# Mauke Power Sector Feasibility Report 2004

*Prepared as part of the UNDP/UNESCO Technical Assistance Project "Increase the Utilisation of Renewable Energy Technologies in the Cook Islands Energy Supply"*

## Foreword

The consultants would like to thank the many people who provided information for this report, participated in the energy survey and assisted in carrying out the energy survey. These include the Director and staff of the Energy Division who assisted in the many aspects of the field visits and data collection as well as advising on cultural and traditional protocols, the respective Island Councils, Mayors, Island Secretaries, Administrations and Aronga Mana for their kind assistance and hospitality, Government Ministries and Departments which provided assistance and the people of Atiu, Mauke and Mitiaro for their warmness and generosity whilst visiting their communities. However, the contents are the responsibility of the undersigned and do not necessarily represent the views of the Government of the Cook Islands (national as well as local), UNESCO, UNDP, nor the many individuals who kindly provided information on which the study is based.

Bruce Clay

Herb Wade

October 2004

| | |
|---|---|
| **A** | Amp |
| **a.g.l.** | Above ground level |
| **a.s.l.** | Above sea level |
| **AAGR** | Average Annual Growth Rate |
| **ABC** | Arial Bundled Cable |
| **AC** | Alternating Current |
| **ACP** | African Caribbean Pacific Countries |
| **ADB** | Asian Development Bank |
| **Al** | Aluminium |
| **CEO** | Chief Executive Officer |
| **COE** | Cost of Energy |
| **DSM** | Demand Side Management |
| **EEZ** | Exclusive Economic Zone |
| **Eff** | Efficiency |
| **EIA** | Environmental Impact Assessment |
| **ENSO** | El Niño/El Niña oceanic climate cycle |
| **EU** | European Union |
| **FED** | Forum for Energy and Development |
| **GEF** | Global Environment Facility |
| **GDP** | Gross Domestic Product |
| **GoCI** | Government of the Cook Islands |
| **Ha** | Hectare |
| **hr** | Hour |
| **HV** | High Voltage |
| **Hyab** | Hydraulic hoist truck |
| **Hz** | Hertz |
| **IA** | Island Administration |
| **IRR** | Internal Rate of Return |
| **JCB** | Loader/backhoe tractor |
| **kg** | Kilogram |
| **kM** | Kilometre |
| **$km^2$** | Square kilometre |
| **kV** | Kilo Volts |
| **kVA** | Kilo Volt Amps |
| **kVAr** | Kilo Volt Amps Reactive |
| **kW** | Kilowatt |
| **kWh** | Kilowatt Hour |
| **kWp** | Kilo Watt Peak |
| **LPG** | Liquid Petroleum Gas |
| **lt** | Litre |
| **LV** | Low Voltage |
| **m** | Metre |
| **m/s** | Metres per second |
| **$m^3$** | Cubic Meter |
| **MFEM** | Ministry of Finance and Economic Management |
| **MIA** | Mauke Island Administration |
| **MIC** | Mauke Island Council |

| | |
|---|---|
| **min** | Minute |
| **mm** | Millimetres |
| **MPS** | Mauke Power Supply |
| **MWh** | Mega Watt Hour |
| **NEP** | National Energy Policy |
| **NPV** | Net Present Value |
| **OMIA** | Office of the Minister of Island Administrations |
| **PACER** | Pacific Agreement on Close Economic Relations |
| **PEIA** | Preliminary Environmental Impact Assessment |
| **PIC** | Pacific Island Countries |
| **PICTA** | Pacific Islands Trade Agreement |
| **PIEPP** | Pacific Islands Energy Policy and Plan |
| **PREFACE** | Rural Renewable Energy France-Australia Common Endeavour (SPC) |
| **PV** | Photovoltaic |
| **qty** | Quantity |
| **RE** | Renewable energy |
| **RET** | Renewable energy technologies |
| **SEC** | Sustainable Energy Committee |
| **SFC** | Specific Fuel Consumption |
| **SHS** | Solar Home System |
| **SHW** | Solar Hot Water |
| **SOC** | Specific Oil Consumption |
| **Sq km** | Square kilometre |
| **SPREP** | Secretariat of the Pacific Regional Environment Programme |
| **TA** | Technical Assistance |
| **TAU** | Te Aponga Uira O Tumu-Te-Varovaro |
| **$t_{C02}$** | tonnes of $CO^2$ |
| **THD** | Total Harmonic Distortion |
| **TOR** | Terms of Reference |
| **UNCCD** | United Nations Convention to Combat Desertification |
| **UNCED** | United Nations Convention of Biological Diversity |
| **UNDP** | United Nations Development Programme |
| **UNESCO** | United Nations Educational, Scientific and Cultural Organisation |
| **UNFCCC** | United Nations Framework Convention on Climate Change |
| **V** | Volt |
| **W** | Watt |
| **WTG** | Wind Turbine Generator |

$ = NZ$ unless stated otherwise

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# 1 SUMMARY OF FINDINGS AND RECOMMENDATIONS

This report has investigated the current power system on Mauke and the local renewable energy (RE) options available to supplement in the short to medium term and replace in the long term the current diesel generation.

In the short term refurbishment of the present diesel based system is required to ensure provision of reliable supply and minimise environmental degradation through fuel handling practises. Staff training and service equipment should be provided. Initiation of a wind monitoring programme will substantiate the available wind resource whilst investigations into the biomass will evaluate medium to long term potential.

Grid connected wind power is the recommended local renewable energy option in the short to medium term. Up to 20kW of grid connected wind power generation can be installed and operated under the current Mauke Power Supply (MPS) situation and would provide approximately 12% of Mauke's electricity requirements. With 40 to 50% capital cost subsidy through donor agencies the wind generated power is financially viable and will substitute over 6,000lt of fuel annually. Wind power meets the Government of the Cook Islands (GoCI) National Energy Policy (NEP) 2003 criteria of being technically and commercially proven and environmentally friendly but is presently only financially viable with some form of capital subsidy.

Biomass and battery hybrid systems offer the most long term potential to eliminate the reliance on diesel fuel. Whilst presently not financially feasibly based on full capital costs, grant funding of 50% and fuel price increases of 20% would have hybrid systems on a even cost of generation basis with diesel based systems.

Table 1-1 summarises the major findings and recommended interventions which form the basis of an overall power sector plan for Mauke Power Supply.

**Table 1-1 Summary of Findings and Recommendations**

| | Findings | Short Term | Medium Term | Long Term |
|---|---|---|---|---|
| Power Station | Installed capacity marginal<br>Building in need of upgrade | New 60kW generator<br>Building upgrade | Phasing out of two generators as renewable energy input increases | Possible conversion or replacement of gensets to suit biofuel |
| Fuel Handling | Lack of spill containment<br>Handling procedures lacking in areas | Upgrade handling facilities<br>Instruct staff on correct procedures | Maintain handling procedures | Introduction of biofuel storage and handling facilities |

| | Findings | Short Term | Medium Term | Long Term |
|---|---|---|---|---|
| Distribution | HV reticulation in reasonable condition<br>New transformer and LV feeder required<br>Areas of LV in need of replacement<br>No transformer maintenance | LV distribution upgrade incl. New 50kVA transformer<br>Consumer metering refurbishment<br>Transforming servicing | Ongoing maintenance and upgrading | Ongoing maintenance and upgrading |
| Administration and Personnel | Computerised billing system upgrade<br>Staff training required<br>Workplace safety lacking<br>Only part time manning of power station | Implement new billing system.<br>Implement staff training programme<br>Improve workplace safety<br>Increase power station manning<br>Instruction in renewable energy system operation and maintenance | Maintain correct staffing levels and human resource development to suit increased renewable energy capacity | Maintain correct staffing levels and human resource development to suit increased renewable energy capacity |
| Demand Side Management | Significant use of incandescent lighting and electric cooking appliances.<br>Limited use of solar hot water systems(SHS) | Promote energy efficiency and alternate cooking fuels<br>Investigate means of encouraging use of fluorescent lighting<br>Encourage use of SHS for new developments | Continued development of energy efficiency initiatives and load management.<br>Continued promotion of SHS | Continued development of energy efficiency initiatives and load management<br>Continued promotion of SHS and new energy saving technologies |
| Power Quality | Acceptable | Monitor parameters | Continued monitoring and maintenance of power quality | Continued monitoring and maintenance of power quality |
| Tariff | Full Cost Recovery Tariff - $1.19/kWh | Discussions with stakeholders on revision of tariff structure | Aim towards consumer tariff structure reflecting full cost recovery | Tariff structure to reflect full cost recovery |
| Local Renewable Energy Resource | Wind, solar and biomass offer most potential in line with National Energy Policy (NEP) | On-site wind monitoring<br>Commence evaluation of biomass potential and financial viability | Installation of grid connected 20kW wind turbine<br>Possible battery hybrid or biofuel implementation to increase renewable energy input | Displace all diesel fuel with renewable energy technologies |
| Load Growth | Several smaller eco-resort developments<br>Water pumping upgrade required | Encourage energy efficiency for new developments.<br>Consider use of renewable energy for water pumping<br>Repair of wind powered water pumps where financially feasible | Monitoring of load growth and capacity planning | Monitoring of load growth and capacity planning |

The Asian Development Bank (ADB) Cook Islands Power Development Study from 1998 carried out an extensive evaluation of outer island power supplies and provides a baseline for comparison to current systems. Key statistics and there comparison to the current situation is shown in Table1-2. Of particular importance is the increase in current landed fuel price of 63% and full cost recovery tariff of 56% over the 1998 figures whilst the billed tariff has effectively remained unchanged except for the domestic tariff that is not charged the $5/month service charge. In approximate figures this amounts to an effective increase in Government subsidy of more than $100,000 p.a. Future tariff structures will need to reflect true cost of energy delivery and the social cost the Government of the Cook Islands (GoCI) applies to the outer islands.

Whilst population has decreased approximately 32% power consumption has increased 24%. On a per capita basis consumption has increase by close to 69% indicating a greater reliance on electricity. Increased hours of supply from 19 to 24 hours would account for a portion of this increase although the amount is difficult to enumerate.

**Table 1-2 Comparison of 1998 ADB Study of Atiu and current study**

| | Unit | 1998 ADB Study | June 2004 | % Change |
|---|---|---|---|---|
| Fuel Price Rarotonga Wharf | $/litre | $0.458 | $0.899 | +96 |
| Fuel Price Landed | $/litre | $0.658 | $1.069 | +63 |
| Full Cost Recovery Tariff | $/kWh | $0.765 | $1.19 | +56 |
| Domestic Tariff | $/kWh | $0.36 + $5/month | $0.36 | ~0 |
| Commercial Tariff | $/kWh | $0.58 + $5/month | $0.58 + $5/month | 0 |
| Population[1] | No. | 639 (1991) | 470 (2001) | -32 |
| Installed Capacity | kW | 144 | 168 | +17 |
| Maximum Demand | kW | 80 | 78 (80)[2] | -2(0)[2] |
| Supply Hours | Hours | 19 | 24 | +26 |
| Households with refrigeration | % | 72 | 93 | +21 |
| Households with Electric Jug | % | 70 | 90 | +20 |
| Households with Video | % | 9 | 23 | +14 |
| Power Supply staff number | No. | 4 | 4 | 0 |
| Commercial Customers | No. | 31 | 25 | -19 |
| Domestic Customers | No. | 153 | 156 | +2 |
| Billed kWh p.a. | kWh | 181,382 | 225,403 | +24 |
| Specific Fuel Consumption | kWh/litre | 2.73 | 2.18 | -20 |
| Projected/Actual generation for 2004[3] | kWh | 263,675 | 254,548 | -3 |
| Projected/Actual peak load 2004[3] | kW | 101 | 80[4] | -21 |
| Proposed LV distribution reconstruction | $ | US$53,000 | NZ$196,825 | |

1. Census figures
2. Peak load recorded during field visit (peak load from station log)
3. 1998 ADB Study projected figures for 2004
4. Peak load from station log

# 2 INTRODUCTION

## 2.1 Project Background and Objectives

The goal of the Government of the Cook Islands (GoCI) for renewable energy, as stated in its National Energy Policy (2003), is to increase the utilisation of renewable energy technologies in the Cook Islands energy supply.

UNDP (Samoa) funded a Technical Assistance (TA) project to further this goal for renewable energy covering the islands of Atiu, Mauke, Mitiaro and Pukapuka. The project was executed by UNESCO (Apia) in cooperation with the Energy Division, Ministry of Works, GoCI.

The project has the following specific objectives with regard to the islands of Atiu, Mauke, and Mitiaro:

(a) To determine in detail what improvements, in the *short term,* should be undertaken in the current diesel based power systems.

(b) To determine in detail the technical, socio-cultural, economic, financial and institutional/management feasibility, in the *medium term,* of supplementing the current diesel systems with renewable energy sources.

(c) To determine in detail the technical, socio-cultural, economic, financial and institutional/management feasibility, in the *long term,* of replacing 100% of the current diesel based power systems with renewable energy sources.

With regard to the island of Pukapuka the specific project objective is:

(a) To preliminary assess and recommend if the most optimal power solution is to improve the existing PV Solar Home Systems (SHS) or to install (in addition) an AC power system based on diesel generators.

For detailed Terms of Reference (TOR) please refer to Annex A.

## 2.2 Methodology

Project execution for the three Southern Group islands was undertaken in the following four stages.

**Stage 1: Inception Note/Project Preparation**[1]

- Review of relevant background material, studies and investigations already undertaken.
- Identify key stakeholders.
- Preparation of inception note.
- Develop field visit schedule in consultation with stakeholders.

**Stage 2: Field Visit**

Visit to Rarotonga involving:

- Discussions with the Ministry of Works, Energy Division, on existing power system experience and issues pertaining to possible project recommendations.
- Following up Stage 1 information gathering with relevant Government Departments, organisations and project stakeholders.

Visits to the 3 Southern Group Islands involving:

- Meeting with stakeholders including Island Councils and community groups to discuss and survey qualitatively the socio-economics of the particular island communities and how these impact power supply services.
- Compile a listing of existing power generation and control equipment, grid composition and their operating status.
- Gather available power system data for existing diesel power systems. Specifically looking at operational regime information, power production, daily load structure and its variability, and fuel consumption.
- Log power data using a power quality analysis. Data logged includes phase voltages and currents, active and reactive power and energy and power factor. Collected data will be used in substantiating/correlating existing data.
- Where current survey data is not available a limited household energy audit and appliance use survey will be carried out and other non-domestic loads identified and inventoried.
- Investigation of potential local energy resources and their technical feasibility.
- Assessment of relevant physical and institutional conditions that may impact power generation development.
- Gathering of information for a preliminary Environmental Impact Assessment (EIA).

**Stage 3: Preliminary Analysis/Debriefing Note**[2]

- Preparation of debriefing note providing recommendations and conclusions based on preliminary analysis and findings. This note maps the path of the projects analysis and report generation.
- Meet with the Director of Energy, Mata Nooroa, to discuss the debriefing note, its conclusions and recommendations and matters pertaining to the project outputs, including their consistency with the National Energy Policy (2003).
- Presentation, where possible within time constraints and availability, of the debriefing note to the Minister of Energy & Finance.

[1] See Annex C for complete Inception Note

[2] See Annex F for complete Debriefing Note

**Stage 4: Detailed Analysis/Report Preparation and Recommendation Paper**

- Description of project background and immediate objectives
- Socio-economic consequence description based on field qualitative survey and where available existing survey data. This brief description will cover areas including but not limited to: demographics, geography, employment, public services, economic potentials, beneficiaries willingness and ability to pay for services, per capita income and in general the relationship of socio-economics in the context of power services.
- Power Sector description based on gathered data describing the various roles on a national and local community level of relevant public authorities, institutional and legal frameworks in place for the power sector, standards, ownership, Government policies, plans, budgets and objectives.
- Examination, description and assessment of potential trends in electricity tariff and demand based on gathered information including the Cook Islands National Energy Policy (2003) and its influence on the feasibility of introducing renewable energy technologies.
- Analysis of existing power and load structure data in association with field recorded power analysis logged data.
- Based on field visits and collected data relating to existing power generation short term options will be examined to improve efficiencies in diesel generation and distribution. Such options may include supply side, distribution and demand side management options.
- Local energy resource preliminary assessment will be based on available resource data and field visits.
- Assessment of project engineering for the each of the three island's power systems when considering short, medium and long term options.
- The consultants will investigate organisational requirements for power plant construction/upgrade, operation and maintenance.
- Training and technical assistance programmes will be outlined. These will include training programme target groups, content and delivery.
- A preliminary Environmental Impact Assessment of the short, medium and long term power supply options will be carried out. The assessment will be based on Asian Development Bank Environmental Guidelines for Selected Industrial and Power Development Projects (1993).
- Preparation of capital and operational budgets. Based on budgets and cash flows, an economic and financial analysis (including sensitivity analysis) will be performed on the various options.
- Develop a power sector plan encompassing the synthesis of project recommendations and power supply options feasibilities consistent with the Cook Islands National Energy Policy.

