SELF-SUFFICIENCY IN DOMESTIC ENERGY SUPPLY IN TASMANIA

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ABSTRACT

This paper outlines the results of a study into the use of Renewable Energy Remote Area Power Supply (RERAPS) systems in Tasmania. A postal questionnaire and case studies were used to gather data on RAPS systems that use renewable energy supplies exclusively or in conjunction with fossil fuel generation. The study investigated self-sufficiency in domestic energy supply through renewable energy use and found that while many respondents (59%) considered themselves to use only renewable energy (that is they considered themselves to be energy self-sufficient), only 13% of the sample were truly self-sufficient in their energy supply. Some significant differences between Tasmanian systems and those in other states were observed. The battery bank, PV array and maintenance costs were smaller in Tasmania, while the use of micro-hydro turbines was greater. Economic factors were important when choosing RERAPS systems, but other factors such as self-reliance, independence, and using renewable energy were rated as more important. Over half reported no problems with their electricity supply, nearly 60% considered the system to be safe, easy to use and a good investment, and 99% would choose RERAPS again. RERAPS use has led to the development of small businesses, community power generation and increased individual and community skill levels.

INTRODUCTION

This paper reports on a study of the viability of Renewable Energy Remote Area Power Supply (RERAPS) systems in Tasmania. The terms “viability” and “viable” relate to more than just economic values in this paper since the economics of RERAPS systems are often distorted (for instance by subsidies for grid connection) and the impact of grid connection may be such that other highly prized non-economic values are destroyed. Two hypotheses are tested: (1) RERAPS systems are viable in Tasmania with available technology and at current costs; and (2) significant differences exist between RERAPS systems in Tasmania and those in use on the mainland. To test these hypotheses, four specific aims were developed: (1) to gather data on various aspects of RERAPS and create a database that would provide a snapshot of Tasmanian systems in 1994; (2) to determine what factors influenced the choice of RERAPS; (3) to assess the installation and operating experiences of Tasmanian RERAPS users; and (4) to increase understanding of Tasmanian RERAPS, so that informed decisions could be made by governments, utilities, manufacturers and individuals. A postal questionnaire and four case studies were used to gather technical information about installed systems and user attitudes.

Little previous effort had been devoted to gathering information on domestic RERAPS in Tasmania. Studies by Greenwood (1984), Prendergast (1983), Vivian (1983), and the 1980 Hydro-Electric Commission (HEC) (cited in Vivian 1983) provided some information on wind options, particularly on King Island, but did not give an overall picture of RERAPS opportunities or experiences.

The factors influencing the viability of RERAPS systems in Tasmania cannot be deduced from experiences in other Australian states. One major difference is the extensive nature of Tasmania’s electricity grid, which services 98–99% of domestic dwellings (pers. comm. Bird, HEC 1996), despite Tasmania having Australia’s most decentralised population, with nearly 60% living outside the capital city statistical division (Rogers 1995). However, Tasmania has Australia’s highest fixed charges for the privilege of being connected to the grid; a household with normal tariff plus off peak pays $380 per year before using any electricity (1999 tariffs). Another important difference is that Tasmania has Australia’s largest integrated renewable energy supply, its hydro-electric system, thus there is less ‘moral’ pressure to change to RERAPS for people concerned about fossil fuel use. Climatic and environmental differences are also marked. The intensity and duration of solar radiation exemplifies these differences, with the Tasmanian west coast receiving under 1750 hours of sunlight annually, the lowest in Australia (Rogers 1995). Other differences include sustained winds, with wind speeds of 6-8 m/s average, at 10 m height, in areas of western Tasmania and some off-shore islands (Vivian 1983, Greenwood 1984), and the State’s regular rainfall of 500-3 500mm annually (Rogers 1995). Easy access to firewood supplies and the frequent low temperatures experienced, especially above 300m where no months are frost free (Rogers 1995), are also major differences between Tasmania and the mainland.

