Cook Islands

Feasibility of Solar Pumps for Mauke Water Supply

By
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Document Purpose

This document contains a brief feasibility analysis of using solar pumps in a water supply project on Mauke Island.

Description
Feasibility Analysis

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1.0 Introduction

The Director of Waterworks Cook Islands Mr Ben Parakoti requested PIEPSAP in October 2005 to assist in analysing the feasibility of using solar pumps to replace diesel pumps in the Mauke water supply system. Water Works currently plans a general rehabilitation of the scheme which will be funded by NZaid. In line with the ongoing co-operation with the Government of the Cook Islands under the PIEPSAP project it was agreed that PIEPSAP would:

- Size the Pumps and the Solar arrays
- Compare available technology
- Request quotes from hard ware suppliers
- Perform an economic analysis of the project
- Recommend a supplier
- Assist in commissioning the units and
- Assist in operator training.

2.0 Background

Economic vulnerability is significant in Cook Island’s energy sector. Cook Islands currently require approximately 25 million litres per year of liquid fuels for land, sea and air transport, electricity generation, water pumping, agricultural production and household use. In the absence of development of local energy resources, imported fuel is the lifeblood of the economy and the society.

In the year 2005 the world has experienced a period of price volatility for petroleum that saw petroleum prices increase from US$ 40/bbl in mid March to US$ 70/bbl in September. More than ever, fuel imports are a major component of the country’s import bill. At the same time affordable, stable and secure sources of energy are vital for Cook Islands future economic growth and prosperity and it is Government policy to reduce the country’s vulnerability through the development of renewable energies and energy conservation. Current supply cost to outer islands are in the order of NZ$ 2.5 - 3 per litre of diesel.
3.0 Pumping Requirements

As per design of the Mauke water scheme average demand will be 60 m$^3$ per day. The water will be pumped into 2 storage tanks with a total capacity of 180 m$^3$ equivalent of 3 days consumption. Distance between the wells and the storage tanks is approx 120 meters.

Total energy required to pump is 2.5 KWh per day. As the volume will be pumped from 5 different wells, each pumping unit should be able to deliver 0.5 KWh per day. This is a power range where standardized solar pumping units are available. Windmills of the type that were used for water pumping prior to the 1970s could also pump the required volume. This technology, however, suffered damage from cyclones and is therefore no longer used in the Cook Islands. Realistic alternatives are therefore diesel or solar pumps. Using new, efficient diesel pumps would result in a daily fuel consumption of approx 5 – 6 litres. In the past diesel consumption was in the order of 20 liters per day, but this was due to heavy losses of water and the poor state of repair of the old diesel units. The advantage of using diesel is that pumping can be flexibly adjusted to demand – provided that diesel fuel is always readily available. Solar pumps have little flexibility and the storage capacity only equals 3 days consumption.

4.0 Solar Resources Cook Islands

There are two seasons on this island with a hot and relatively humid period from November to April and a warm, relatively dry period from May to October. The island has experienced cyclones in the past and is also affected by the El Niño and La Niña cycles. El Niño episodes cause drought periods, while higher than normal rainfall is associated with the La Niña periods.

The Meteorological Office collects global solar radiation data, on a horizontal surface near the Rarotonga Airport. Data are adequate for sizing of solar systems. The Pacific Islands Forum Secretariat also measured horizontal, global solar radiation for two years (1995-1996) under the Southern Pacific Wind and Solar Monitoring Project. Results are depicted in the graph below.
All radiation measurements in the Cook Islands record radiation on horizontal surfaces. Because the sun’s position in the northern sky is on average lower in the northern sky than directly overhead, tilting a solar collector by approx 20 degrees toward the north increases the energy collected and also reduces the amount of seasonal change in radiation. When the measurements are corrected to the latitude angle for a tilted collector, the average rises to over 5.5 kWh/m² per day. This is consistent with experience made with solar equipment installed by Telecom. Telecom also reports high reliability and availability of their installations that are serviced by well-trained staff.

For the purpose of sizing the solar pumps it is assumed that average radiation in the order of 5 kWh/m² per day. Further it is assumed that overall system efficiency is 35 %. i.e. 65 of the solar energy produced by the panels is lost in pumping and in pipe losses. Panel output required is therefore 1.4 KWh per unit. At 5 kWh/m² per day this translates into a panel peak output of minimum 280 Watts. This output should be increased by approx 20 % to make allowances for cloudy periods.