Several previous studies and reports are particularly relevant to this project and were relied on among others for information regarding power sector, institutional structure, background to power systems on each of the islands, renewable energy resource data and EIA guidelines. These include but were not limited to:

- Cook Islands National Energy Policy 2003;
- Environment Act 2003;
- Environment Service Environmental Significance Declaration;
- 2001 Census;

- Budget Policy Statement 2004-2005;
- Outer Island Budget Outputs 2004-2005;
- GEF/ UNDP Pacific Islands Renewable Energy Project (PIREP) Draft Cook Islands National Report May 2004;
- ADB Cook Islands Power Development Study 1998;
- ADB EIA Guidelines for Power Projects 1993; and
- Mauke Strategic Plan 2000-2008.

For a detailed list of all the documentary sources consulted please refer to Annex D.

Field visits to each of the Southern Islands of Mauke, Mitiaro and Atiu were a key to undertake the activities as specified for the consultancy. These trips involved logging of power generation data, undertaking of energy surveys, consultation with Island Councils, power system administration, consumers, and the general gathering of information.

Whilst in Rarotonga, consultations were held with other project stakeholders including the Energy Division, Environment Services, Office of the Minister of Island Administration (OMIA), Te Aponga Uira O Tumu-Te-Varovaro (TAU) and the Tourism Corporation.

Of particular relevance for Atiu was the meeting with the CEO, Apii Timoti, of TAU to discuss the Cabinet Memorandum instructing TAU to assume responsibility for operations of Atiu Power Supply.

Please refer to Annex B for a full list of stakeholders and interested parties consulted.

The field visits were structured as two missions;

**Mission 1:** 26th June – 9th July. Rarotonga, Mauke and Mitiaro

**Mission 2:** 17th July – 30th July. Atiu and Rarotonga and delivering debriefing note.

## 2.3 National Background Information

### 2.3.1 Physical Description & Population[3]

**Map 2-1 – Cook Islands**


Source – CIA Factbook 2004

The Cook Islands, as shown in Map 2-1, consists of fifteen small islands with a total land area of only 240 square kilometres ($km^2$) located between latitudes 9º-22º South and longitudes 157º-166º West, about half way between Hawaii and New Zealand. Over 88% of the land is concentrated in the southern group of eight mostly elevated, fertile, islands where 90% of the populace lives. The northern Cook Islands are low-lying, sparsely populated, coral atolls. There are 120 km of total coastline. Arable land comprises 17% of the total and 13% is under permanent crops. The Exclusive Economic Zone (EEZ) is 1.8 million $km^2$.

The total population of the Cook Islands, as enumerated on 1 December 2001, was 18,027 including 3010 visitors, a 5.6% decline since the 1996 Census. Rarotonga, with 12,188 people, grew by 8.6% since 1996, the other Southern Group islands (4,013 people) declined by 26.0%, and the Northern Group (1,826 people) dropped by 25.6%. Although Rarotonga's total population has grown, the resident population – i.e. those usually resident on the island – decreased by 17% since the 1996 Census, largely due to out migration to New Zealand since Cook Island citizens have free access to New Zealand and through New Zealand on to Australia. Overall growth is due to an increase in tourists and short-term foreign workers. Current estimated population is 21,200 showing an increase over the 2001 Census figure of 18,027.

Table 2-1 summarises key physical characteristics and population by island. The capital, Avarua, is located on Rarotonga, the country's largest and highest island. All islands are inhabited except Manuae and Takutea although Suwarrow has only a caretaker living on the island.

[3] The GEF/UNDP Pacific Islands Renewable Energy Project (PIREP) Draft Cook Islands National Report, May 2004 was used extensively for National background information

**Table 2-1 – Key Features by Island**

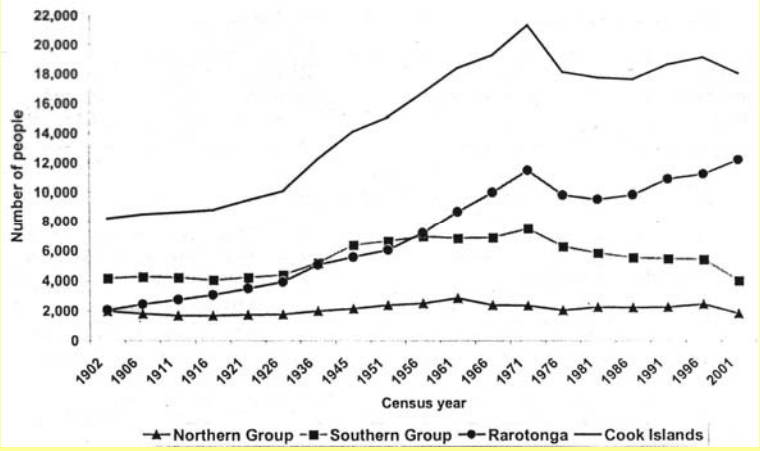
| Island | Island Type | Area Sq Km | Maximum Elevation (meters) | Population (Dec 2001) | Principal Habitat |
|---|---|---|---|---|---|
| **Southern** | | | | | |
| Rarotonga | High Volcanic | 67.1 | 652 | 12,188 | Strand vegetation, extensively modified coastal forest & wetlands, fern lands, cloud forest, inland forest |
| Aitutaki | Volcanic & Coral | 18.3 | 124 | 1,946 | Strand vegetation, lowland forest greatly modified by agriculture, salt marsh wetlands |
| Atiu | Raised Coral | 26.9 | 72 | 623 | Makatea forest, wetlands greatly modified by agriculture, freshwater lake, fern lands |
| Mangaia | Raised Coral | 51.8 | 169 | 744 | Makatea forest, wetlands modified by agriculture, fern lands, cloud forest, inland forest, freshwater lake |
| Manuae | Atoll | 6.2 | 10 | 0 | Strand vegetation; significant seabird nesting sites |
| Mauke | Raised Coral | 18.4 | 29 | 470 | Makatea forest, wetlands greatly modified by agriculture, fern lands |
| Mitiaro | Raised Coral | 22.3 | 15 | 230 | Makatea forest, wetlands greatly modified by agriculture, freshwater lakes |
| Takutea | Sand cay | 1 | 5 | 0 | Strand vegetation; seabird & turtle nesting sites |
| **Northern** | | | | | |
| Manihiki | Atoll | 5.4 | 5 | 515 | Strand vegetation; seabird & turtle nesting sites |
| Nassau | Sand cay | 1.3 | 9 | 72 | Strand vegetation; seabird & turtle nesting sites |
| Palmerston | Atoll | 2.1 | 5 | 48 | Strand vegetation; seabird & turtle nesting sites |
| Penrhyn | Atoll | 9.8 | 5 | 357 | Strand vegetation; seabird & turtle nesting sites |
| Pukapuka | Atoll | 1.3 | 5 | 664 | Strand vegetation; seabird & turtle nesting sites |
| Rakahanga | Atoll | 4.1 | 5 | 169 | Strand vegetation; seabird & turtle nesting sites |
| Suwarrow | Atoll | 0.4 | 5 | 1 | Strand vegetation; seabird & turtle nesting sites |

Source – SPREP/UNDP/GEF Pacific Islands Renewable Energy Project (PIREP) Draft Cook Islands National Report May 2004'

Figure 2-1 shows the population trend from 1901 – 2001. In November 2003, the Ministry of Finance and Economic Management (MFEM) projected population through 2022, shown in Figure 2-2, with low, medium and high growth rates dependent on government policies regarding migrant labour, absorptive capacity for tourists (the mainstay of the economy) and assumptions regarding economic growth.

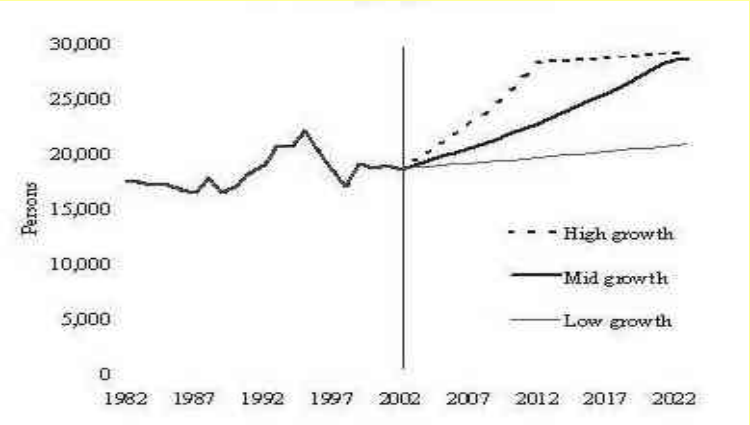
For the low growth scenario, the population's average annual growth rate (AAGR) over the next twenty-years is 0.8%; for the medium and high scenarios, it is about 1.6%. There are no projections by island or island group but outer island populations are expected to continue to decline. Assumptions regarding population growth and the distribution among islands have, of course, implications for the likely patterns of future energy use and the preferred options to provide energy.

**Figure 2-1 Cook Islands Population from 1901 – 2001**




**Source: SPREP/UNDP/GEF Pacific Islands Renewable Energy Project (PIREP) Draft Cook Islands National Report May 2004**

**Figure 2-2 Population Projections**




**Source: SPREP/UNDP/GEF Pacific Islands Renewable Energy Project (PIREP) Draft Cook Islands National Report May 2004**

### 2.3.2 Environment

With the northern most island at 9º and the southernmost at 22º, the southern group experiences a somewhat different climate than the northern group. Throughout, however, the conditions are maritime tropical with a small range of temperature between day and night and only modest seasonal changes in temperature that increase in degree towards the south.

Rainfall typically is around 2000 mm with two thirds falling from November to April. Winds tend to be easterly trade winds with some seasonal variation. Rainfall patterns are strongly affected by the El Niño-Southern Oscillation (ENSO) with southern group rainfall falling by as much as 60% and northern group increasing by up to 200% during El Niño conditions.

On average, three cyclones every two years occur with November to April the usual cyclone season. A cyclone severe enough to seriously disrupt the economy occurs often enough for there to be a significant risk of flooding, storm surge and wind damage warranting its consideration in development activities.

The southern group, largely of volcanic origin, has 88% of the land area in the country and with its fertile soils represents most of the agricultural production and a land based life style.

The northern group, mostly atolls, is more dependent on the sea – particularly the atoll lagoon – as the land has poor soil and problems with water supply.

Biodiversity is not high anywhere in the Cook Islands but the northern atolls are very low in land-based biodiversity.

The Cook Islands has signed various treaties and conventions related to environmental protection, including the United Nations Framework Convention on Climate Change (UNFCCC), the Kyoto Protocol, the United Nations Convention to Combat Desertification (UNCCD) and the Convention on Biological Diversity (CBD). The initial national communication to the UNFCCC , indicating greenhouse gas emissions, and vulnerability and adaptation to climate change, was submitted in October 1999. Table 2-2 summarises the status and date of signing of key environmental conventions.

**Table 2-2 Status of Ratification of Environmental Treaties and Conventions by Cook Islands**

| Status in Cook Islands | ? ? (SPREP Convention) | Conservation of nature (Apia Convention) | Hazardous wastes (Waigani Convention) | Nuclear free Pacific (Rarotonga Treaty) | GHG reductions (Kyoto Protocol) | Ozone depleting substances (Montreal Protocol, et al.) |
|---|---|---|---|---|---|---|
| Signed<br>Ratified<br>Entered into force | 25 Nov 87<br>9 Jul 89<br>22 Aug 90 | <br>24 Jun 87<br>26 Jun 90 | 17 Sep 95<br>30 Oct 00<br>? | 06 Aug 85<br>28 Oct 85<br>11 Dec 86 | 16 Sep 98<br>27 Aug 01<br>n/a * | Acceded to Vienna Convention,<br>21 Mar 86 |

Note: The above treaties and conventions are briefly described in volume 1, the PIREP Regional Overview report
* The Kyoto Protocol is in force from 15 February 2004 for European Union members only.

Source: SPREP/UNDP/GEF Pacific Islands Renewable Energy Project (PIREP) Draft Cook Islands National Report May 2004

### 2.3.3 Political Development

Named after Captain James Cook, who sighted them in 1770, the islands became a British protectorate in 1888, with administrative control transferred to New Zealand in 1900. In 1965 Cook Islanders chose self-government in free association with New Zealand, with the right to full independence at any time by unilateral action. The GoCI is fully responsible for internal affairs, with New Zealand retaining responsibility only for external affairs and defence. The government is a Westminster-style parliamentary democracy with Queen Elizabeth II as head of state. Parliament is unicameral with 25 members elected by popular vote to five-year terms under a voting system which gives considerable power to very small outer island constituencies**.** There is also a House of Ariki (chiefs), which controls large areas of customary communal land (and all land is customary), advises on traditional matters, and maintains considerable influence, but has no legislative powers. Each outer island has an elected Island Council presided over by a mayor.

**Table 1-3 The Cook Islands and Regional Economic Treaties**

| Status | SPARTECA | PACER | PICTA |
|---|---|---|---|
| Signed<br>Ratified<br>Entered into force | 14 July 1980<br>12 Nov 1980<br>01 Jan 1981 | 18 Aug 2001<br>28 Aug 2001<br>3 Oct 2002 | 18 Aug 2001<br>28 Aug 2001<br>13 Apr 2003 |

Source: SPREP/UNDP/GEF Pacific Islands Renewable Energy Project (PIREP) Draft Cook Islands National Report May 2004

As shown in Table 2-3, the government is signatory to the three Pacific regional trade and economic trade agreements, the most important of which are the Pacific Islands Trade Agreement (PICTA) and the Pacific Agreement on Closer Economic Relations (PACER; between PICTA signatories and Australia and New Zealand). The GoCI has also signed the Cotonou Agreement, providing

membership in the African Caribbean Pacific (ACP) group of countries, and thus access to further development assistance from the European Union (EU).

### 2.3.4 Economic Overview

The Cook Islands' economic development is hindered by the isolation of the country from foreign markets, the very limited size of domestic markets, limited natural resources, periodic devastation from natural disasters, a diminishing skilled labour force due to emigration, and inadequate infrastructure, particularly in the more remote islands. Tourism provides the economic base, agriculture has limited potential, and manufacturing is mainly fruit processing, clothing, and handicrafts. In 2002, pearls – although less than half the value of 2000 and 2001 exports – constituted 60% of all exports followed by fish and fruit. Trade deficits are offset by remittances from emigrants and by aid supplied overwhelmingly from New Zealand. In the 1980s and 1990s, the country lived beyond its means, maintaining a bloated public service and accumulating a large foreign debt. Recent trends in Gross Domestic Product (GDP) are summarised in Table 2-4 below and key economic indicators are shown in Table 2-5.

