Environmental concerns, such as the greenhouse effect, were not mentioned as primary motivators. The study found that the introduction of renewable energy was predominantly due to obtaining affordable 24-hour power, which often resulted in marked increases in electricity consumption in some pastoral stations [4].

From the available historical research there is at least thirty years of recurring issues of cost and reliability stifling the renewable energy RAPS/SPS system market. The technical performance and reliability of renewable energy versus diesel-only SPS systems is now known to be approximately equal, except for wind capacity unwisely located in areas with a poor wind resource [4]. Servicing support for renewable energy in SPS systems, especially in the remote context has continued to be a significant problem. Intriguingly, over the last 30 years there have been significant improvements with individual technologies, but system integration issues persist. Table 1 represents the major technical and non-technical issues identified by major research in WA conducted over the last few decades.

3. 2006 research respondent perception results

In 2006, the author conducted further research into pastoral SPS systems performance and users perspectives. The survey was based on the CAT/ACRE survey as a demonstrated research instrument. Respondents were asked to provide details on the systems they used for both pumping water and providing electricity for domestic and industrial loads. Almost half of respondents used diesel-only systems. The percentage of respondents with one or more renewable energy components in their SPS systems was slightly over 46%. This is a considerable increase from the CAT/ACRE (2000) survey with only 15% respondents with renewable energy SPS system components and the Watt et al. (1992) survey with only 7.4% [4].

The participants were asked their opinion about the advantages of using renewable energy components in a SPS system. Of the 78 responses, 33 stated the ability to

reduce diesel costs, 21 cited 24-hour power, and twelve respondents each included reduction in noise and environmental reasons. When asked about what they saw as the disadvantages of renewable energy components in SPS systems there was a variety of responses. Of the 78 responses, 30 viewed high costs and 21 viewed servicing issues as the most significant. Other perceived disadvantages of renewable energy SPS systems was the need for battery replacement (10), system unreliability (9), backup requirements (4), design/installation issues (3), and short component lifetimes (1). Some of the respondent comments about what they saw as the disadvantages of using renewable energy components were:

- *None, provided it has been designed accurately;*
- *I can't fix electronics;*
- *Lack of technicians for repairs and maintenance - we are very isolated;*
- *Very expensive to set up, even with the subsidy;*
- *Lack of reliability due to the failure of modern type electronic circuitry in hot and humid conditions;*
- *Too many fast-talking salesmen, need better batteries and backup/service.*

Respondents who did not have renewable energy components in the SPS system were asked what would sway them to include renewable energy technologies. Of the 30 responses, 15 included lower renewable component costs and seven indicated improved renewable system reliability. The remaining reasons were predominantly related to higher diesel fuel prices (5), reduced battery replacement costs (2), and improved servicing infrastructure (1). Some of the comments received included:

- *Being able to afford it;*
- *Guarantees and life expectancy commensurate with price;*
- *A decrease in diesel rebates;*
- *Improved reliability and a significant improvement in battery life.*

Respondents who did have renewable energy systems were asked why they chose to install them over conventional generation capacity. Of the 88 reasons given, 27 were to reduce diesel fuel costs, 21 were to obtain 24-hour electricity, 14 responses were related to noise reductions, 13 were for environmental reasons, and 13 respondents indicated that it was the cheapest option for them. The survey asked: "Has the renewable energy system performance met your expectations?" The responses varied

but were overwhelmingly answered “Yes”. Representative satisfied respondent comments were:

- *Yes - exceptionally good;*
- *Yes and no, as our power demand keeps growing and stretches its capacity.*

Of the 33 respondents with renewable energy components in their SPS system, there were four respondents that indicated that their expectations were not met. One system was a solar pumping system, one SPS system was self-installed, and the same installer designed and built the two other SPS systems. These two respondents that shared the same installer stated that the installer significantly over estimated the system performance, and therefore the system did not meet their expectations. By the quality of most responses received to the authors’ survey, there was a growing understanding of the limitations of renewable energy technologies generally. When respondents were asked if their renewable energy systems were as reliable as their diesel-powered systems, the majority (75%) of the 33 respondents indicated that renewable technologies were as reliable. Representative respondent comments from those who did find renewable systems as reliable were:

- *No, because we quite often can't fix inverter problems, but we can fix generators;*
- *No, small problems with inverters are a constant interruption.*

The reliability research indicates a steady improvement in the renewable energy component technologies when compared to diesel technology. However, this does not indicate that renewable SPS systems can be described as reliable, as diesel-powered systems are also major causes of SPS system failure.