The 3 day storage facility would compensate for short term short falls in solar radiation, during sustained cloudy periods, however, there is a risks of supply interruptions. Sustained cloudy periods, on the other hand, would be associated with rainfall, i.e. rainwater catchment, which is also part of Mauke’s overall water supply, would mitigate such an event. If security of supply from the pump schemes needs to be maintained at all times it would be advisable to increase storage capacity to a 4-5 day demand.
5.0 Call for Quotes

In order to test the market three reputable suppliers of solar equipment have been asked to provide quotes for 5 solar pumps. These suppliers have implemented projects in Pacific Island countries, are familiar with the conditions and are from our experience responsive to the needs of clients in the region.

The suppliers are listed below:

1) Reidtechnology NZ
   Travis Burr
   Telephone 09-489 8100
   Fax 09-448 1631
   Mobile 0275 363 300
   travis.burr@reidtechnology.co.nz
   www.reidtechnology.co.nz

2) Pacific Energy/Total
   Alexander Abbass
   Sales Manager
   PB 7306 Ducos
   98801 Noumea
   New Caledonia
   a.abbass@canl.nc

3) Solar Sales Pty Ltd
   Durmus Yildiz
   2-10 Kewdale Rd
   Welshpool, WA, 6106
   Australia
   T: +61 (08) 9258 8244
   F: +61 (08) 9258 6700
   M: 0407 755 671
   E: durmus.yildiz@solarsales.com.au
   www.solarsales.com.au

All suppliers quoted for 5 units seaworthy packaged. The quote of Solar sales does not include sea freight cost to Rarotonga. Reid quoted in NZ $, Solar Sales in Australian $ and Pacific Energy in US$. In order to compare prices, the quotes have been converted into NZ$ at the exchange rates on 2 November 05.

The table below summarizes the quotes and the prices.
### Comparison of Quotes in NZ$

<table>
<thead>
<tr>
<th>Company</th>
<th>Pump Type</th>
<th>Flow @ 15m head</th>
<th>PV Output proposed</th>
<th>Unit Cost CIF Raro</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reid Technology</td>
<td>Lorentz, Helical Rotor HR 14 PS 200</td>
<td>2.1 m3/h</td>
<td>Sharp 360 Watts</td>
<td>6062</td>
</tr>
<tr>
<td>Pacific Energy</td>
<td>TSP Progressing cavity 6-50</td>
<td>2.2 m3/h</td>
<td>Total 300 Watts</td>
<td>11680</td>
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<tr>
<td>Solar Sales</td>
<td>Lorentz, Helical Rotor HR 14 PS 200</td>
<td>2.1 m3/h</td>
<td>Sunpower 270 Watts</td>
<td>3854</td>
</tr>
</tbody>
</table>

Exchange Rates 2 Nov. 05: 1 Aus $ = 1.07 NZ$ 1 US$ = 1.46 NZ$

The three quotations are not fully comparable as there are different scopes of supply involved. Pacific Energy and Solar Sales did not include racks. Solar Sales did not include freight. Also there is a significant difference in solar power offered. Reid Technology offers 33 % more solar power output then Solar Sales although both suppliers propose the same pump. Making adjustments for freight, racks and output, the Reid Technology proposal appears to be the most attractive.

The additional power output of the panels proposed will result in a higher pumping rate and can therefore be considered as an additional safety margin. The estimated average volume supplied on 360 Watt PV output per pump is 13 m3. The Pacific Energy quote is financially out of range as the unit price is double of the Reid Technology proposal without offering superior technology. In the economic analysis presented below, the figures quoted by Reid Technology will be used.

### 6.0 Economic Analysis

In the following analysis long run levelized water pumping cost are compared for the two technology alternatives solar and diesel. Long run levelized cost are expressed as the net present value (NPV) of all cost over an assumed 20 years lifetime divided by the NPV of water pumped.