**Table 2-4 GDP at Constant 2000 Prices by Industry: 1997 – 2002 (NZ$ millions)**

| Year | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | % contribution in 2002 |
|---|---|---|---|---|---|---|---|
| Total | 153.3 | 152.1 | 156.2 | 177.8 | 186.6 | 193.3 | 100 % |
| Agriculture & fishing | 16.3 | 21.8 | 23.8 | 23.8 | 23.1 | 25.3 | 13.1 % |
| Mining & manufacturing | 4.0 | 5.0 | 5.1 | 6.1 | 7.0 | 6.9 | 3.6 % |
| Electricity & water | 2.8 | 2.8 | 3.1 | 3.5 | 3.7 | 3.9 | 2.0 % |
| Construction | 3.3 | 4.0 | 4.3 | 5.1 | 6.1 | 6.8 | 3.5 % |
| Wholesale & retail trade | 29.2 | 30.7 | 33.6 | 39.7 | 42.3 | 45.6 | 23.6 % |
| Restaurants & accommodation | 16.5 | 15.9 | 17.0 | 23.3 | 25.0 | 24.7 | 12.8 % |
| Transport & communications | 18.4 | 17.1 | 20.2 | 25.2 | 28.0 | 29.0 | 15.0 % |
| Finance & business services | 14.2 | 15.8 | 15.0 | 16.9 | 17.0 | 16.8 | 8.7 % |
| Community & personal services | 3.8 | 3.8 | 4.4 | 5.2 | 5.7 | 6.4 | 3.3 % |
| Public administration | 377.8 | 29.0 | 23.8 | 23.2 | 22.6 | 22.4 | 11.4 % |
| Ownership of dwellings | 11.6 | 11.5 | 11.4 | 11.3 | 11.3 | 11.2 | 5.8 % |
| *Less* imputed bank charges | 4.6 | 5.3 | 5.6 | 5.5 | 5.3 | 5.3 | 2.7 % |

Source: SPREP/UNDP/GEF Pacific Islands Renewable Energy Project (PIREP) Draft Cook Islands National Report May 2004

**Table 2-5 - Key Economic Indicators for the Cook Islands: 1997 - 2004**

| Indicator | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 e | 2004 p |
|---|---|---|---|---|---|---|---|---|
| GDP growth (% per year) | -1.5 | -3.5 | 0.7 | 7.9 | 5.1 | 0.3 | 2.4 | 2.5 |
| GDP/capita growth (% per year) | – | 1.2 | 7.8 | 14.5 | 9.6 | 4.0 | 1.5 | 3.2 |
| Value added in agriculture (% per year) | 12.2 | -17.2 | -28.2 | 32.3 | -24.0 | – | – | – |
| Value added in industry (% per year) | 6.4 | 3.3 | 7.0 | 6.8 | -0.8 | – | – | – |
| Value added in services (% per year) | -7.4 | -0.8 | 13.9 | 6.6 | 0.6 | | | |
| Inflation rate (% per year) | -1.2 | 1.2 | 1.3 | 1.7 | 9.4 | 3.9 | 3.4 | 3.4 |
| Growth in merchandise exports (% per year) | -39.5 | -10.0 | 41.2 | 38.6 | 100.9 | -39.1 | – | – |
| Growth in merchandise imports (% per year) | -4.8 | -10.2 | -3.6 | 18.0 | 13.0 | -8.8 | – | – |
| Balance of trade (US$ m / yr) | -41 | -37 | -35 | -40 | -41 | -40 | – | – |
| BOP on current account (US$ m / yr) | -4 | -2- | -2 | -2 | 5 | 6 | – | – |
| BOP on current account (% of GDP) | -3.7 | -2.9 | -2.2 | -2.6 | 6.3 | 6.3 | 5.9 | – |
| External debt outstanding (US$ m) | 31 | 65 | 64 | 58 | 53 | 54 | – | – |
| Debt service ratio (% of exports) | 11.0 | 3.7 | 4.8 | 3.5 | 3.5 | – | – | – |
| Exchange rate NZ$ / US$1.00 (annual ave.) | 1.5 | 1.9 | 1.9 | 2.2 | 2.4 | 2.1 | – | – |

Note: GDP and exchange rates for calendar year; other data for fiscal year (e.g. FY2003 = July 2002–June 2003); – = unavailable Data from ADB differ somewhat from that of GoCI but both sets are broadly indicative of economic trends.
Source: *Asian Development Outlook* (ADB, 2003)
e = estimated; p = projected; BOP = balance of payments

Source: SPREP/UNDP/GEF Pacific Islands Renewable Energy Project (PIREP) Draft Cook Islands National Report May 2004

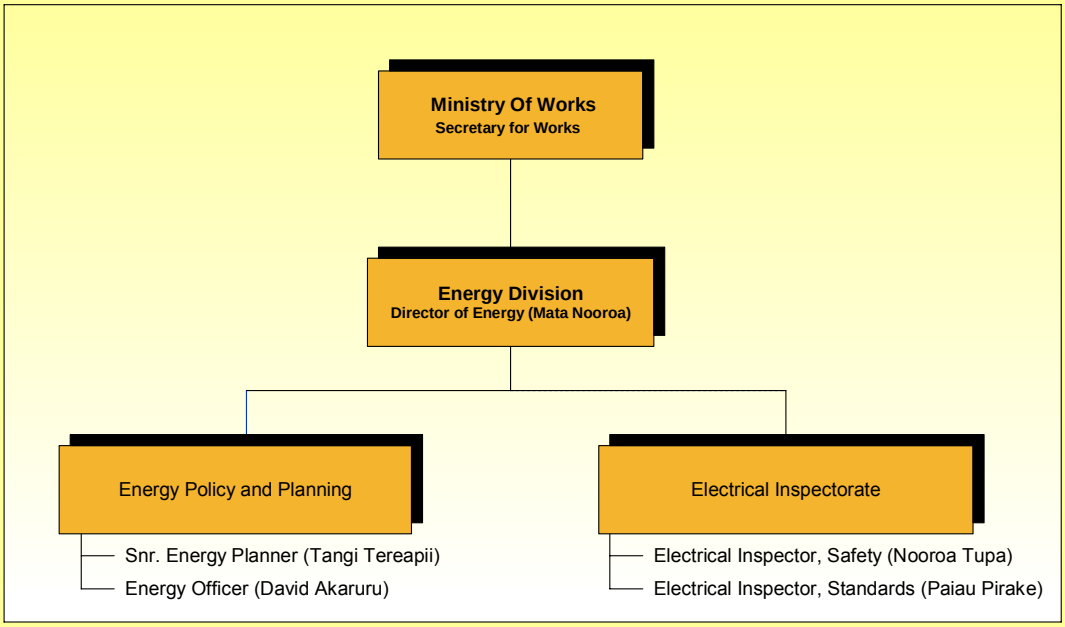
Reforms from the mid-1990s, including the sale of state assets, the strengthening of economic management, a dramatic reduction in public sector employment, the encouragement of tourism, and a debt restructuring agreement have collectively rekindled investment and growth.

Outer islands development suffers from poor infrastructure and emigration. Outer island populations have decreased over the last decade since reforms were introduced to reduce the size of the public sector and bring about improved economic management. Public sector employment on outer islands has nearly been halved in the process. These reforms and the growth in tourism have seen positive GDP growth for the last five years.

### 2.3.5 National Government Energy Arrangements

The Energy Division established within the Ministry of Works, is responsible for development of national energy policy, energy planning and electrical inspection. Its organisational structure is shown in Figure 2-3. An important function is to act as the interface between internal and external agencies supplying funding for renewable energy and energy efficiency projects. The Minister of Works is responsible for energy policy and electrical safety while the Minister of Energy is responsible for renewable energy through the Sustainable Energy Committee (SEC).

**Figure 2-3 Organizational Chart of the Ministry of Works, Energy Division (2004)**




Source SPREP/UNDP/GEF Pacific Islands Renewable Energy Project (PIREP) Draft Cook Islands National Report May 2004

The capacity for energy planning, administration and policy is even weaker than the small number of staff suggest. Two of them deal primarily with inspections of electrical wiring and related electrical standards and safety issues, matters not normally handled by energy planning officials in other Pacific Island Countries (PIC). The Director is also the Chief Electrical Inspector and spends up to half of his time managing inspection and safety matters.

**Table 2-6 - *De Facto* Ministerial Responsibilities for Energy Matters (December 2003)**

| ***Ministerial Responsibility:*** | **Prime Minister** | | **Minister for Energy †** | | **Minister for Island Administration** | **Minister for Works** | **Minister for Internal Affairs** | |
|---|---|---|---|---|---|---|---|---|
| *Responsible for:* | Oil spills; Waste oil management; Env. impact assessments; Emissions | Electricity policy and tariffs on Rarotonga | Renewable energy; Sustainable Energy Committee | TAU social issues (e.g. street lighting) | Implicit subsidy for outer islands electricity (See note 5) | Energy policy overall; Electrical safety | Petroleum storage and safety | Petroleum pricing and quality |
| *Responsible through:* | Environmental Services | TAU | OMIA as Committee secretariat | Cabinet | OMIA | Energy Division | Labour and Consumer Services (including Dangerous Goods Inspector) | |

*Notes:* 1) Energy Division staff report informally to the Minister of Energy for renewable energy matters and to the Minister for Works for energy policy matters (including electricity planning, electricity tariff and monitoring fuel standards and quality)
2) The PM is responsible for government-owned corporatised entities, including TAU, through the Cook Islands Investment Corporation.
3) A 'Sustainable Energy Committee' was established by Cabinet in September 2001 but apparently has never met.
4) There are no formal cash subsidies for outer island electricity supply. The office of the Minister for Outer Island Administration (OMIA) administers general grants to the islands some of which are used for electricity.

Source: SPREP/UNDP/GEF Pacific Islands Renewable Energy Project (PIREP) Draft Cook Islands National Report May 2004

The Director is also responsible to the Minister for Energy for some aspects of the Division's work with an informal allocation of responsibilities shared between the Energy and Works Ministers. As shown in Table 2-6, Ministerial responsibilities for matters related to energy are actually scattered over a number of separate ministries and the mandates overlap. There appears to be some confusion among public servants and others regarding authority, responsibility, accountability and reporting.

The Energy Division responsibilities include the development of national energy policy, energy planning and the gathering of energy related statistics. The Division monitors electricity tariffs and petroleum usage but has no regulatory power or responsibility. The majority of the activity of the Energy Division is in the electrical inspection area and in acting as an interface between internal and external agencies supplying funding for renewable energy or energy efficiency projects and the project recipients. Energy Division staff also regularly provide technical advice and support to the outer island governments in energy matters though not formally mandated to provide that service.

In PIC, it is normal that the Energy Division does not handle all energy sector matters. For example, in small countries with petroleum fuel price controls the Finance Ministry often administers pricing whereas other Ministries or the petroleum company (with better technical skills) will oversee petroleum transport, storage and safety. It is also common for an energy office to deal with overall electricity utility policy but with Cabinet, the Finance Ministry or utility itself having the final say on tariff levels. However, the responsibilities for energy in the Cook Islands are unusually dispersed and are seen to hinder the development and implementation of consistent energy policies and their administration.

Each of the outer island local administrations is responsible for the operation of their respective electrical generation and distribution under the provisions of the Energy Act 1998, particularly the areas of electrical safety and inspection. OMIA is responsible for implicit subsidies for the outer islands in the form of grants that offset the island's budget deficits.

TAU is the government owned electricity utility on Rarotonga. The Director of Energy is a board member of TAU. The utility has become increasingly commercialised and expected to recover all operating costs from consumers. A GoCI Cabinet Memorandum of May 2004 has directed TAU to take over responsibility of the Aitutaki and Atiu Power Supplies as requested by the Island Councils of the two islands. At present the procedures and budgetary implications are being investigated by TAU.

### 2.3.6 National Energy Policy

In 2003, Cabinet endorsed a National Energy Policy (NEP), which is similar to the format and structure of the 2002 Pacific Islands Energy Policy and Plan (PIEPP). The NEP includes an overall national energy policy statement, "to facilitate reliable, safe, environmentally acceptable, and cost-effective sustainable energy services for the people of the Cook Islands" and a number of guiding principles with goals for sustainability, self-sufficiency, efficient service delivery, and financial independence. Over time, for example, cross-subsidies among electricity users are to be eliminated and those who receive electricity through renewable energy systems are to pay monthly fees sufficient to meet operating and maintenance costs – including the eventual replacement of the system components. There are broad policies for overall energy planning and management, the power sector, renewable energy, petroleum fuels, transportation, and environmental aspects of energy – with efficient energy use specified throughout. The NEP includes a Strategic Plan with specific activities, lead agencies, indicators of success, assumptions and risks, and a time frame for each policy area. The policies and activities are well thought-out, clear and consistent. However, there are no specific budget allocations for implementing any activities or indications of priority among them. The NEP has not been an input to a new economic national planning exercise coordinated by MFEM, but the planning only began in September 2003.

# 3 MAUKE

## 3.1 Background

### 3.1.1 Physical Description and Population

Mauke lies 240km North East of Rarotonga, is some 6.5km long by 4km wide and comprises a central volcanic area 3km by 2km, surrounded by Makatea[4] generally 1 km wide and a narrow fringing coastal reef.

Mauke is the 7th most populous island with a population of 470 (Dec 2001 Census). Paid employment numbers 73 with 291 people engaged in unpaid employment.

The majority of the population resides in Kimiangatau Village on the North Eastern coast and Oiretumu Village toward the centre of the island.

**Map 3-1 - Mauke**

Source – New Zealand Department of Survey and Land Information

### 3.1.2 Local Government

The governing body of the island is the Mauke Island Council (MIC). The Council composition is a Mayor and five councillors elected every three years. Included in the Island Council as ex-officio members without voting rights are three Arikis, a representative of the Koutu Nui, the Member of Parliament and the Central Government Representative.

A Secretary of Island Administration appointed by the GoCI Cabinet through consultations with the Island Council, is responsible for administering and managing the various Island Administration departments and works closely with the Mayor and Island Council for the benefit of the island community.

4 Makatea are high islands which have sunk to sea level, developed coral reefs, and then elevated by volcanic activity. Their central hills are surrounded by elevated dead coral.

### 3.1.3 Mauke Strategic Plan 2000-2008

Key sectors identified in the strategic plan and where applicable there relevance to the Mauke Power Supply (MPS) are as follows:

- Social Services;
- Health, Education, Judiciary, Natural Disaster management;
- Economic Development;
- Agriculture, Tourism;
- Community Development;
- Good Governance; and
- Infrastructure Development and Maintenance.

Infrastructure development and maintenance is a key area identified by the MIC. At the time of writing the plan in year 2000 the Island Council was committed to undertake the following:

- Continue to upgrade and maintain electrical power supply and distribution reticulation network to provide 24 hour service to the island and improve low voltage service to consumers;
- Tar seal main roads;
- Purchase a dredging machine, 7 ton tip truck, bulldozer, pickup vehicle;
- Provide new diesel engines for bore pumping;
- Provide electrical equipment for distribution services; and
- Service and overhaul power supply generators.

As stated in the Strategic Plan, Mauke is determined to direct its resources again into agriculture, tourism, marine and other income avenues to boost the economy of the island and make it attractive to reduce outward migration flows and to provide its people with a better future.

### 3.1.4 Infrastructure

Unsealed roads run around the coast of the island with the main road running from the Airport though Kimiangatau Village, Taunganui Landing and inland to Oiretumu Village. The unsealed airstrip on the Northern Coast has regular scheduled services to Rarotonga and neighbouring islands and is serviced by Air Rarotonga's Banderante and Saab turbo prop aircraft.

**Picture 3-1 Mauke Airport**

Photo: Bruce Clay, 2004

Water supply is from bores in the centre of the island which are pumped to elevated reservoirs and gravity fed through underground reticulation to consumers. Low water pressure is a problem identified for attention in the Strategic Plan.

Both water and power have been identified in the Mauke Strategic Plan 2000 - 2008 as priorities for infrastructure advancement. Of particular relevance to this project is the intention to repair the windmill water pump to reduce fuel costs.

**Picture 3-2 Water Reservoir**

**Picture 3-3 Water Pumping Windmill**

Photo: Bruce Clay, 2004

Taunganui Landing on the North West coast provides access for inter island ships operated by Taio Shipping, which steam from Rarotonga at irregular intervals of two to eight weeks. The ships carry the majority of the island's requirements including diesel fuel and oil with air freight used for perishables and more urgent supplies. Ships anchor offshore and a lighter carts freight to the landing for unloading. Ships cannot unload cargo in rough weather as the

surge at the wharf and shallow entrance to the landing is a concern. Dredging of the entrance channel is required for safer access.

**Picture 3-4 Taunganui Landing**

**Picture 3-5 Lighter**

Photo: Bruce Clay, 2004

Telecom Cook Islands provides full direct dial and data services via satellite with underground reticulation to the majority of properties. Solar power is used as the main power source with connection to Mauke Energy's grid supplying backup power.

**Picture 3-6 Telecom Solar PV Facility**

Photo: Bruce Clay, 2004

Whilst exporting fresh vegetables to New Zealand was a significant income in the 1980's currently Mauke's principal exports are Maire ei's and Nono.

Attempts at cultivating Maire have been unsuccessful and naturally occurring Maire provide the only source. Locally grown fruit and vegetables with locally raised livestock provide relative food independence. These include staple root crops such as Taro and tapioca, pigs and, to a lesser extent, cattle.

**Picture 3-7 Maire Export**

Photo: Bruce Clay, 2004

Tourism, whilst presently relatively minor in an economic sense, has been identified with fruit production in the Mauke Strategic Plan 2000-2008, as a sector with potential for growth. Tourism development will have an impact on the islands infrastructure, in particular for power and water.

**Picture 3-8 Ocean Breeze Lodge (under construction June 2004)**

Photo: Bruce Clay, 2004

**Picture 3-9 Gateway Lodge (near completion June 2004)**

Photo: Bruce Clay, 2004

## 3.2 Mauke Power Sector

### 3.2.1 Background

Mauke Power Supply (MPS) is operated as a department of the Mauke Island Administration (MIA). Power generation is by way of diesel powered gensets with underground high voltage (HV) distribution and overhead low voltage (LV) distribution.

**Picture 3-10 Mauke Power Station**

Photo: Bruce Clay, 2004

During July 2003 power supply hours were increased from 19 hours per day to continuous 24 hours per day. Unfortunately inconsistencies in the monthly technical reports prepared for the Energy Division make it difficult to asses the increase in power consumption due to 24hour power. Generation records show a 44% increase however fuel usage shows an increase of only 16%.

MPS is staffed by one Officer in Charge, a linesman/mechanic and

two operators. Manning of the power station is only part time. The power station is located approximately 200 meters south east of Tanunganui.

Table 3-1 lists the plant size and tariff structure.