Respondents were also asked whether they thought their investment in renewable energy technologies was cost effective and to estimate any savings or losses. Of the 33 respondents, 70% believed their renewable investment was cost effective, while 18% did not believe so, and 12% were unsure. Of the respondents that indicated no, some representative comments were:

- *Not without the government rebate;*
- *Not really cost effective including all of the components.*

Representative responses from individuals that answered “Yes” when asked if their renewable energy generators were cost effective were:

- *Yes, the R.E. system is cost effective, but only if I undertake some of the minor maintenance myself, as contractors in this locality are not cheap;*
- *It is because we run our generator less. Unfortunately the batteries need replacing every 4 years and that’s a large upfront cost, even with the rebate;*
- *Yes, cost savings are too hard to estimate. 5000+ litres of fuel per year and [AUD]\$120,000 for generators every ten years;*
- *Yes, diesel and generator servicing savings, approx [AUD]\$15,000 to [AUD]\$17,000 per year for equivalent 24 hr power.*

Respondents who were unsure of the renewable investment cost-effectiveness usually had either installed systems relatively recently, or were cautious with their response:

- *Very debatable, very little savings due to maintenance costs being so high due to remoteness.*

There was wide agreement among the vast majority of respondents that renewable energy technologies were more cost-effective than diesel in times of high diesel prices^a. Respondents were also asked to give an opinion about the difference between running, servicing and the capital costs of a diesel system compared to a (non specific) renewable energy system. Some indicative responses were:

- *Capital costs – [diesel] gen[erator is] cheaper. Maintenance - solar [system is] cheaper so far. Running costs – solar [system is] cheaper;*
- *About the same, replacing renewable components is expensive compared with diesel gensets;*
- *Capital cost of solar is too high, so too is maintenance costs. We would save only [X] amount off the fuel bill, but have to put up with poor reliability of inverters and batteries etc.*

^a “High” diesel prices at this time in remote WA were thought of as a level approaching AUD\$1.50/L and above, before the diesel fuel rebate subsidy available in Australia to farmers.

One question specifically asked about respondents experience with the renewable energy industry in terms of sales service and after sales support. Responses varied, but are fairly represented by the following responses:

- *A fledgling industry and we have been fortunate with [supplier]. Manufacturers need to improve reliability;*
- *Verging on the mediocre. Meaning if we didn't have access to an excellent electrician in Port Hedland, we could've been without power for a considerable time;*
- *Installer of our system is very difficult to contact. Thinking of changing to more reliable people;*
- *[Supplier] have been very good in there after sales service and didn't come over with a sales pitch, but sat down and discussed our needs;*
- *The tyranny of distance affects everything we do, but a careful choice of supplier and proper installation should result in little hassle.*

In contrast to the conflicting experience with system suppliers, the responses about the availability of the 50-55% renewable energy capital component subsidy available were consistently positive:

- *Maintain existing rebate incentives;*
- *I believe the current subsidy to be essential to maintain for homestead power in particular;*
- *Without the government rebate renewables would not have been used due to cost;*
- *Replacing components is very expensive and without the RAPS scheme we would use diesel exclusively.*

Twenty-seven of the twenty-nine respondents with renewable energy components received the capital subsidy, indicating high awareness of the rebate. Interestingly, one respondent indicated that they had received a rebate and installed the system themselves. If this were the case, this would violate the conditions of the subsidy.

Respondents were also given an opportunity to provide any other comments to the author. The quality and knowledge expressed in many of the responses was impressive and shed light into many seldom mentioned, but notable aspects of remote life and energy needs in remote Australia. The following comments are only a small representative selection of the wide variety of respondent observations:

- *For the money we spend on solar pumps they do not last. In 8 years we have over 8 pumps that are no longer usable or fixable. This is compared to windmills that last for over 50 years;*
- *The solar water pumping system installed on the property have been a great benefit as they have been a lot more reliable than the windmills;*
- *The cost of battery replacement on top of system cost makes it not cost-efficient for us to have a system;*
- *Aside from our power supply, I know of other station people, who, after spending thousands of dollars, are encountering annoying power supply problems since installing R.E. systems. In my opinion we need a reliable system that is heat and dust tolerant;*
- *4 years of drought here and debt levels are high, but will convert to solar wind a.s.a.p.;*
- *I have visited many stations' [systems] like ours [with solar power] but in ALL cases the systems are unreliable and lack elasticity of power requirements. On economics they don't pencil out with our load. Fine for small loads. Solar power battery life has a long way to go;*
- *The emphasis on selling RAPS seems to be on the rebate with little regard for reliability, serviceability, or real ongoing costs. If it wasn't for the rebate few would be bought on merit alone;*
- *Too many agents try to sell units according to budget, not accurately ascertaining required performance. This results in small units that are not up to the job – It's also expensive to upgrade units;*
- *The MAJOR problem is when the inverter fails as its hard to find a qualified electrician out here;*
- *The biggest problem with RE in the Kalgoorlie area is theft!!!!.*

4. Discussion & Observations of the Study

Overall, most respondents were willing to provide much more information than was required to complete the survey. Many pastoralists' technical knowledge of their energy systems was exceptional. One common remark was that the respondents rarely see the results of any renewable energy surveys that they complete. Many

respondents explicitly asked that they would like a copy of the survey results to see how representative their experience has been in the state^b.

While this research has shown significant progress in market penetration of renewable energy technologies into remote SPS systems in WA, there remain significant issues. These issues are not new and have surfaced repeatedly and consistently in SPS system research over the past 30 years in WA. They can be appropriately grouped into three themes:

- The high capital costs of renewable energy technologies;
- Lack of service infrastructure, especially in remote regions;
- Poor reliability of SPS systems.

Many previous studies (SERIWA 1981; SERIWA 1985; SERIWA 1985; Blakers, et al. 1987; Philips, et al. 1988; Philips 1989; Harman, et al. 1991; Wyder, et al. 1995; Lloyd, et al. 2000) identified the need for innovative approaches to address the issue of high capital costs of renewable energy system components. The introduction of the capital rebate programmes has effectively remedied this issue for the most part, although the government funding for these programmes are in the process of change at the present time.

The lack of qualified servicing professionals willing to travel large distances to remote SPS systems is a major ongoing problem, especially with the recent state skills shortages. Owner and user training may be able to provide part of the solution to some minor maintenance issues akin to minor diesel generator servicing. With the increasing electrical currents in many of these newer systems, safety must remain a factor in these remote regions where access to medical services is generally poor or non-existent.

The reliability of individual components has improved over the last 30 years. Battery reliability has advanced significantly over time according to the available research, as

^b The author mailed a 15 page printed summary of some relevant results and some additional information regarding the available government subsidies and low interest loan options available to all survey respondents. The author has since met some of the respondents. They said that they were genuinely surprised to receive feedback from researchers.

their prevalence in component failure has decreased markedly [6]; [7]. However, inverters have consistently been a significant cause of SPS system failure over time. **“Fig. 1 approx. here”** Fig. 1 shows the percentage of SPS systems failures believed to be due to a particular technology component. The data has been compiled from the WA Governments’ Sustainable Energy Development Office (SEDO) SPS system capital rebate programme data and response data from the authors’ research. All data is less than eight years old and includes a total of 315 responses from WA. The SEDO data included component failures in the first year^c and from years two to five after installation^{d,e}. While the vast majority of systems had no failures over the period, the data clearly shows the prevalence of inverter and diesel related failures. Equally significant is the “other” category, which included minor design and system integration issues, such as cabling and minor electrical component problems. The prevalence of system integration problems seems to be either growing or remaining unchanged relative to other component improvements over the previous few decades. Minor technical interruptions in remote regions are costly and frustrating to owners, and unreliable support technologies are prohibiting many potential renewable energy SPS system users from entering the market.

5. Conclusion

The pastoralist perceptions and experience with renewable energy components in SPS systems are based on a foundation of practicality and a focus towards system reliability. Governing reasons for the expanding uptake of renewable energy components in WA SPS systems include obtaining 24-hour power, noise reduction, and lower diesel costs. Environmental concerns rate relatively poorly when pastoralists were asked why they chose to install renewable energy technologies. Therefore, this niche renewable energy industry market requires reliable and cost-effective systems to underpin its continued growth.

^c The number of respondents that reported a component failure in the first year was 114.

^d A total of 171 respondents reported component failures from year’s two to five.

^e The author only included component failure data from the 30 respondents with diesel-hybrid SPS systems to ensure continuity of data.