METHODOLOGY

The systems of interest in this study were those that were not connected to the electricity grid and did not rely solely on a diesel or petrol generator for electricity. The first task in collecting information was to identify suitable households. No lists of non-grid connected houses were available. The total number of such houses was known to be very low so a random survey would not have been very productive. The most effective contact information came from the State's four suppliers of RERAPS equipment (61 contacts) and suggestions from people with such systems (70 contacts). A total of 136 households were identified and supplied with a questionnaire (mailed out in 1994). Seventy eight completed questionnaires were returned. This compares to the 175 000 occupied buildings in Tasmania with roughly 2000 of these not connected to the grid. It has not been possible to determine what proportion of RERAPS systems were surveyed.

The questionnaire was developed to complement other surveys of renewable energy systems conducted in Australia (i.e. it contained similar questions). In particular, it reflected the SECV/VSEC (1989) survey in Victoria and the Watt and MacGill (1994) NSW survey. The questionnaire was quite substantial, running to 15 pages. Given its size, it was pleasing to receive a 57% return. The questionnaire, presented in full in O'Brien (1996), sought details of the dwelling, occupants' energy requirements, all energy generating, storage and use equipment, estimates of energy use, attitudes to RERAPS, and the households experience with the equipment (reliability, repairs, service).

A number of operating systems and communities were visited in 1996 in order to gain a greater understanding of Tasmanian RERAPS systems through the development of case studies. The systems ranged from very small PV set ups, through slightly larger RERAPS systems utilising PV, wind, micro-hydro, or a combination of energy sources (Figure 1). Two commercial ventures were inspected: Lemonthyme Lodge, with a 52 kW micro-hydro system; and Creek Power also operating a micro-hydro system. Two communities with high RERAPS use were also visited. Lorinna has at least ten household RERAPS systems plus a micro-hydro grid supplying community facilities and households. Trial Harbour operates wind turbines and PV modules and is investigating sewage pumping and a television receiver powered by separate micro-hydro turbines.

RESULTS

A summary of selected results from the survey are provided in Table 1. The large amount of data collected means that only selected information can be presented and discussed in this paper. More detail is provided in O'Brien (1996). The following text provides discussion of some of the findings that are considered particularly interesting.

RERAPS SYSTEMS USED IN TASMANIA

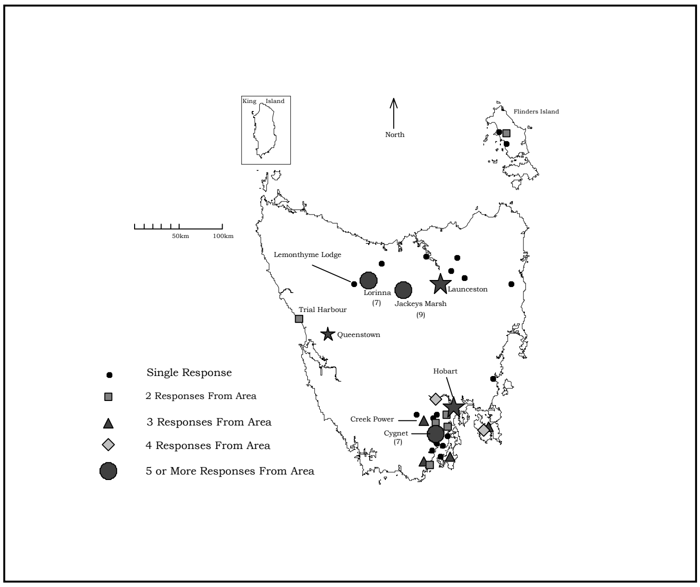

Figure 1
Map showing locations of RERAPS systems surveyed in this study.

Characteristic	**%**
Passive solar design of house	60
Photovoltaics used	82
Micro-hydro used for electricity	27
Wind turbines used for electricity	10
Battery used for electricity storage (2/78 replied no, 4/78 no answer)	92 - 97
Back-up/supplementary diesel/petrol generator	60
Firewood used for space heating	97
Electric space heating (3% electric only, 5% electric plus wood)	8
Gas space heating (all used gas plus wood)	3
Solar hot water (1 solar only, 12/13 solar + wood)	17
Wood for cooking	86
Gas for cooking	49

Table 1 Proportion of households using various energy supply systems (78 questionnaires completed).