**Table 3-1 Atiu Power Supply Installed Capacity and Tariff Structure**

| Supply Hours | Generators | Installed Capacity (kW) | Base/Max Load (kW)* | Tariff | |
|---|---|---|---|---|---|
| | | | | Domestic | Commercial |
| 24 | 4 x Lister 6 cylinder air cooled HR6 engines driving Stamford 60kVA alternators with AVRs | 168 | 25/78 | $0.36/kWh | $0.58/kWh + $5/month service charge |

* Loads based on logged data during field visit

### 3.2.2 Generation

The installed generation capacity of 168kW appears adequate though little spare capacity is available for future load growth. A maximum of two gensets can be operated at any one time giving a maximum generation capacity of 84kW. Peak loads have occurred twice in the past year that has come close to requiring load shedding. One such incident occurred whilst the system was being logged during the evening peak of 30th June 2004.

**Picture 3-11 Lister HR6 42kW Generator Installations**

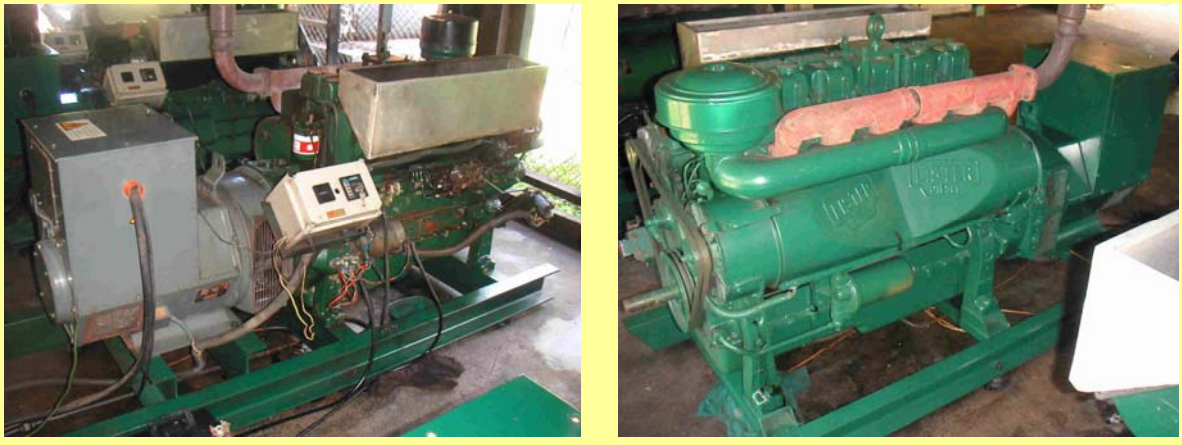


Photo: Bruce Clay, 2004

### 3.2.3 Electrical Distribution Network

Each of the four generators connects to the main switchboard which houses a manual synchronising panel that enables up to 2 generators to be operated at any one time with little difficulty. The 415V supply from the main switchboard is stepped up to 3.3kV through a 100kVA (compact) transformer and distributed via two 16mm copper underground feeders to 1 x 50kVA and 3 x 30kVA compact transformers for overhead LV distribution.

As of June 2004 there are 156 residential and 25 commercial consumers connected to the grid. Churches are metered but not billed. Street lights are installed and un-metered but are not operated in order to conserve fuel.

### 3.2.4 Station Manning Hours

The power station is presently manned during peak loads from 5am – 9am and 5pm – 10pm. During these periods two generators are operated whilst only one generator is used to carry the off-peak/base load. Operators synchronise the second generator in at the beginning of their shift and revert back to the single generator at the end of the shift providing loads have decreased sufficiently.

### 3.2.5 Fuel Handling

Fuel is carried in hull tanks on the inter island vessels and discharged to 1,600 litre (lt) mobile tanks on the islands lighter for transport to the landing where the MPS truck fitted with a Hyab crane lifts the tanks out of the lighter and transports them to the power station. The lighter can carry one mobile tank at a time. Fuel deliveries can be in the order of 20,000 lt per shipment which is equivalent to around two months fuel consumption. Fuel orders are timed so as to not carry less than one months supply at any one time. Lubricating oil and benzine are supplied in 205lt drums.

**Picture 3-12 Fuel and Oil Storage**

Photo: Bruce Clay, 2004

Fuel is stored in the mobile tanks at the power house and pumped as required to the two main bulk tanks of 3,690 lt capacity each. From the bulk tanks, fuel is manually pumped into 2 x 50gallon day tanks. The main bulk tanks are dipped each morning at 9.00am and the quantity remaining is recorded in the station log.

A Capital Expenditure of $30,000 has been included in the Mauke 2004/2005 Budget for upgrading of the bulk fuel tanks and associated works. This may include works on fuel spill containment however no designs have been seen, as the works were not included in the budget submission by the MIA.

### 3.2.6 Current Power Supply Situation

*Power Quality*

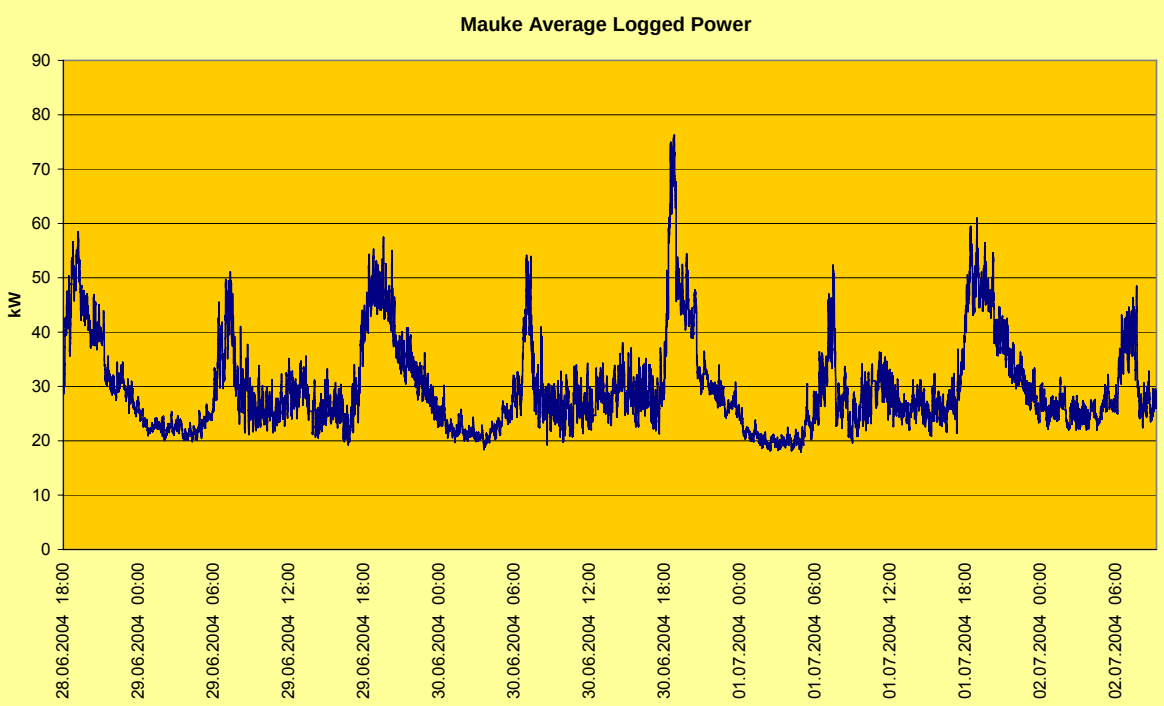
A Metrel Power Quality Analyser model MI2192 was connected to the main switchboard bus and recorded data from 28/6/04 17:20 – 2/7/04 09:15. Iteration period was 20 secs with logging of the variables listed in table 3-2.

**Table 3-2 Logged Power Variables**

| |
|---|
| Phase Voltages; V1,V2,V3 in Volts (V) |
| Phase Currents; I1,I2,I3 in Amps (A) |
| Frequency in Hertz (Hz) |
| Phase and Total Power in kilo Volt Amps (kVA) |
| Reactive Power in kilo Volts Amps Reactive (kVAR) |
| Power Factor (0 – 1 inductive or reactive) |
| Current and Voltage Total Harmonic Distortion in % (THD) |
| $3^{rd}$,$5^{th}$ and $7^{th}$ Phase Current and Voltage Harmonics in % |

Logged data is analysed using Powerlink software

**Figure 3-2 Average Logged Power**




Average power logged during the field visit is shown in Figure 3-2

Logged power was in the range 18.5 – 76.0 kW with an average loading of 29.8kW. Peak loads were occurring from 6:00 – 8:00am and 18:00 – 23:00pm. The evening peak load being the larger and longer of the two peaks.

Phase balancing is reasonable with an average load distribution per phase of:

| Phase 1 | Phase 2 | Phase 3 |
|---|---|---|
| 28% | 33% | 40% |

Peak load periods have balanced phase loading whilst the off-peak phase loadings are more unbalanced.

Frequency was logged in the range of 47.7 – 52.8 Hz, which is acceptable for a generation system of this size operated at genset loads varying from 45-90% of their rated capacity.

Power factor was in the range 0.74 – 0.95, which is acceptable.

Voltage Total Harmonic distortion was a maximum of 3.5%, which is acceptable.

Current Total Harmonic Distortion was a maximum of 13.9%, which is acceptable though high.

**Picture 3-13 Switchboard with logger connected**

Photo - Bruce Clay, 2004

*Consumers*

As of June 2004 there were 156 residential and 25 commercial connections. An energy survey was carried out with 87 households and 8 commercial customers available for interviews. On the day of survey many households were vacant with the residents either engaged in activities elsewhere on the island or off island. Whilst the number of residences surveyed is 56% the survey provides a clear indication on the reliance of the islands residents on electricity as the major energy source. All larger commercial consumers were interviewed. Not all commercial consumers were open at the time of interview. Please refer to Annex E for a copy of the survey format.

Key findings of the survey are listed in Tables 3-3 & 3-4.

**Table 3-3 Residential Electrical Appliance Usage**

| | |
|---|---|
| Lighting; incandescent: fluorescent ratio | 7.4:1 |
| Refrigeration; % of households using | 93% |
| Electric Jugs; % of households using | 90% |
| Electric Frypans: % of households using | 50% |
| Electric Clothes Iron; % of households using | 87% |
| Electric Toaster; % of households using | 44% |
| Electric Washing Machine; % of households using | 52% |
| TV; % of households using | 23% |
| Electric Hot water Systems; No. of households using | 1 |

NB Limited use of solar hot water heating

**Table 3-4 Commercial Survey Main Points**

- Largest consumer averages 66kWh/day running three upright display chillers and seven large chest freezers.
- Discussions with commercial consumers indicated they were generally satisfied with the quality of power service and kWh tariff however do not necessarily agree with the $5/month service charge.
- Bakery using an electric oven bakes generally from 7.00pm until 10.00pm.

*Developments and Load Growth*

Developments underway and planned for Mauke and the estimated loading are listed in Table 3-5.

**Table 3-5 Developments and Load Growth**

- The newly constructed hospital was due to open late July 2004. Fluorescent lighting used throughout. Estimated consumption would be 7 kWh/day with a maximum demand of 1.5kW. Solar hot water system installed.
- Gateway Lodge tourism development consisting of 3 villas nearing completion. Estimated consumption would be around 5 kWh/day with maximum demand of 2kW at full occupancy.
- Tiare Motel has one new unit under construction which will add approximately 1.6kWh/day and 0.7kW maximum demand. A further two units may be constructed if tourism continues to grow.
- Ocean Breeze Lodge with 5 units under construction is on the South East coast away from the grid and as such will have to generate power independently. There is potential for a small wind/diesel hybrid system.

**Picture 3-14 New Hospital**

Photo – Bruce Clay, 2004

### 3.2.7 Water System

Water is pumped from a series of four bores using Lister single cylinder diesel engines driving Southern Cross reciprocating pumps. Water is stored in four reservoirs at a height of around 6 meters above ground level.

Diesel consumption of the pumps is around 400 l/month. The diesel pumps leak considerable fuel and oil, which is contaminating the ground area directly above the bores.

Two Southern Cross 1ZC 10' multi-blade (drag) wind turbines are awaiting spare parts to enable them to be put back in service. Parts are in Rarotonga awaiting shipment. Apparently these wind powered bore pumps performed well when last in service.

#### 3.2.8 Maintenance

Routine engine maintenance is carried out by the MPS Linesman/Mechanic. This mainly involves changing engine oil and filters every 250 hours of generator operation.

Major engine overhauls are scheduled for every 16,000 hours with a mechanic flown from OMIA in Rarotonga to carry out the overhaul.

Unscheduled maintenance is dealt with according to available parts, tools and personnel. During the field visit #3 generator was out of service due to a failed automatic voltage regulator (AVR). The operators were waiting on a new AVR to be flown from New Zealand.

#### 3.2.9 Distribution

HV, 3.3 kV, underground distribution appears to be in reasonable condition with the 1 x 50kVA and 3 x 30kVA step down transformers operated under their rated capacity.

LV overhead distribution using insulated aluminium conductors is in need of significant maintenance with replacement of up to 50% of the wooden poles, a considerable number of insulators, the cross arms and the cabling. Extensive tree cutting is also required.

A new 50kVA transformer, associated switchgear and HV/LV cabling has been included in the Mauke Capital Expenditure Budget 2004/2005 at a value of $57,000. This will be installed in Oirtumiu Village and will increase the capacity of the LV distribution toward the East of the village.

#### 3.2.10 Full Recovery Tariff

The full cost recovery tariff for Mauke was calculated using the data in the following tables based on a 15 year break even Net Present Value (NPV)[5] at a 6% discount rate.

**Mauke Full Cost Recovery Tariff $1.19/kWh**

[5] [5] Net Present Value is the present value of the projects future earnings over the project life (savings against diesel in this case) based on the discount rate (cost of capital) of 6%

Results from system modelling with Homer[6] calculated a cost of generated energy of $1.11/kWh which equates to $1.25/kWh full cost recovery tariff based on the generated/sold kWh ratio as per the technical report shown in Table 3-6. Homer results provide a reasonable validation of the calculated full cost recovery tariff.

The following table 3-6 for the period July 2003 – June 2004 showing the monthly power generation and fuel use was generated from the MPS Technical Reports submitted to the Energy Division, Ministry of Works. Only June 2004 data for unbilled kWh was available.

**Table 3-6 Mauke Technical Reports**

| Period | Generated (kWh) | Sold (kWh) | Unbilled (kWh) | Loss (kWh) | Eff. (%) | S.F.C (kWh/l) | Fuel Use (litres) | S.O.C (kWh/l) | Oil Use (litres) |
|---|---|---|---|---|---|---|---|---|---|
| **Jul-03** | 17260 | 16842 | | 418 | 97.6 | 1.75 | 9874 | 269.7 | 64 |
| **Aug-03** | 17740 | 15939 | | 1801 | 89.8 | 1.85 | 9601 | 181.0 | 98 |
| **Sep-03** | 19351 | 17560 | | 1791 | 90.7 | 2.03 | 9555 | 284.6 | 68 |
| **Oct-03** | 21860 | 20552 | | 1308 | 94.0 | 2.21 | 9873 | 508.4 | 43 |
| **Nov-03** | 21677 | 19880 | | 1797 | 91.7 | 2.27 | 9555 | 258.1 | 84 |
| **Dec-03** | 23840 | 21643 | | 2197 | 90.8 | 2.41 | 9873 | 283.8 | 84 |
| **Jan-04** | 23160 | 16577 | | 6583 | 71.6 | 2.31 | 10010 | 263.2 | 88 |
| **Feb-04** | 20340 | 19666 | | 674 | 96.7 | 2.20 | 9236 | 462.3 | 44 |
| **Mar-04** | 23440 | 18818 | | 4622 | 80.3 | 2.37 | 9874 | 234.4 | 100 |
| **Apr-04** | 21900 | 19902 | | 1998 | 90.9 | 2.29 | 9555 | 185.6 | 118 |
| **May-04** | 22480 | 17486 | | 4994 | 77.8 | 2.28 | 9874 | 562.0 | 40 |
| **Jun-04** | 21500 | 20538 | 198 | 764 | 96.4 | 2.18 | 9874 | 325.8 | 66 |
| ***Total*** | ***254548*** | ***225403*** | ***198*** | ***28947*** | ***88.6*** | ***2.18*** | ***116754*** | ***318.2*** | ***897*** |

Acronyms - Specific Fuel Consumption; SFC, Specific Oil Consumption; S.O.C

Fuel and Oil Costs were calculated as per table 3-7.