A functional collaborative research institution specifically for the renewable technology SPS industry may reduce the number of dissatisfied renewable energy technology users to an acceptably low level. Improved system standards development and better service and support would go a long way to expanding and sustaining the renewable energy industry in WA, even after capital costs subsidies are inevitably removed. The author recommends a renewed effort on the three fundamental areas of improving remote renewable SPS system integration, service infrastructure, and reliability of SPS systems generally for remote communities.

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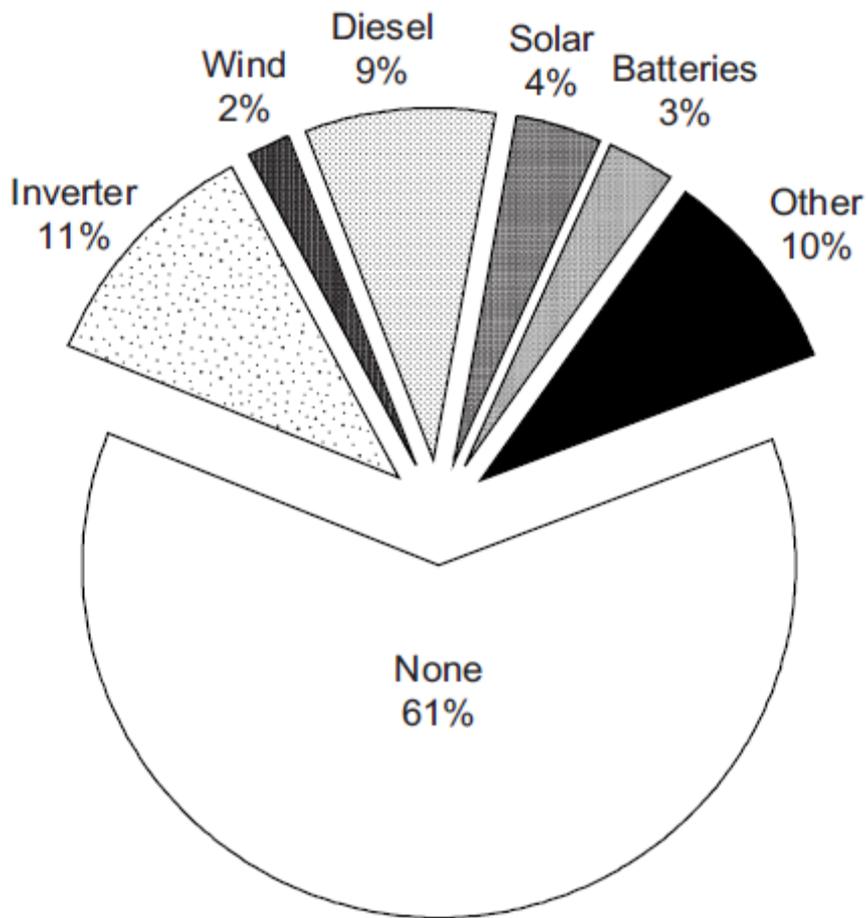


Fig. 1 : WA SPS system technology failures from 2001-2006^a.

^a The number of responses that generated this data set totalled 315. All SPS systems contained both diesel and renewable technology.

Table 1: Historical research of technical and non-technical SPS system issues in Western Australia over time. Sources: [3]; [4]; [5]; [8]; [9]; [10]; [11]; [12].

Study	Technical issue	Non-technical issue
SERiWA (1981) [3]	System variability	High capital cost
SERiWA (1985) [8]	Reliability, inverter	High capital cost, lack of service personnel
SERiWA (1985) [9]	Inverter, batteries, poor load match	High capital cost, load management, system integration
Blakers et al. (1987) [5]	Reliability	High capital cost, fossil fuel subsidies, lack of R&D, fossil fuel energy externalities, lack of information
Phillips et al. (1988) [10]	Batteries	High capital cost
Phillips (1989) [11]	Batteries, inverters, reliability	High capital cost
Harman et al. (1991) [5]	Reliability	High capital cost, lack of information, poor sales support, lack of service personnel
Wyder et al. (1995) [12]	Batteries	High capital cost, lack of R&D, fossil fuel subsidies
Lloyd et al. (2000) [4]	Reliability, load management, batteries, inverters	High capital cost, lack of maintenance; poor after sales service, lack of training, poor industry feedback