One interesting result of the survey was that 59% of respondents considered their systems used only renewable energy when, in fact, only 13% were in this category because of occasional use of fossil fuel generators (FFG) or gas for cooking. Electricity generation was entirely renewable in 47% of systems. Hybrid RERAPS systems were utilised in 68% of cases, while 18% relied solely on PV and 14% used only micro-hydro. PV/petrol (19%) is the most common combination of renewables and generators for electricity generation, with PV/diesel used in 13% of systems.

All wind systems included some PV (50% also operated a FFG), while 33% of micro-hydro systems included PV, (29% utilised a FFG). One system ran a wood-fired steam engine supplied from the user's own woodlot.

Respondents who used a micro-hydro turbine (21 households) operated it with a head of 20m or less in 7 cases, 20 to 100m in 9 cases, and over 100m in 5 cases. Peak turbine output ranged from $50W_{peak}$ to $52kW_{peak}$, with 60% producing under $1kW_{peak}$. The oldest turbine dated from circa 1900, but 14 were bought in the period 1990-4. Where there is access to a reliable stream, micro-hydro systems can operate 240V AC without a battery bank. This was the case for six systems in the sample.

AC only was used in 31% of households, DC only in 21% and a combination of AC and DC in 48%. Of the 45 responses to questions about inverter types, 42% used a stepped wave form, 33% used a sine wave, 20% used a square wave and one system used both stepped and sine wave forms because of equipment requirements.

The questionnaire asked how much grid connection would have cost the household. The average for 50 respondents was $25 362, with a median price of approximately $14 000 and the most common quote $10 000.

The questionnaire also asked for the total initial cost to set up the RERAPS. Based on 69 responses the median cost was $5000. The system cost $10 000 or less in 83% of responses. Of 47 responses that listed both grid connection and RERAPS costs, 19% paid more for their system than the grid quote, 4% spent the same amount and 77% spent less.

OVERVIEW OF TYPICAL TASMANIAN SYSTEM

In an attempt to provide a summary of the 'typical' Tasmanian RERAPS system, a description based on median values from questionnaire answers is presented. The dwelling would be a two-storey owner/builder occupied house, built in 1988, with two bedrooms and a floor area of $107m^2$. It would be 3km from the electricity grid. Three people that had lived there for almost five years would occupy it all year. The age range of the occupants would potentially vary from the very young (a baby) through to the elderly (the sample included an 86 year old woman living by herself).

If PV is used, the array's peak output (three modules) would be 152 W. When purchased in 1991, the PV array would have cost $1600 and no maintenance costs would have been incurred since then. If a wind turbine system is used the unit would be mounted 9m above ground and would produce a rated output of 86W. It would have been acquired in 1989 at a cost of $1300, and $10 would be spent annually on maintenance. If using a micro-hydro unit, it would have cost $2500 in 1992, would use a head of 40m and a flow rate of 5.8L/s to produce $510W_{peak}$. Maintenance would cost $32.50 per year. The fossil fuel generator, if used, would have cost $1300 when purchased in 1989. It would produce 3kVA, be used for two hours per week consuming 95L annually, which would cost $84 and yearly maintenance would cost $27.50. This hypothetical system would use six batteries with a capacity of 450Ah, and would use an inverter and both AC and DC.

The system would use wood for domestic heating. A slow combustion wood-fuelled stove is used for cooking, with bottled gas as a supplementary cooking fuel.

The initial set up cost of the whole system would have been $5000 and the operator would spend $125 on wood, $120 on LPG, and $50 on maintenance each year. Overall, the annual running costs would be approximately $400.