**Table 3-7 Fuel & Lube Oil Cost**

| | $/litre | Source |
|---|---|---|
| Diesel Fuel Price | 0.899 | Toa Petroleum Invoicing 1/7/04 |
| Shipping Freight | 0.14 | Taio Shipping Invoicing 1/7/04 |
| Wharfage | 0.03 | Charged at around $30/m$^3$ |
| **Total Fuel Cost** | **$ 1.069** | |
| Lube Oil Price | 3.19 | Toa Petroleum Invoicing 1/7/04 |
| Shipping Freight | 0.273 | Taio Shipping Invoicing 1/7/04 |
| Wharfage | 0.03 | Charged at around $30/m$^3$ |
| **Total Lube Oil Cost** | **$ 3.493** | |

[6] [6] Homer is an optimisation modelling software (Version 2.09 Feb 2004) for distributed power. It is developed by the National Renewable Energy Laboratory (NREL). Please visit www.nrel.gov/homer

Personnel, maintenance and other operating expense data were gathered from the MIA accounting records as shown in table 3-8.

**Table 3-8 Operating & Maintenance Costs**

| Cost | Amount | Source |
|---|---|---|
| Personnel | $ 50,595 | June 2003 YTD Financials |
| Maintenance | $ 4,515 | June 2003 YTD Financials |
| Admin Telecom & Consumables | $ 2,635 | June 2003 YTD Financials |
| Est. share of office staff on IA payroll | $ 4,000 | 25% of $20,000 accounts salary |
| ***Total*** | ***$ 61,745*** | |

Estimated current capital and recurrent costs for power station and distribution are listed in table 3-9.

**Table 3-9 Estimated Current Capital and Recurrent Costs**[7]

| Estimated Full Capital Cost for Current Power Station | | | | |
|---|---|---|---|---|
| Engineering/Civil Design | 1 | fee | $ 20,000 | $ 20,000 |
| Building cost | 100 | sqm | $ 1,000 | $ 100,000 |
| Switchboard incl. sync panel | 1 | at | $ 20,000 | $ 20,000 |
| HV Transformer 100kVA | 1 | at | $ 10,000 | $ 10,000 |
| Fuel & Elec. fitout incl. labour | 1 | at | $ 8,000 | $ 8,000 |
| Fuel Storage bulk tanks | 2 | 3690 litre | $ 3,500 | $ 7,000 |
| Mobile tank | 12 | 1600 litre | $ 2,000 | $ 24,000 |
| Deutz gensets ~ 50kW | 4 | each | $ 37,000 | $ 148,000 |
| Hyab truck | 1 | 2nd hand | $ 50,000 | $ 50,000 |
| Tools, meters etc | 1 | set | $ 5,000 | $ 5,000 |
| Spare Parts kept on hand | 1 | assorted | $ 10,000 | $ 10,000 |
| Billing Computer/Printer | 1 | at | $ 4,000 | $ 4,000 |
| Contingency | 10% | Of | $ 406,000 | $ 40,600 |
| | | | ***Total*** | ***$ 446,600*** |

[7] [7] Costs where based on current market values with allowance for transport to site from point of origin

| Estimated Full Capital Costs for Current Power Distribution | | | | |
|---|---|---|---|---|
| **HV Distribution** | **qty** | **unit** | **cost** | |
| 16mm Cu underground cable | 2950 | meters | $ 17.05 | $ 50,298 |
| 50mm HD PVC conduit | 750 | lengths | $ 17.85 | $ 13,388 |
| 50kVA Transformer | 1 | each | $ 5,000.00 | $ 5,000 |
| 30kVA Transformer | 3 | each | $ 4,000.00 | $ 12,000 |
| Concrete & misc. items | 1 | each | $ 5,000.00 | $ 5,000 |
| Equipment Freight NZ to Mauke estimate | 20% | of | $85,685.00 | $ 17,137 |
| Allow 350 man hours to install mains @ $20/hr | 350 | each | $ 20.00 | $ 7,000 |
| Equipment allowance (ditch digger etc) | 1 | each | $ 4,000.00 | $ 4,000 |
| Contingency | 10% | Of | $ 113,822 | $ 11,382 |
| | | | ***Total HV*** | ***$ 125,204*** |
| **LV Distribution** | | | | |
| Arial Bundled Cable 95mm Al | 11000 | meters | $ 9.65 | $ 106,150 |
| Poles incl. ABC fittings every 60meters | 185 | each | $ 385.00 | $ 71,225 |
| Supply feeder connection to the ABC & install | 200 | each | $ 100.00 | $ 20,000 |
| Installation priced per pole incl. labour & equipment | 185 | each | $ 220.00 | $ 40,700 |
| Contingency | 10% | Of | $ 238,075 | $ 23,808 |
| | | | ***Total LV*** | ***$ 261,883*** |

| Estimated Current Recurring Costs | | | | |
|---|---|---|---|---|
| | **Period** | **Qty** | **Unit Cost** | **Cost** |
| Generator Major Overhauls @ 35% of initial cost | 5 years | 4 | $ 12,950 | $ 51,800 |
| Alternator Replacement @ 18% initial cost | 10 years | 4 | $ 6,660 | $ 26,640 |
| Billing computer replacement | 4 years | 1 | $ 4,000 | $ 4,000 |

## 3.3 Short Term Recommendations

MPS as for Atiu and Mitiaro, suffers from limited resources, both physical and human, for the sustainable and reliable operation of the power generation and distribution system. As specified in the Mauke Strategic Plan 2000-2008 the goal for the energy/power sector is "Continue to upgrade and maintain electrical power supply and distribution reticulation network to provide 24 hour service to the island and improve low voltage service to consumers ". Whilst budget constraints are a limiting factor, the following areas should be considered to improve the safe, reliable operation of the existing diesel generation system.

### 3.3.1 Power Station

Generation capacity needs to be increased to cater for developments currently underway (approximately a 4.2kW increase) and potential load growth. If load growth is 2% p.a. then the peak load would approach 100kW in 10 years. Presently peak loads of nearly 80kW have been experienced which is only just under the power station capacity of 84kW.

Two new generators of 60kW each would allow peak loads of up to 120kW with both sets running or 102kW with one new set and an existing 42kW Lister. All four existing gensets are aging and spare parts are becoming more expensive and difficult to locate. Replacement of at least two of the sets with new sets should increase efficiency and reduce maintenance costs.

Investment would be in the order of $45,000 per 60kW set installed.

Refurbishing the power station would improve working conditions with improved lighting, wiring, noise suppression in the operating room and general amenities. This would require an investment of approximately $15,000 - 25,000.

Fuel storage and handling facilities should be upgraded with increased bulk storage, improved fuel filtration and pumping, spill containment bunds and new day tanks. Investment needed would be approximately $20,000 - 30,000.

### 3.3.2 Distribution

HV distribution is to be upgraded with the installation of a new 50kVA transformer and associated LV feeder. This is a budgeted capital expenditure of $57,000 for 2004/2005.

Much of the LV distribution requires replacement. Aerial Bundled Cable (ABC) as used on Rarotonga has proved to be more serviceable and with lower maintenance costs than the existing separated aerial cables. Approximately 60% of existing poles would be considered suitable for the ABC. Investment Estimated investment is shown in Table 3-10.

**Table 3-10 LV Distribution Upgrade Investment**

| LV Distribution (incl. Freight) | Qty | Unit | Unit Cost | Extension |
|---|---|---|---|---|
| Arial Bundled Cable 95mm Al[8] | 11000 | meters | $ 9.65 | $ 106,150 |
| Replaced poles | 35 | each | $ 385.00 | $ 13,475 |
| Supply feeder connection to the ABC & install | 200 | each | $ 100.00 | $ 20,000 |
| Installation price per existing pole | 150 | each | $ 110.00 | $ 16,500 |
| Installation priced per replaced pole incl. labour & equipment | 35 | each | $ 220.00 | $ 40,700 |
| | | | ***Total LV*** | ***$ 196,825*** |

[8] Al is the abbreviation for Aluminium referring to the conductor material

**Picture 3-15 Sub-standard LV Distribution**

Photo – Bruce Clay, 2004

### 3.3.3 Administration and Personnel

Implement a staff training program. Presently there is no formal training program. MPS , Energy Division and OMIA should discuss what avenues are available for staff training and funding requirements. Training areas to be addressed are listed in table 3-11.

**Table 3-11 Training**

| TRAINING | CONTENT | OUTCOME |
|---|---|---|
| Electrical Wireman theory and practical. | Electrical theory and wiring rules<br>Electrical circuit calculations<br>Fault diagnosis<br>Wireman safety<br>Practical attachment to private firms regionally and/or utilities | Mauke Power Supply would have licensed electricians and improve safety awareness. |
| Electrical/Mechanical generator theory and maintenance. | Principals of generation<br>Metering and indication<br>Protection and control equipment<br>Maintenance and troubleshooting faults<br>Practical attachment to private firms or Government maintenance workshops | Increased skill level for generator operation and maintenance |
| Electrical Distribution | Distribution theory and circuit calculations<br>HV equipment maintenance and safety procedures<br>Practical attachment to TAU | Increased skill level for linesman and improved safety awareness. |

Upgrade billing system with simple computer generated billing and record keeping software. Atiu Energy has a simple spreadsheet billing system that could be employed. Energy staff would record the monthly meter reading and billing would be done using the billing software. This should help reduce erroneous billing plus enable more accurate record keeping. Likewise power station records could be incorporated.

Improve workplace and staff safety through investment in safety equipment such as insulated gloves, ear muffs, hard hats, high visibility vests, work boots and electrical maintenance tools. The power station should be secured from unauthorised and accidental access by way of compound fencing.

#### 3.3.4 Demand Side Management (DSM)

Mauke has no significant large intermittent loads that could assist in demand side management (DSM). The detailed energy survey undertaken clearly documents that the greatest contribution to peak loading is electric jugs, frypans and irons. It would be beneficial to investigate ways and means of encouraging consumers to use other forms of power for water heating and cooking such as gas or wood. The electric jugs are convenient being simple and fast.

Promotion and implementation of utilising energy efficient appliances and lighting has significant potential to reduce overall power consumption. This in turn can reduce the need for increased capacity in both generation and distribution. There may be an opportunity for a central organisation such as TAU or OMIA to provide energy efficient refrigeration and fluorescent lighting at near cost. The range of refrigerators and freezers could be minimised to assist in servicing and limit spare parts stocking.

Energy efficient compact fluorescent lighting is available from local stores however the cost appears relatively prohibitive for the majority of consumers. Relative to Atiu the ration of incandescent to fluorescent lighting is high indicating perhaps lack of availability and affordability issues. The high cost of shipping and margins required by the shop keepers contributes to their high retail price. Atiu Power Supply and other island power supplies may well consider a means of supplying lower priced lighting as the avoided cost of increased generation capacity would be significantly higher than any subsidy offered on efficient lighting.

### 3.4 Potential Local Renewable Energy Technologies

#### 3.4.1 Introduction

Various indigenous RE resources are available in the Cook Islands. These in theory include; solar, wind, wave, ocean thermal, biomass and biogas. The National Energy Policy (NEP) clearly sets the guidelines and policies for acceptable renewable energy technologies (RET). These include:

Self-sufficiency; *The provision of energy services shall utilise wherever practical and financially and economically feasible, indigenous energy resources, local expertise and local capital available within the Cook Islands*

Flexibility; *In general, the government will not consider the use of any technologies for energy production or savings that have not been technically proven and adopted commercially elsewhere. The national energy policy and all strategies and activities to implement it will be carried out with prudence and flexibility. It is likely, for example, that donors may support energy demonstration projects, which are technically proven and reliable and could benefit the country but may not be strictly commercial in the Cook Islands. It will approve non-commercial demonstrations based on these criteria:*

- *Experimental or unproven energy projects will not be tried in any island or remote communities. Communities that receive demonstration projects will provide in-kind assistance during planning and construction. They will pay a reasonable monthly fee (based on a national cost policy to be developed) for energy services received thereafter.*
- *For large- scale grid-connected commercial or pilot programmes based on renewable energy, any additional costs will not be imposed on consumers. The government will assure that any unusual financial risks to the utility (TAU or Island Councils) would be borne by the donor, supplier or financer.*

Policy 3.1; *Promote the increased use of appropriate renewable energy technologies, technically and commercially proven, financially and economically viable, and environmentally friendly.*

These policies and guiding principals exclude RETs that are not technical and commercially proven. Infant technologies; wave and Ocean Thermal Energy Conversion (OTEC) will not be considered in this report as they have not been proven, particularly in remote areas, either technically or commercially. Biomass, biogass, solar and wind are investigated further in the following chapters.

### 3.4.2 Biomass

As reported in the Cook Islands 2001 Population Survey, 35% of households use wood as their primary means of cooking. Liquefied Petroleum Gas (LPG) and electricity are the predominant means of cooking being relatively more convenient to use. As wood can be collected and does not require purchasing it can be reasonably assumed that its use is more prevalent in low income households. As the island develops economically the use of fuel wood is expected to decrease accordingly.

Fuel oil from coconuts offers the best biomass potential to substitute diesel fuel however present high labour and transport costs probably would result in a more expensive fuel than imported diesel. Fuel oil from coconut production has suffered from labour shortages in Fiji trials where the labour costs could be considered to be less than half that of the Cook Islands. Currently the Cook Islands imports coconut oil for cooking and cosmetics and there doesn't appear to be any drive from the private sector to develop milling facilities.

The 2000 Census of Agriculture and Fisheries shows Mauke has 64 households using 10,095 coconuts weekly for feeding livestock and 73 households using 2,039 coconuts weekly for consumption. The census shows approximately 2,400 "cultivated" coconut palm trees whilst the number of "wild" coconuts is not counted. 52 acres of tree crops are planted on Mauke and whilst the 2000 Census does not distinguish between crops it could be reasonably assumed most is used for coconut.

Despite apparent high production costs, coconut fuel oil combined with other local renewable resources could provide a long term solution to diesel substitution. A more detailed study of potential biofuel resources should begin in the short to medium term to ascertain the contribution that can be made in the longer term.

### 3.4.3 Biogas

The 2000 Census of Agriculture and Fisheries indicates more than 1,200 pigs and 600 goats on Mauke. Biogas production through anaerobic digestion of their wastes offers some potential. Biogas can be used for cooking and heating in a similar fashion to LPG.

As is the current situation in Southern Islands many of the pigs are not contained in pens and waste collection would be difficult. The MIC recognises that the significant number of pigs grazing freely is a concern given that they are causing damage to agricultural crops and the environment in general.

### 3.4.4 Solar

There is no measurement of solar radiation on Mauke however data collected from the Meteorological Office adjacent Rarotonga Airport is sufficient for preliminary design purposes. Mauke and Rarotonga are of similar latitude whilst Rarotonga being mountainous in comparison. Due to Mauke's low elevation it is reasonable to assume that solar radiation would be marginally higher than that of Rarotonga. For this assessment as we have no specific data for Mauke we will assume the same as Rarotonga.

Collected solar radiation data for Rarotonga is show in Table 3-12. This shows average solar radiation as 4.965 kWh/$m^2$/day, which is a significant resource by global averages. Minimum radiation in Winter is on average 3.510 kWh/m2/day due to the Cook Islands relatively low latitude. In higher latitude countries Winter minimum radiation can be particularly poor. Solar radiation data in table 3-12 has been measured on a horizontal surface rather than inclined. This also will underestimate the annual average as solar modules will be inclined to increase the total radiation collected over the year.