Cost for the diesel pumps is assumed to be NZ$ 2400 per unit, installation cost for solar and diesel technologies are assumed to be NZ$ 8000 and NZ$ 4000 respectively. Diesel consumption is assumed to be 5 litres per day a figure that is achievable by using new, efficient diesel pumps.
For diesel, it is assumed that O&M cost including engine oil change; fuel and oil filters etc are 8 % p.a. of the initial investment. For solar which is less maintenance intensive 2 % have been assumed. It is further assumed that both diesel and solar units be replaced after 10 years. This is a conservative assumption as for solar most probably only the pumping units would have to be replaced. The solar panels should last the full 20 years lifecycle.

The solar project shows a good performance in comparison with the diesel unit under the assumption that diesel supply cost to Mauke are NZ$ 2.5 per litre. Pumping cost using solar are NZ$ 0.23 per m3 as opposed to NZ$ 0.32 for the diesel alternative.

At an assumed discount rate of 10 % the net benefits of solar savings equal an economic rate of return of 31.5 %, i.e. the solar project is quite robust in economic terms. Average diesel supply cost have to drop to NZ$ 1.24 per litre to equalize cost of solar and diesel at a 10 % discount rate. This does not seem to be a realistic scenario over the next 20 years. It is therefore recommended to use solar pumps.

There are other benefits of using solar that have not been accounted for in monetary terms. These include environmental benefits as discussed below and an increased in supply security as the island’s water supply would no longer depend on a regular supply of diesel.

Table: Base Case Scenario Solar versus Diesel

<table>
<thead>
<tr>
<th>Year</th>
<th>Water Supplied 000 m3</th>
<th>COST (NZ$) Solar</th>
<th>COST (NZ$) Diesel</th>
<th>Benefits</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>INVEST. O&amp;M Total Cost</td>
<td>INVEST. O&amp;M Fuel Total Cost</td>
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<td></td>
</tr>
<tr>
<td>0</td>
<td>30,310.00 30,310.00</td>
<td>16,000.00 16,000.00</td>
<td>(14,310)</td>
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<tr>
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<td>(14,310)</td>
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<tr>
<td>2</td>
<td>22,539 666 666</td>
<td>960 4,563 5,523</td>
<td>4,856</td>
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<td>3</td>
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<td>4,856</td>
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<td>4</td>
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<td>17,523 (16,454)</td>
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<td>22,539 666 666</td>
<td>960 4,563 5,523</td>
<td>4,856</td>
<td></td>
</tr>
</tbody>
</table>

Discount rate | 10.0% |
Cost Solar NZ$ | 43,324 |
NP Water NZ$ | 191,885 |
Water Cost NZ$/m3 | 0.226 |

Cost Diesel NZ$ | 61,111 |
NP Water NZ$ | 191,885 |
Water Cost NZ$/m3 | 0.316 |

EIRR | 31.5% |

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7.0 Environmental Considerations

Tony Falkland\textsuperscript{1} reports pollution from oil and diesel as a problem in the area surrounding the pump bases. This is inevitably caused by small spills at regular intervals. There was an instance in 2003 when oil/diesel was washed down borehole No 2 following draining of the gearbox and subsequent washing of the pump base. The water supply was temporarily contaminated and there were complaints from consumers about oil in the supplied water.

Beyond these events handling and storage of diesel fuel poses an environmental risk for a small island environment. The main environmental problem with diesel use is related to fuel and waste oil handling and disposal. Any spills of either fuel or waste oil are a direct threat to the freshwater lenses that support life on the island. There is also the hazard of fuel fires in the storage areas with possibly catastrophic consequences.

It should be noted that the operation of small, diesel powered pumps is a safe and environmentally sound way of supplying electricity and water to a rural village as long as certain procedures and standards are maintained. Numerous remote area water and power supply systems around the world are being powered by diesel motors of all sizes and experience has shown that environmental risks can be managed without jeopardizing the economics of the energy supply. Unfortunately, however, there are also a large number of examples - many of them in the South Pacific - where unsafe fuel handling, inadequate disposal of waste oils, noise pollution and air borne emissions from diesel motors pose environmental threats and sometimes serious hazards.

PV based water pumping would eliminate most of the environmental problems related to the use of fossil fuels.

8.0 Recommendations

It is recommended to procure 5 solar pumps according to the proposal of Reid Technology, New Zealand. The supplier should supervise installation and perform operator training during installation. It is also recommended to procure a spare part package.

\textsuperscript{1} Tony Falkland Ecowise Environmental, for GHD Pty Ltd, April 2004