The refrigerator would be used (turned on) all week and would be six years old, while the washing machine would be 6.5 years old and would use 600W. This washing machine would be used for 3.25 hours per week, so it would require less power to operate per week than the refrigerator (2kWh compared to >7kWh). There would be no heat pumps or air conditioners used, roof and wall insulation would be installed and the dwelling would have three lights on during the evening, out of a total of thirteen with a combined wattage of 250W. The household would use entertainment equipment, such as TV, stereo and radio, along with power tools and vacuum cleaners, while dishwashers, food blenders, freezers or electric jugs would not be used.

UNIQUE FEATURES OF TASMANIAN SYSTEMS

A number of differences are evident between Tasmanian RERAPS households and the rest of Tasmania and renewable energy systems in other Australian states. Tasmanian RERAPS households are more likely to use insulation (wall, slab and ceiling) and solar hot water than the rest of Tasmanian households.

Comparisons with Victoria (SECV/VSEC 1989) and NSW (Watt and MacGill 1994) indicate that the typical Tasmanian household with RERAPS spends less on the RERAPS system than does the typical RERAPS using household in other states. This may be due to the small size of many of the systems in the Tasmanian sample. Smaller PV arrays are used in Tasmania (around one quarter the peak output of average NSW PV systems) and smaller battery banks. A significant portion of Tasmanian RERAPS systems use micro-hydro turbines. Also, a square wave inverter is less likely to be used in RERAPS in Tasmania than in NSW.

The quoted grid connection costs are lower in Tasmania than other states, with the majority of Tasmanian cases quoted $15 000 or less, compared to less than 10% of systems in NSW in this range. The use of gas and electricity for refrigeration in the Tasmanian sample is different to the other surveys, with Tasmania's cooler climate reducing the need for extensive use of refrigeration.

ATTITUDES MOTIVATING THE CHOICE OF RERAPS SYSTEMS

The questionnaire sought information about the householders' motivation for choosing RERAPS. Eleven non-economic reasons, including individual and small group control of technology, the desire to be independent and concern for the environment, were rated as a major influence by 80% of respondents. In contrast, the cost of installing the system was rated as a major influence by 69% of respondents.

The 12 most important reasons for selecting RERAPS, in decreasing order of significance averaged across all households, were: isolation of dwelling; less reliance on centralised energy supply; ideal of self-sufficiency; desire to be independent; desire to use renewable energy; cost of connection to grid; cost to install a RERAPS system; lower running cost of a RERAPS system; desire for individual control; concern for the environment; need to provide comfortable conditions; and ability to carry out own maintenance.

No significant differences in terms of attitudes towards economic factors were found between users of various system types, but the small sample size means that only large differences in opinion will show up as statistically significant. Users of RERAPS, excluding micro-hydro users, tended to rate the same attitudes: non-reliance on external energy; less reliance on the centralised energy supply system; the ideal of energy self-sufficiency and the system being understandable to users, as a major influence prior to the purchase of the RERAPS system. The majority of Tasmanian owners of RERAPS, unlike their counterparts in the mainland States, did not consider the danger of overhead power lines to be influential.

The number of owner-built micro-hydro and wind turbines in the sample demonstrated a trend that RERAPS users enjoy hands-on experience and that many possess do-it-yourself values and skills. This is supported by the high rate of power tool usage in these households. There appears to be a common perception amongst these operators that it is possible for individuals or small groups to construct RERAPS systems, and many attempt to build their own system. This trend is also demonstrated by the high percentage of owner-built dwellings. This do-it-yourself mentality, as opposed to reliance on "experts" has been important in the development of a number of small RERAPS businesses.

The overall conclusion on attitudes to RERAPS is that, while economic factors are important, other attitudes, such as self-reliance and sufficiency, the desire to be independent and to use renewable energy are rated as more important by users. There also appears to be a strong preference for hands-on experience, which, with the ability to carry out maintenance, is influential in attempts to build micro-hydro and wind turbines.