**Table 3-12 Solar Radiation Measurements, Meteorological Office site, Rarotonga (1995 data not complete)**

**kWh/m$^2$/day on a horizontal surface**

| | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC | YEAR |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **1986** | | | | | | 3.283 | 3.658 | 4.118 | 4.493 | 5.501 | 6.163 | 6.422 | 4.805 |
| **1987** | 5.098 | 5.616 | 5.242 | 4.925 | 3.082 | 3.600 | 3.600 | 3.917 | 5.098 | 6.192 | 5.990 | 5.875 | 4.853 |
| **1988** | 5.299 | 5.789 | 5.962 | 3.773 | 3.974 | 3.312 | 3.485 | 4.723 | 5.386 | 6.278 | 5.299 | 5.558 | 4.903 |
| **1989** | 5.645 | 6.394 | 0.000 | 4.378 | 3.888 | 3.715 | 3.686 | 4.723 | 5.443 | 5.443 | 5.270 | 5.933 | 4.956 |
| **1990** | 6.941 | 5.386 | 5.933 | 4.349 | 3.514 | 3.974 | 3.917 | 5.126 | 5.242 | 5.645 | 6.278 | 6.019 | 5.194 |
| **1991** | 5.962 | 5.386 | 5.818 | 4.608 | 3.629 | 3.456 | 3.859 | 4.378 | 6.048 | 0.000 | 6.336 | 5.990 | 5.043 |
| **1992** | 6.019 | 6.422 | 5.472 | 4.435 | 3.859 | 3.658 | 3.686 | 4.262 | 5.990 | 5.962 | 6.739 | 6.768 | 5.273 |
| **1993** | 6.509 | 5.962 | 5.184 | 4.550 | 3.946 | 3.686 | 3.370 | 4.003 | 5.069 | 5.933 | 6.710 | 6.019 | 5.078 |
| **1994** | 5.386 | 5.990 | 5.386 | 4.320 | 3.571 | 3.686 | 3.110 | 4.579 | 4.694 | 6.106 | 6.480 | 5.558 | 4.906 |
| **1996** | 5.069 | 5.213 | 5.299 | 4.176 | 3.283 | 3.226 | 3.773 | 4.406 | 5.184 | 5.472 | 6.134 | 6.048 | 4.774 |
| **1997** | 6.653 | 6.509 | 4.637 | 4.147 | 3.773 | 3.629 | 3.226 | 4.349 | 4.579 | 6.163 | 6.480 | 5.904 | 5.004 |
| **1998** | 6.250 | 4.723 | 5.069 | 4.982 | 4.003 | 3.571 | 3.254 | 4.464 | 4.954 | 6.221 | 6.480 | 5.674 | 4.970 |
| **1999** | 5.875 | 4.867 | 5.155 | 4.954 | 3.168 | 3.427 | 3.686 | 3.917 | 4.666 | 4.694 | 6.278 | 5.702 | 4.699 |
| **2000** | 5.990 | 6.250 | 5.472 | 4.579 | 3.485 | 3.312 | 3.370 | 4.147 | 4.954 | 5.357 | 6.451 | 5.933 | 4.942 |
| **2001** | 6.250 | 5.472 | 5.069 | 4.090 | 3.542 | 2.794 | 6.106 | 4.522 | 4.608 | 5.933 | 6.365 | 6.163 | 5.076 |
| **2002** | 6.077 | 5.760 | 5.242 | 4.435 | 4.320 | 3.514 | 3.859 | 4.061 | 5.386 | 5.155 | 5.155 | 6.422 | 4.949 |
| **2003** | 6.394 | 5.789 | 4.579 | 4.320 | 3.600 | 3.600 | 3.859 | 4.032 | 5.126 | 5.501 | 6.336 | 4.694 | 4.819 |
| **Average** | **5.963** | **5.720** | **4.970** | **4.439** | **3.665** | **3.510** | **3.740** | **4.351** | **5.152** | **5.378** | **6.174** | **5.891** | **4.965** |

Source – Cook Islands Meteorological Service (2004) and SPREP/GEF/UNDP Pacific Islands Renewable Energy Project (PIREP) Draft Cook Islands National Report May 2004

Considerable land area in excess of 150,000 m$^2$ is available for solar installation in the Nooangatua area located in the centre of the island. Most of the water bore holes are located in the area and no residential development is allowed to protect the quality of the water catchment. The area is the highest point on the island at 29m above sea level and is relatively flat with little vegetation making it ideal for a solar installation. The original airport was located adjacent and the HV feeder is within 300m.

### 3.4.5 Wind

Two wind assessment projects in the Cook Islands are the only source of long term wind data.

**1/** Southern Pacific Wind and Solar Monitoring Project by the Forum Secretariat installed a 10m wind and solar monitoring tower in November 1994 at Ngatangiia Point on the Eastern extremity of Rarotonga. Monitoring was carried out over a 2 year period and recorded an annual average wind speed of 5.5m/s @ 10m above ground level (a.g.l). The wind masts unobstructed exposure was from the North West through East to the South West. 60% of winds were from the Eastern quadrant as expected with the predominant Easterly trade wind patterns of the South Pacific.

Long term correlation with six year averages measured at the Meteorological Office at Rarotonga Airport indicate that the 1995 and 1996 wind speeds were on average lower by 5% to the long term mean. Subsequent wind mapping by Vergnet in May 1999[9], and COWI/Risoe 1998[10], using the Ngatangiia data, identified potential sites with estimated averages of 7.0 to 7.5 m/s at 30m height.

**2/** Vergnet carried out a wind power feasibility study for grid connected wind turbines on Mangaia Island in the Southern Cooks[11]. A 30m high monitoring tower was installed on a ridge 110m above sea level (a.s.l.) and commenced data logging in April 2001 until July 2002. The tower with two anemometers installed at 20 and 30mtr recorded 10minute average wind speed and wind direction.

Rurutu Island (French Polynesia) located 700 km to the East of Mangaia was chosen for long term correlation as there is a long term wind monitoring program in place and the monitoring station is unobstructed from all wind directions and located on a ridge at 250m a.s.l., unlike Rarotonga Airport near sea level on the North West coast.

The Mangaia monitoring station recorded an average wind speed at 30m a.g.l. of 6.3 m/s for the period while the Rurutu station recorded at 24m a.g.l. an average wind speed of 6.1 m/s and appeared to be in close correlation.

The long term average (from 14 years of data) for Rurutu at 24m a.g.l. is 7.4 m/s which put the Mangaia long term average at 30m a.g.l. at 7.5 m/s. Other wind data factors calculated through this study included:

| | |
|---|---|
| Wind Shear Ratio | $\alpha = 0.25$ |
| Weibull k factor | 2.8 |
| Open sea average wind speed at 10m a.s.l. | 5.9 m/s |

Mauke has two potential wind sites. One in the centre of the island adjacent the old airstrip at Nooangatua while the other is the South Eastern coastal area. Whilst the Nooangatua site is within 300m of the HV grid the South Eastern coastal area would require extension of the HV grid by approximately 3km.

[9] Cook Islands – Pre-feasibility study of wind power projects on Rarotonga, Atiu & Mangaia – May 1999 – Prepared by Vergnet SA, Laurent Albuisson

[10] Forum for Energy and Development (FED), Pacific-Danish Environmental Education and Action Program – Feasibility Study of Phase 1, prepared by COWI/Risoe, January 1998

[11] PREFACE Mangaia – Cook Islands Feasibility Study for a Wind Farm Connected on the Diesel Grid, prepared by Vergnet SA December 2001

**Picture 3-16 Nooangatua Wind and Solar Site**

Photo – Bruce Clay, 2004

Due to the islands relative flatness and small slope to the highest centre section of the island little acceleration due to terrain is expected. Wind speed deceleration in the centre of the island due to vegetation is assumed to be insignificant. The South East coast has several areas of lesser vegetation to minimise that effect but would have a degree of obstruction from the North through West to the South West.

Based on the monitored data from Mangaia and open sea predictions the average wind speeds for the two sites in Mauke have been estimated. These estimates are strictly for preliminary analysis and the financial analysis will test the sensitivity of varying these figures. Estimated average wind speeds for the two sites are shown in table 3-13.

**Table 3-13 Mauke Estimated Average Wind Speed**

| | |
|---|---|
| **Nooangatua** | |
| Commencing with Managia annual average @ 30m a.g.l. | 7.5 m/s |
| Decrease in wind speed due to less terrain effect | 10% |
| Assumed wind shear ratio as per Mangaia | α = 0.25 |
| Then Nooangatua annual average @ 24m a.g.l. | 6.4 m/s |
| and @ 30m a.g.l. | 6.5 m/s |
| **South East Coast** | |
| Commencing with Open Sea Average @ 10m a.s.l. | 5.9 m/s |
| Decrease in wind speed due to obstruction from island | 10% |
| Assumed wind shear ratio with little vegetation | α = 0.20 |
| The South East Coast annual average @ 24m a.g.l. | 6.3 m/s |
| And @ 30m a.g.l. | 6.4 m/s |

Given the cost of transmission from the South East Coast site the central Nooangatua site would be more financially attractive provided land use is not a serious issue.

On-site wind monitoring to verify the wind resource would be a prerequisite for any larger scale implementation of wind energy involving considerable capital investment. A long term monitoring station should be established in the Southern Group to enable long term correlation of wind data collected from various potential wind sites in the Southern Group. A project is presently underway to install a monitoring station on Aitutaki, which could perhaps be the long term station. In this way short term monitoring (6 to 12 months) on specific sites, such as on Mauke, would allow quite accurate wind energy estimation. Siting of this long term station will be critical in gathering quality data.

## 3.5 Project Engineering Considerations

Transportation of equipment to Mauke and then to site is the first consideration for any project design. Handling of equipment is limited to what the inter island ship, island barge and trucking can manage. It is safe to assume items up to 3 tonnes can be managed. Small trucks, 4WD vehicles and mobile fuel tanks can be supplied by the existing infrastructure. Individual components should be below 3 tonne. This will not be an issue with the solar or wind systems being considered as individual components are not likely to exceed 800kg.

Table 3-14 list the Island Administration's equipment which could be used on power development projects.

**Table 3-14 Mauke Island Administration Equipment**

| Type and Description | Current Status | Charge out Rate |
|---|---|---|
| 6 tonne hydraulic hoist truck (Hyab). Used for unloading barge and general lifting/carting works on island | Operative in reasonable condition | $45/hr |
| JCB Brand 3CX-14 loader/backhoe (JCB) 14 years old | Requires hydraulic overhaul. Run down with body in poor condition. Uses excessive hydraulic and ATF oil | $60/hr |
| 5 tonne tip truck. Purchased 2nd hand form New Zealand | Reasonable condition | $20/hr |
| 2 x engine driven cement mixers | Working condition | N.A. |
| 4 tonne barge powered by a two Yamaha 40 outboards[12] | Good condition | ~$30/$m^3$ |

Both a new Hyab truck and JCB have been requested by the MIA however no capital expenditure authorisation has been given to date. Both of these items of equipment would be important for any wind power installation.

**Picture 3-17 Hyab Truck and JCB Loader**

Photo – Bruce Clay, 2004

12 **A new larger barge is included in the current 2004/2005 budget.**

Due to the lack of aggregate on the island, cement is mixed using broken up Makatea and coral sand. Care should be taken in foundation design to account for this with perhaps the use of a cement additive to strengthen the mix. Most wind turbine and ground mounted solar array foundations rely more on mass so this may not be a serious hindrance to their development.

The centre island Nooangatua site is characterised by red friable soil with rare limonitic boulders scattered around the surface and would not hinder foundation excavation or trenching which could be carried out by the JCB backhoe.

The South East coastal site is characterised by Makatea which is more difficult for excavation and more engineering design would be required for an optimal foundation solution for a wind power development. Running of a HV feeder from the sit would also need to consider trenching in the Makatea.

### 3.6 Personnel and Organisational Considerations

Both small scale wind and solar power development would require training of current personnel in their operation and maintenance. Given that the power station staff already have experience in diesel station operation, training would not need to be extensive.

Telecom has been successfully operating a 6kWp solar power system since 1992. A correctly installed PV system should require little maintenance with bi-annual inspections for array and module physical integrity and annual testing of system performance.

The smaller wind turbines in the 20kW class use mechanical regulation and standard asynchronous generators with little electronic competence required. Maintenance training would be carried out during installation and for the first inspection/servicing when a representative from the turbine suppliers should be present.

Preparation of maintenance and operation training videos available for use by power station personnel may assist in an ongoing programme of skill development.

Given Mauke's limited number of energy personnel it may be prudent to budget for an extra operator for a wind power system, particularly during the night when the rest of the energy staff is off duty.

### 3.7 Most Optimal Local Energy Resource in Short and Medium Term

When applying the criteria of available resources, past experience in Cooks and the region, project engineering considerations and personnel and organisational considerations it can be concluded that solar and wind energy are the most optimal local energy resources in the short and medium term. Without the addition of any battery energy storage to the system, the amount of solar or wind energy that can be fed into the diesel grid is limited due to grid instability issues such as fluctuating renewable energy input, frequency stability and power factor. Experience from the operation of 2 x 20kW grid connect wind turbines on Mangaia Island has show that between 35 – 50% of load has been able to be supplied by wind energy without reducing the system power factor below 0.7. For grid connected solar PV we have assumed the generally maximum acceptable level of 20% of solar energy input.

Both direct AC grid-connected solar and wind energy do not provide any firm capacity to the power system and as such the avoided cost of energy is for all practical purposes equivalent to avoided fuel cost. This is calculated as:

Mauke SFC 2.18 kWh/l (average for period July 2003 – June 2004)

Present Landed Fuel Cost - $1.069/l

**Avoided Cost of Energy - $0.49/kWh**

With battery storage renewable energy inputs can be increased to above the current load levels with excess energy being stored in the battery bank. Should the renewable energy level be insufficient to supply the load, energy will be used from the battery bank to make up the short fall. If battery levels fall to a level requiring re-charging and sufficient renewable energy input is not available then the diesel generation can be used to re-charge and supply loads. Hybrid battery storage systems and their associated integration are generally very costly. This approach, however, offers the only present opportunity to increase the percentage of renewable energy input to the power supply.

Whilst addition of battery storage theoretically enables a power system to be purely renewable energy based, the added complexity of operation and maintenance requirements can put the system out of reach unless suitably qualified technicians and operators are on hand. Experience in other Pacific Island countries has shown the difficulty in providing and keeping trained personnel for rural power services.

### 3.7.1 Option 1 Grid Connect Solar PV

Mauke's midday loading is in the order of 25-28kW which should allow the inclusion of 5-6kWp (i.e. 20%) of solar. The array could be mounted on the roof of a suitably aligned public building. Modelling of grid connected PV was carried out using both RETScreen[13] and Homer software based on the use of standard grid-connect PV equipment. Assumed system nominal specifications and estimated costs and financial parameters are listed in table-3-15. Results were tested for sensitivity to installed cost and the avoided cost of energy as shown in tables 3-16,17,18.

**Table 3-15 Grid Connect PV Specifications, Cost and Financial Parameters**

| | |
|---|---|
| PV Array | 5.76 kWp |
| Array Area | 53 $m^2$ |
| Grid Inverter | 5 kW |
| Annual energy production | 8,667 kWh |
| RE Fraction of total energy production | 3.3% |
| Diesel Fuel Substituted | 1,786 litres p.a. |
| Installed Total Cost | $89,180 |
| Installed Cost/Wp | $15.48 |
| O&M/year | $660 |
| System Life | 25 years |
| Discount | 6% |
| Project life | 15years |

**Table 3-16 Capital Cost Sensitivity**

| Installed Cost ($) | Variation | RE Production Cost ($/kWh) |
|---|---|---|
| 44,589 | -50% | **0.50** |
| 66,884 | -25% | **0.76** |
| **89,178** | **0%** | **1.03** |
| 111,473 | 25% | **1.29** |

**Table 3-17 Net Present Value (NPV)[14]**

| | | Avoided Cost of Energy ($/kWh) | | | |
|---|---|---|---|---|---|
| **Installed Cost** | | 0.39 | **0.49** | 0.61 | 0.74 |
| ($) | Variation | -20% | **0%** | 25% | 50% |
| 44,589 | -50% | -8808 | **-586** | 9692 | 19970 |
| 66,884 | -25% | -31102 | **-22880** | -12602 | -2324 |
| **89,178** | **0%** | **-53396** | **-45174** | **-34896** | **-24618** |
| 111,473 | 25% | -75690 | **-67468** | -57190 | -46913 |

[13] RETScreen is a renewable energy project analysis software (Version 3.0 Wind Energy) developed under the authority of the Ministry of Natural Resources, Government of Canada

[14] Net Present Value (NPV) is the present value of the projects future earnings over the project life (savings against diesel in this case) based on the discount rate (cost of capital) of 6%

**Table 3-18 – Internal Rate of Return (IRR)[15]**

| Installed Cost | | Avoided Cost of Energy ($/kWh) | | | |
|---|---|---|---|---|---|
| | | 0.39 | **0.49** | 0.61 | 0.74 |
| ($) | Variation | -20% | **0%** | 25% | 50% |
| 44,589 | -50% | 3.5% | **5.8%** | 8.6% | 11.3% |
| 66,884 | -25% | -0.5% | **1.3%** | 2.5% | 5.5% |
| **89,178** | **0%** | **-3.1%** | **-1.6%** | **0.3%** | **2.1%** |
| 111,473 | 25% | -5.0% | **-3.6%** | -1.9% | -0.4% |

At present avoided cost of energy the solar PV would only be financially viable with capital costs reduced by around 50%. With an increase of around 25% in avoided cost of energy (i.e. diesel fuel cost) and PV capital costs reduced 50% the system would be financially viable.

### 3.7.2 Option 2 Grid Connect Wind

A 20kW wind turbine would be the maximum feasible size to connect to Mauke's grid. At an estimated average wind speed of 6.4m/s the 20kW wind turbine should be able to deliver 83% of its output to the grid with 17% excess. Some DSM could be considered to utilise the excess.

Assumed system nominal specifications and estimated costs and financial parameters are listed in Table 3-19.