EXPERIENCES OF RERAPS SYSTEM USERS

One objective of this study was to assess the experiences of RERAPS users in Tasmania while installing and operating their systems. Awareness of energy self-sufficiency arose primarily through reading, necessity, the users own interest or their general knowledge. Initially, information was usually obtained from friends and literature, with equipment sales people being used less frequently in Tasmania than on the mainland. The majority of RERAPS owners rate the available information as useful and, with effort, understandable to those without technical training. The skills required to install and operate a RERAPS system are considered learnable, though a number of users suggested that the system's installation should be left to an expert. The ability to carry out maintenance was considered extremely valuable.

The impression gained of users' satisfaction with RERAPS is that the majority are reasonably satisfied with their system. It needs to be remembered, however, that more satisfied users may have been more likely to complete the survey so there may be a non-return bias showing up here. Over half of the respondents reported experiencing no problems with their electricity supply system, while nearly 60% considered their system to be safe, convenient, easy to use and a good investment.

An indication of the high satisfaction level was the fact that 99% of respondents would chose RERAPS again. Satisfaction was cited as a perceived benefit by nearly 20% of respondents, while over 20% reported no negative aspects to their attempt to be energy self-sufficient. 'Liking the system' was mentioned almost as often as economic reasons as a reason for choosing RERAPS again. The quality-of-life achieved with RERAPS appears to be a major determinant of satisfaction level to the majority of the sample.

Batteries represent a major expense for RERAPS systems, even though many in this survey use six or less batteries. By using a hybrid system with a number of RERAPS inputs (PV, micro-hydro, wind), most RERAPS systems are able to maintain a steady supply of electricity to the batteries, especially in those cases where micro-hydro and wind are employed in good sites. In this way, the number of batteries is minimised. This may partially explain the larger size of the average battery bank in NSW.

Many users of older systems reported initial problems with the components supplied, problems which discouraged some users. However, these problems appear to have been reduced in recent years, with a number of users recommending specific suppliers and manufacturers. Only one user mentioned high maintenance as a negative aspect of RERAPS. This contrasts with the findings of the other Australian studies that found maintenance among the main problems expected.

CASE STUDIES

Four case studies were used to complement the questionnaire in this research project. Two were small communities where a high proportion of households used RERAPS systems, one was a small industry and one a tourist lodge.

Lorinna is a community of about 100 people on the shores of Lake Cethana. Two thirds of the households use RERAPS including 9 individual micro-hydro turbines plus a mini-grid powered by a community micro-hydro turbine (2kW Pelton wheel). The community grid powers the community hall and one household with other houses to be connected. It will supplement, rather than replace, individual household systems. The Lorinna community also uses PV systems, but no wind as yet. One household had used a fossil fuel generator, but it was no longer used at the time of the survey. Firewood is used by all households. Within the community, good skills in RERAPS have been developed, including two small businesses based on RERAPS.

Trial Harbour, on Tasmanian's west coast, offers an interesting contrast. In this small community of 35 households (including 30 'weekenders') there are seven wind turbines and 12 PV systems. The mean wind speed at nearby Granville Harbour is 6.9m/s at 10m. The community is considering installing their own micro-hydro system to power a small sewage treatment plant and another micro-hydro system to power a TV transponder.

Creek Power is a small business in southern Tasmania that has grown out of the owner's experience of building his own 4kW cross flow turbine. With the experience gained through experiments over about eight years, a small business supplying micro-hydro systems has developed. In 1995-96, ten turbines were constructed and installed, the largest being 6kW.

Lemonthyme Lodge is an ecotourist development in north-west Tasmania, close to popular Cradle Mountain National Park. A 52kW micro-hydro system (if this is small enough to be called 'micro') has been installed using a 208m head and flow of 45L/s. This meets the electricity needs of an 18 bedroom lodge and conference facility, eight self-contained cabins, a workshop and staff accommodation. The electricity is used for lighting, appliances, water heating, cooking and some space heating. Firewood is also used for space heating. Some gas is also used for some cooking and some water heating. One consideration in selecting a renewable energy system was the desire to project an image consistent with the wilderness qualities of the area. The noise and fumes associated with a diesel generator were considered undesirable.