**Table 3-19 Grid Connect Wind Specifications, Cost and Financial Parameters**

| | |
|---|---|
| Wind Turbine Generator | 20kW |
| Hub Height | 24m |
| Average wind speed at hub height | 6.4m/s |
| Weibull k factor | 2.8 |
| Annual RE production | 31,150kWh |
| Annual Excess RE | 5,110kWh |
| RE fraction of total production | 11.8% |
| Diesel Fuel Substituted | 6,030 litres |
| | |
| Installed Total Cost | $202,430 |
| O&M/year | $5,830 |
| System Life | 20 years |
| Discount | 6% |
| Project life | 15years |

Financial sensitivity is tested as per the following Tables 3-20,21,22.

**Table 3-20 Capital Cost Sensitivity**

| Installed Cost | | RE Production Cost |
|---|---|---|
| ($) | Variation | ($/kWh) |
| 101,215 | -50% | **0.54** |
| 151,823 | -25% | **0.74** |
| **202,430** | 0% | **0.94** |
| 253,038 | 25% | **1.14** |

[15] Internal Rate of Return (IRR) is the precise discount rate that gives a Net Present Value of 0.The IRR should be above the required discount rate (in this study 6%) for financially viability.

**Table 3-21 – Net Present Value (NPV)**

| Avoided Cost of Energy ($/kWh) | | | | | | |
|---|---|---|---|---|---|---|
| **RE delivered** | | 0.25 | 0.37 | **0.49** | 0.61 | 0.74 |
| **(MWh)** | Variation | -50% | -25% | **0%** | 25% | 50% |
| 13 | -50% | -207,011 | -191,548 | **-176,086** | -160,623 | -145,160 |
| 19 | -25% | -191,548 | -168,354 | **-145,160** | -121,967 | -98,773 |
| **26** | **0%** | **-176,086** | **-145,160** | **-114,235** | **-83,310** | **-52,385** |
| 32 | 25% | -160,623 | -121,967 | **-83,310** | -44,653 | -5,997 |
| 39 | 50% | -145,160 | -98,773 | **-52,385** | -5,997 | 40,391 |
| **Installed Cost** | | | | | | |
| **($)** | Variation | | | | | |
| 101,215 | -50% | -74,871 | -43,945 | **-13,020** | 17,905 | 48,831 |
| 151,823 | -25% | -125,478 | -94,553 | **-63,628** | -32,702 | -1,777 |
| **202,430** | **0%** | **-176,086** | **-145,160** | **-114,235** | **-83,310** | **-52,385** |
| 253,038 | 25% | -226,693 | -195,768 | **-164,843** | -133,918 | -102,992 |
| 303,646 | 50% | -277,301 | -246,376 | **-215,450** | -184,525 | -153,600 |
| **Annual costs** | | | | | | |
| **($)** | Variation | | | | | |
| 2,915 | -50% | -147,775 | -116,849 | **-85,924** | -54,999 | -24,073 |
| 4,373 | -25% | -161,930 | -131,005 | **-100,080** | -69,154 | -38,229 |
| **5,830** | **0%** | **-176,086** | **-145,160** | **-114,235** | **-83,310** | **-52,385** |
| 7,288 | 25% | -190,241 | -159,316 | **-128,391** | -97,466 | -66,540 |
| 8,745 | 50% | -204,397 | -173,472 | **-142,546** | -111,621 | -80,696 |

**Table 3-22 IRR**

| Avoided Cost of Energy ($/kWh) | | | | | | |
|---|---|---|---|---|---|---|
| **RE delivered** | | 0.25 | 0.37 | **0.49** | 0.61 | 0.74 |
| **(MWh)** | Variation | -50% | -25% | **0%** | 25% | 50% |
| 19 | -50% | 13 | -50% | -11.7% | -9.9% | **-8.3%** |
| 29 | -25% | 19 | -25% | -9.9% | -7.5% | **-5.3%** |
| **38** | **0%** | **26** | **0%** | **-8.3%** | **-5.3%** | **-2.5%** |
| 48 | 25% | 32 | 25% | -6.7% | -3.2% | **0.0%** |
| 57 | 50% | 39 | 50% | -5.3% | -1.3% | **2.3%** |
| **Installed Cost** | | | | | | |
| **($)** | Variation | | | | | |
| 101,215 | -50% | -3.8% | 0.4% | **4.4%** | 8.1% | 11.7% |
| 151,823 | -25% | -6.4% | -3.0% | **0.2%** | 3.1% | 5.8% |
| **202,430** | **0%** | **-8.3%** | **-5.3%** | **-2.5%** | **0.0%** | **2.3%** |
| 253,038 | 25% | -9.7% | -6.9% | **-4.5%** | -2.2% | -0.1% |
| 303,646 | 50% | -10.8% | -8.3% | **-6.0%** | -3.9% | -2.0% |
| **Annual costs** | | | | | | |
| **($)** | Variation | | | | | |
| 2,915 | -50% | -5.5% | -2.8% | **-0.2%** | 2.1% | 4.3% |
| 4,373 | -25% | -6.9% | -4.0% | **-1.4%** | 1.1% | 3.3% |
| **5,830** | **0%** | **-8.3%** | **-5.3%** | **-2.5%** | **0.0%** | **2.3%** |
| 7,288 | 25% | -9.8% | -6.6% | **-3.8%** | -1.2% | 1.3% |
| 8,745 | 50% | -11.4% | -8.0% | **-5.0%** | -2.3% | 0.2% |

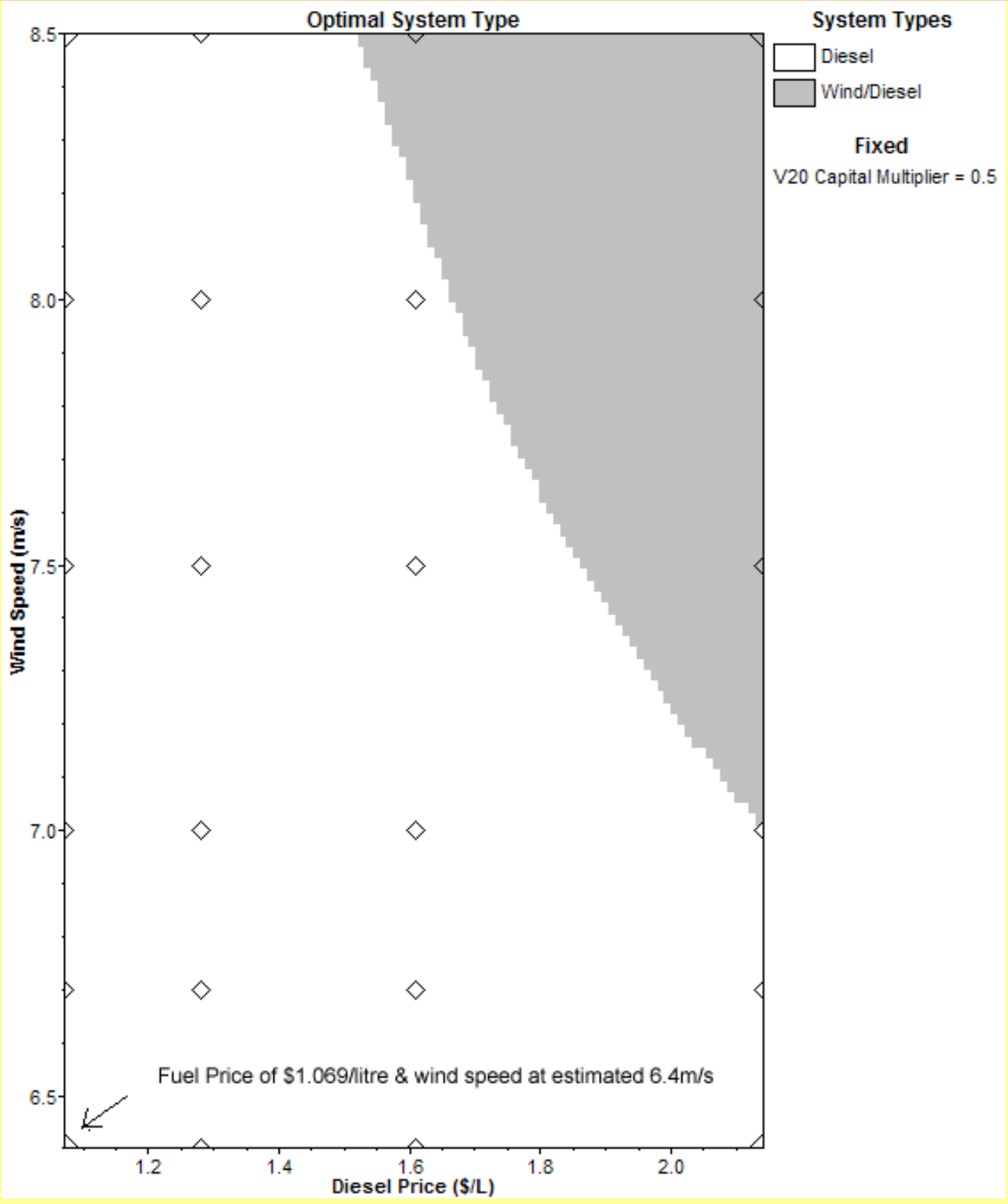
Grid connect wind is both economically and financially more viable than solar PV and would contribute a higher amount of renewable energy to the system. Economic and financial viability is dependent on effectively reducing capital costs through some form of grant funding.

System modelling with Homer investigated the financial viability of wind considering varying Capital Cost multipliers. Figure 3-1 shows graphically the financial sensitivity to wind speed and diesel fuel price with a fixed wind capital cost of 50% "real" cost. The grey shaded area representing wind/diesel system as optimum whilst the white areas represent diesel only as the optimum. For example at a wind speed of 7.0m/s fuel cost needs to be at least $2.15/lt before the wind turbine is viable and e.g. if the average wind speed was 8m/s you require a fuel price of at least $1.65 for the wind turbine to be financially viable.

Figure 3-2 shows graphically the financial sensitivity to varying capital and fuel costs with a fixed wind speed of 6.4m/s (the estimated average for Mauke). Here the grey areas represent diesel only as optimal whilst white areas are wind/diesel. At present fuel cost of $1.069/lt

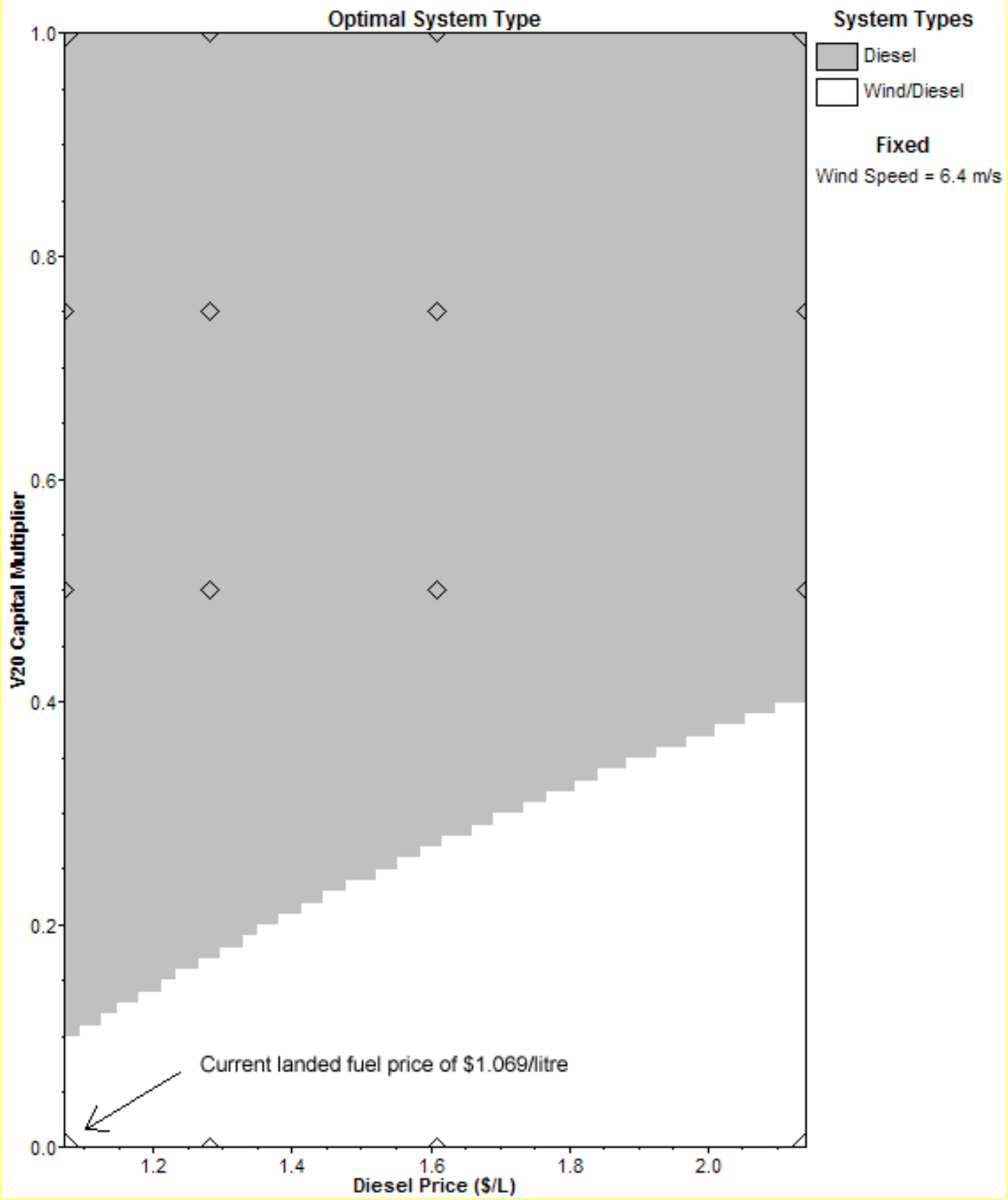
(where the x and y axis intersect) the required capital cost for wind to be financially viable is approximately 0.1 (10%) of the "real" cost.

**Figure 3-1 Optimal System Type with 50% Capital Cost**




Source – Homer

**Figure 3-2 Optimal System Type with varying capital and fuel cost**




Source - Homer

### 3.7.3 Option 3/ Hybrid Battery System

The hybrid system provides the ability to store energy with the addition of a battery bank. Additional costs are however also incurred with the required addition of inverters and rectifiers for the AC grid to interact with the DC battery bank.

Homer was used to evaluate the complex system combinations and provide optimal system configurations and total Cost of Energy (COE) produced by the system.

For wind turbine modelling a Westwind 20kW DC battery charging WTG was selected as being the most economical. This WTG comes standard from Westwind on a 30m tilt-up tower.

Table 3-23 shows the results at wind speed of 6.5m/s, fuel at $1.069/l and full capital costs. Diesel only generation is $0.23/kWh less than with addition of any renewable energy.