DISCUSSION

It is likely that wind systems were under-represented in the survey because there were few replies from the Bass Straight Islands where wind systems are known to be fairly common (Vivian 1983, Greenwood 1984). Wind is as site-specific as micro-hydro, though to be of benefit to the user it requires optimum conditions such as non-turbulent air flows and a reasonably constant wind resource. Monitoring of wind systems throughout Tasmania and on the outlying islands to determine variation between output, mean wind speeds and maintenance is required, since more information on these systems would enable better informed decisions to be made by potential users.

While the application of micro-hydro systems across Australia is limited, from the results of the study these systems are viable in suitable sites in Tasmania. They are able to provide sufficient power in suitable sites and can be combined with other energy sources to overcome any limitations. It is used for individual power production through to community and commercial-scale generation in Tasmania.

The owner-built and installed micro-hydro systems in the survey demonstrate the potential of transferring the technical skills required to develop indigenous power supplies to developing countries. It may be possible to use the electricity from an initial turbine to power a manufacturing facility producing turbines by local people for use by them.

The use of micro-hydro systems has some potential problems. During the course of this study, the lack of information and knowledge regarding the environmental impact of micro-hydro systems was evident. These impacts will need to be addressed if these systems are to be utilised to their full potential. The impact on various aquatic and riparian ecosystems needs to be quantified, so designs that minimise damage can be developed. If a small-scale sale-to-grid option becomes available, micro-hydro users especially will need to monitor their impacts on an area's ecology, so as to minimise damage and over-exploitation of the available resource.

Wood is used throughout Tasmanian RERAPS systems and is often collected from the user's own property. A number of environmental considerations arise from the use of fuelwood, including the depletion of the available resource and the potential loss of species habitat. A number of owners have planted woodlots for their future wood supply, while others have relied on salvaged wood. Air quality problems are unlikely to become a problem for isolated households, unlike those in urban areas. Creosote contamination of water supplies could, however, be a problem (Todd 1989).

Community power generation is being developed and used in areas with relatively abundant supplies of renewable energy in Tasmania, by small settlements for domestic and community power supply. This is demonstrated in the case studies of Lorinna and Trial Harbour. The use of RERAPS allows a community to take a flexible approach with individual power supply, a community grid, the provision of power to the community's facilities, or a mix of these, all possible options. It also enables the spread of energy production skills to individuals and communities, instead of concentrating them within institutions and utilities.

The use of RERAPS for tourist development is viable in Tasmania at suitable sites. This provides an interesting addition to ecotourism developments, with potential for increasing promotion of this rapidly growing sector of the tourism market. The Lemonthyme Lodge case study demonstrates what is possible in Tasmania for tourist developments and provides an example of a viable commercial-scale RERAPS.

Promotion of RERAPS in Tasmania by utilities and governments might help local and national manufacturers develop a competitive industry, with the potential to develop or expand export markets, especially in the Asia/Pacific region. Research into the impact of incentive and assistance schemes on the systems used and the experiences of their users could provide information that enables the targeting of these schemes to increase the rate of adoption of renewable forms of energy.

CONCLUSION

The overriding conclusion of this study is that Tasmanian RERAPS systems, if properly installed, are viable using currently available technology and at today's costs. They are especially so when factors other than economics are considered, as reflected in the satisfaction levels of respondents, their opinions of the system, and whether they would chose RERAPS systems again. In other words, if a household wishes to use renewable energy without grid connection they can do so at reasonable cost and without abandoning all the trimmings of modern society (electric lighting, TV, washing machine, computer, power tools, etc.). However, life-style and selection of electric equipment will need to accommodate the modest electrical supply from RERAPS systems, micro-hydro systems being the exception able to meet high electricity demands.

RERAPS systems are viable in a wide range of situations and are able to cater to mainstream tourists, the elderly, the very young, full time and weekend residents, and computer and office systems. The use of these systems has also led to the development of small businesses, while increasing individual and community skill levels.

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