**Table 3-23 COE of Diesel and Diesel Hybrid Systems**

| | PV Array (kW) | WTG (kW) | Total Capital | COE ($/kWh) | RE Fraction | Diesel (litres) | Diesel (hours) |
|---|---|---|---|---|---|---|---|
| Diesel Only | | | $833,687 | **1.112** | 0 | 118,597 | 8,760 |
| Diesel/Battery | | | $1,374,087 | **1.329** | 0 | 107,435 | 4,864 |
| Wind/Diesel/Battery | | 40 | $1,621,701 | **1.343** | 0.24 | 82,441 | 3,891 |
| PV/Diesel/Battery | 40 | | $1,836,887 | **1.401** | 0.19 | 87,808 | 4,111 |
| Wind/PV/Diesel/Battery | 40 | 40 | $2,084,501 | **1.414** | 0.43 | 62,436 | 3,102 |

Acronyms; Wind Turbine Generator (WTG), Renewable Energy Fraction of production (RE Fraction)

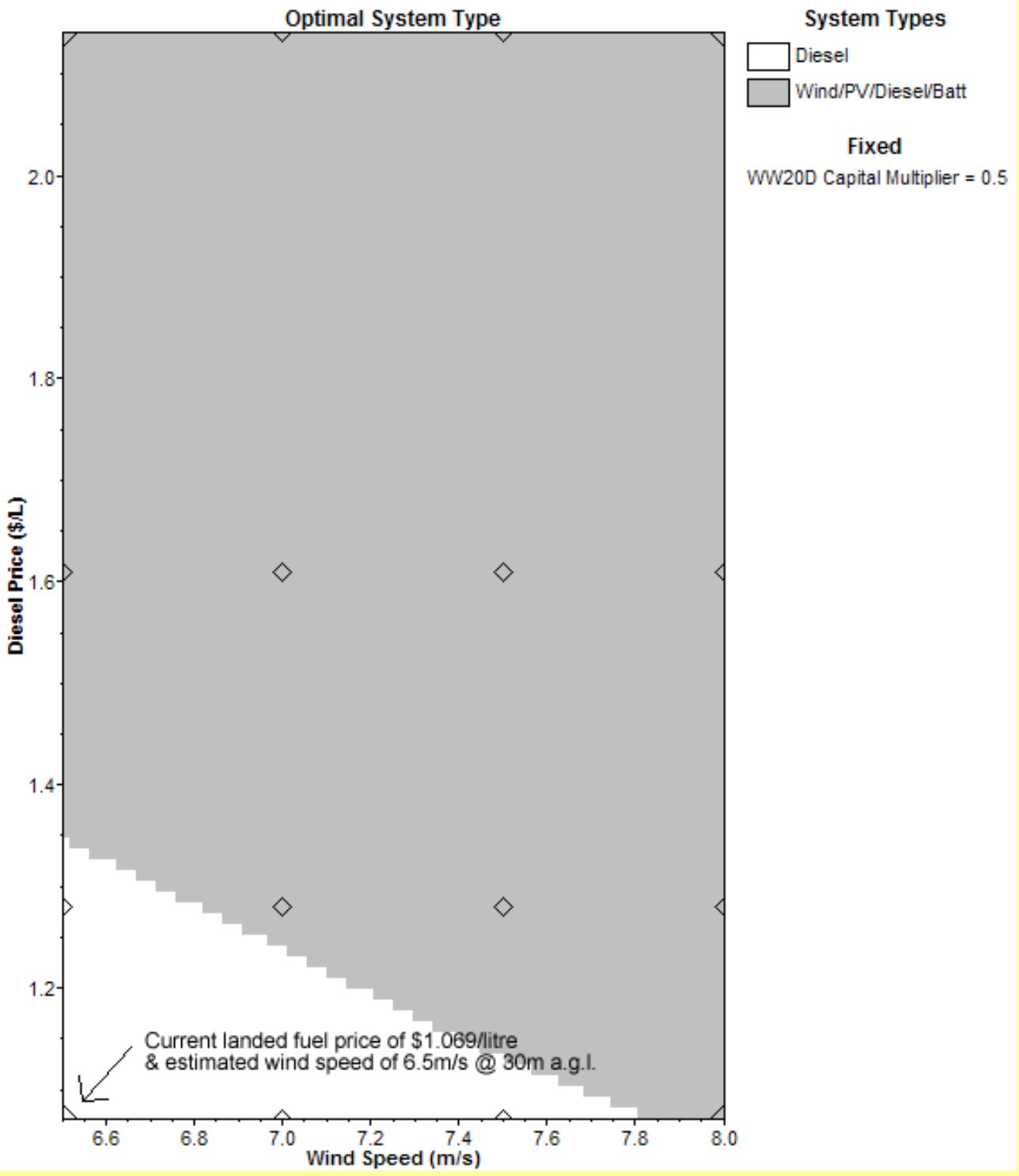
With capital cost reduced by 50% and wind speed of 6.5m/s and fuel at $1.069/l renewable energy systems are within 6% of the COE of the diesel based system. This is shown in table 3-24.

**Table 3-24 COE of Diesel and Diesel Hybrid Systems with 50% reduction of RE & Battery Capital Cost**

| | PV Array (kW) | WTG (kW) | Total Capital | COE ($/kWh) | RE Fraction | Diesel (litres) | Diesel (hours) |
|---|---|---|---|---|---|---|---|
| Diesel Only | | | $833,687 | **1.112** | 0 | 118,597 | 8,760 |
| Diesel/Battery | | | $1,103,887 | **1.209** | 0 | 107,435 | 4,864 |
| Wind/Diesel/Battery | | 40 | $1,227,694 | **1.178** | 0.24 | 82,441 | 3,891 |
| PV/Diesel/Battery | 40 | | $1,335,287 | **1.205** | 0.19 | 87,808 | 4,111 |
| Wind/PV/Diesel/Battery | 40 | 40 | $1,459,094 | **1.173** | 0.43 | 62,436 | 3,102 |

Figure 3-3 shows the sensitivity of the proposed renewable energy systems to wind speed and fuel costs when the capital cost is reduced by 50%. It shows that at the current fuel cost that a wind/diesel system is financially feasible at wind speeds above 7.8 m/s and that the wind/PV/diesel/battery hybrids are financially feasible once fuel prices reach close to $1.35/lt.

**Figure 3-3– Optimal System Type with 50% Capital Cost**




Source – Homer

### 3.7.4 Overall Recommended Option

Grid connected wind offers the most optimal local renewable energy generation in the short to medium term. Grid connected wind meets the NEP 2003 criteria for being technically and commercially proven and can be operated and maintained by local staff as is done currently at Mangaia. Of the various combinations of solar PV, wind and hybrid battery power systems the grid connected wind has been shown to be the most economically and financially viable.

As documented in the sections above direct grid connected wind and solar generation offer the best economical and financial option and in addition with minimum technical personnel requirement and limited environmental impact. However use of a wind turbine offers the greatest energy contribution at close to 12% of the total energy requirements whilst solar can produce a little more than 3% and as such the recommended system would be a 20kW wind turbine generator located on the old Airport site.

The recommended installation would utilise a 20kW wind turbine which would generate 12% of Mauke's power requirements and save over 6,000 litres of diesel fuel annually.

Estimated costs of implementation are shown in Table 3-25.

**Table 3-25 20kW Grid-connected Wind Capital Costs**

| | |
|---|---|
| 20kW WTG with 24mtr tilt-up tower and hydraulic winch | $109,283 |
| Cabling, 30kVA 3.3kV transformer | $12,188 |
| Shipping, handling and insurance to site | $16,099 |
| Project Design and Development | $20,657 |
| Installation, Training and Commissioning | $25,803 |
| Contingency @ 10% | $18,403 |
| **Total Installed Capital Cost** | **$202,432** |

**Picture 3-18 20kW Wind Turbine as recommended for Mauke**

Photo – Bruce Clay, 2004

## 3.8 Most Optimal Long Term (5-10years Local Energy Resources

Biofuel from coconut oil offers long term technical and financial potential to contribute to the provision of 100% renewable energy power generation on Mauke in conjunction with the local renewable energy sources of wind and solar. Biofuel powered generation would not require battery storage and as such would simply replace the present diesel generation.

The addition of battery storage can also be a long term option should biofuel prove to not be practically or financially viable. Experience gained in the medium term through smaller scale renewable energy implementation will give MPS the ability to address the skill requirements of a battery hybrid system.

With the addition of wind energy in the medium term, biofuel can in the long term displace diesel. Investigation into the practical and financial aspects of biofuel production should commence in the short to medium term.

Whilst solar power generation is technically feasible its financial and economic viability should be monitored in the medium to long term given the rapidly expanding solar industry and potential for cost reduction and improved efficiencies.

## 3.9 Preliminary Environmental Impact Assessment

The following preliminary environmental impact assessment (PEIA) has been carried out under the guidelines of the Cook Islands Environment Service and the ADB Environmental Guidelines for Selected Industrial and Power Development Projects (1993).

The GoCI has repealed the Rarotonga Environment Act and enacted the Environment Act 2003 which aim is "to provide for the protection, conservation, and management of the environment in a sustainable manner". Under the Act each Outer Island shall establish an Island Environment Authority with the aim of identifying specific environmental concerns for the island and working with the Environment Service to implement policies and programmes relevant to each island.

This PEIA will discuss the present impact of the islands power system and potential impact of recommended power system future options.

### 3.9.1 Present Situation

Diesel power generation in Mauke is similar to that used throughout the Pacific Island Countries and elsewhere where village size remote power generation utilises diesel generation. Whilst the operation of the diesel generators in them selves should have little

environmental impact, fuel and oil handling, noise and safety issues are common areas for concern.

### *Fuel and Oil Handling*

Fuel is transported by inter island vessels as bulk in hull tanks to the island where the ship anchors just offshore and fuel is pumped into mobile tanks of 1600lt capacity carted by the islands lighter. One mobile tank at a time is handled. A Hyab style lift truck then lifts the mobile tank off the lighter and transport it to the power house.

Lubricating oil is supplied in 205l drums and delivered by the lighter and Hyab truck to the power house.

Once at the power house the mobile tanks are stored on the ground adjacent and pumped to the main bulk tanks as required. Oil drums are likewise stored adjacent and oil pumped into smaller containers for use on the generating sets. There is no provision for spill containment and retrieval.

Evidence of fuel and oil spills was seen in and around the power house and inside the generator building. The generator building floors although showing signs of oil and fuel contamination were generally in a reasonable condition indicating that the generators are maintained and not leaking any considerable amount of fuel or oil.

Whilst there is a fire extinguisher on site its effectiveness would be questionable as there was no sign of recent servicing and its size would only be suitable for a small contained fire outbreak.

The impact of fuel and oil leakage appears to be minimal to the immediate flora and fauna however soakage into the soil strata and it's depth of penetration was unknown. Outside of a 10m radius of the power house the plant life did not appear significantly affected. Due to the porosity of the soil and sub surface Makatea it would be expected that the fuel and oil would make its way to the coastal waters. The oil will affect the ability of contaminated soils to provide a suitable environment for plants and micro organisms to grow and propagate with oil and fuel additives being potentially hazardous to fauna and humans.

Disposal of waste lubricating oil is of great concern. Presently there is no procedure in place for correct disposal. Waste oil is supplied to the community on an ad hoc basis where it may be used for marking playing fields and on mechanical repairs of agricultural and transport equipment. Given that nearly 900 litres of oil is used annually, how this oil is disposed of is of serious environmental concern. Inevitably current practises would indicate all waste oil will be absorbed at some point into the ground and penetrate the ground water. Waste oil should be sent back to Rarotonga for correct disposal or recycling. It has been suggested that the oil companies supplying fuel and oil should be contractually obliged to accept returned waste oil as is done for power generation on Rarotonga by TAU.

Whilst not part of the electrical generation on Mauke it is important to note the environmental impact caused by the diesel driven bore water pumps used for the public water system. Since the windmill pumps fell into disrepair several years ago, single cylinder Lister diesel engines have been used to power the bore pumps. Most of these engines are leaking considerable oil and fuel onto the surrounding ground which is directly above the water source. Parts have been ordered to repair the windmills which will reduce the use of diesel pumps however these diesel engines should be serviced or containment be provided.

#### *Air Pollution*

Whilst the diesel generators do emit both chemical and particulate matter, the amount of the emissions is relatively insignificant and there are no residences in the immediate area of the power station. The pollutants would disperse and dilute to such an extent that threat to flora and fauna would be minimal. In an urban environment with a far greater density of diesel and petrol powered vehicles the engine emissions are a concern with high concentrations of sulphur and nitrous oxides linked to accelerated forms of cancer and chronic raspatory illnesses.

#### *Noise Pollution*

Residents within 200m of the power house will and do hear the operation of the generators. This could be categorised as a subjective effect of annoyance and nuisance noise. Many of the residents would have grown accustomed to the power station noise. Fortunately the closest residence would be close to 100m distant and would not be adversely affected to the point of interference to speech or sleep.

#### *Public Safety*

Mauke's electrical distribution operates at voltages up to 3,300V and consumer connections at 230V. These voltages are particularly hazardous and life threatening. Consumers, public and workers should be made aware of these hazards.

Electrical installations that are to the AUS/NZ 3000 electrical standard minimise the risk of electric shock. Security of metering on consumer premises and aging consumer installations require upgrading to standards to ensure the safer operation of the power system.

The power station compound is not fenced and as such public could enter and expose themselves to potential threats. This is particularly the case when the station is not manned. There should as a minimum be signage highlighting the potential hazards and warning the public not to enter.

### 3.9.2 PEIA for Recommended Short and Medium Term Renewable Energy Option

As documented above the most optimal local energy resource in the short/medium term for Mauke is wind power and more specifically for the addition of a 20kW grid-connected wind turbine without energy storage. Since there is no additional equipment such as batteries banks

the environmental impact is effectively limited to the construction and operation of the wind turbine.

### *Construction*

Construction may begin after an "Environmental Significance Declaration" is made to the Cook Islands Environment Service and a project permit issued. The declaration addresses the following issues:

- Location;
- Project description;
- Existing land use;
- Biological resource effects including loss of habitat or natural vegetation;
- Physical effects to the land;
- Pollution and degradation of water and soil quality;
- Cultural and historical heritage; and
- Social and economic effects.

The wind turbine, tower and associated electrical connection equipment would be transported to the island by inter island shipping and handled in the same many as general cargo. Most of the components of the turbine are ferrous and non-ferrous metals and fibre reinforced plastic and poses no serious threat of environmental contamination. The only hazards during transport are those associated with small quantities of lubricating oil.

There should be minimal earthworks for the turbine foundations or access road as the site is relatively flat and already has reasonable vehicle access. There is little vegetation on the site and as such no clearance is anticipated.

Foundations would consist of four anchor blocks and a central tower pad. Total excavation would be approximately 20 m3 and be filled with concrete. There would be cable trenching involved for connection but impact would be minimum as the area is characterised by grass with few scrubs or trees. The total footprint of the tower would be approximately 600 $m^2$.

Impact during this construction phase should be minimal and mainly associated with the excavation of foundations and trenching.

### *Operation*

Environmental impacts during the turbines operation are limited to the following:

- Noise - As the turbine is to be sited in an open area at least 200 metres from the nearest residence impact of noise will be insignificant.

- Visual – Windmills have been used on Mauke to pump water for many years and the community has grown use to their presence. Visually the wind turbine is far enough from residences to not through shadows and it is unlikely it could be seen from the villages at ground level.
- Birds – Many studies have been carried out on effects of WTG on birds. Bird strikes are very dependent on the number and species of birds and if this was a significant impact the existing windmills would have highlighted the issue.
- Public Health and Safety – Limiting access to the electrical cabinets at the wind turbine is important to prevent accidental electrocution. Most of the WTG tower and structure should be safe unless tampered with. Good signage and perhaps fencing would limit the threat to the public.

The positive impact of the WTG is the substitution of 6,000l of diesel per year. This corresponds to a net greenhouse gas reduction of approximately 23 $t_{C02}$/year plus reduced risk of diesel transportation and handling.

# 4 ANNEXES

## Annex A – Terms of Reference

Terms of Reference for
Power Sector/feasibility Study Report with regard to Atiu, Mauke, and Mitiaro and
Power Recommendation Paper with regard to Pukapuka [16]

### 1. INTRODUCTION

The Government of the Cook Islands recognises the significant potential contribution that renewable energy can make to the economy, the environment and social development in the medium and long term. In this context UNDP (Samoa) has funded the Technical Assistance (TA) project *Increase the Utilisation of Renewable Energy Technologies in the Cook Islands Energy Supply* executed by UNESCO (Apia) in cooperation by the Energy Division (ED), Ministry of Works, Government of the Cook Islands.

In line with the National Energy Policy (2003) and the Budget Policy Statement (2003-2004) the TA is primarily designed to assist the Government of the Cook Islands in assessing the possibilities to increase the utilisation of renewable energy sources on three (3) of the Outer Islands in the Southern Group in the medium to long term. In addition a minor part of the consultancy is designed to advise the Government whether the Outer Island of Pukapuka in the Northern Group should improve the current photovoltaic (PV) Solar Home Systems (SHS) or install (in addition) an AC power system based on diesel generators.

### 2. OBJECTIVES

With regard to the islands of Atiu, Mauke, and Mitiaro:

(a) To determine in detail what improvements, in the *short term,* should be undertaken in the current diesel based power systems.

(b) To determine in detail the technical, socio-cultural, economic, financial and institutional/management feasibility, in the *medium term,* of supplementing the current diesel systems with renewable energy sources.

[16] The Government of the Cook Islands has identified the overall scope for this technical assistance consultancy during a UNESCO Apia mission to Rarotonga, Cook Islands in July 2003. The detailed Terms of Reference (TOR) subsequent has been prepared by UNESCO Apia with input from the Energy Division (ED), Ministry of Works, Government of the Cook Islands. In addition a rural energy expert has provided input on the TOR. UNESCO Apia would like to thank very much the rural energy expert for his invaluable and continued support.

(c) To determine in detail the technical, socio-cultural, economic, financial and institutional/management feasibility, in the *long term,* of replacing 100% of the current diesel based power systems with renewable energy sources.

With regard to the island of Pukapuka:

(a) To preliminary assess and recommend if the most optimal power solution is to improve the existing PV Solar Home Systems (SHS) or to install (in addition) an AC power system based on diesel generators.

## 3. OUTPUTS [17]

(a) An inception note.

(b) A debriefing note and minutes from the debriefing meeting(s).

(c) A power sector/feasibility study report with regard to Atiu, Mauke, and Mitiaro.[18]

(d) A power recommendation paper with regard to Pukapuka.

## 4. ACTIVITIES

The scope of work for the consultancy will include, but not necessarily be limited to, the following activities:

**REGARDING OUTPUT A – INCEPTION NOTE:**

(a) Study and review relevant background material.

(b) Identify key project stakeholders.

(c) Write-up inception note, comprising the consultant's understanding of the consultancy and associated tasks; identification of issues crucial to the viability of the consultancy; and comments to this TOR.

**REGARDING OUTPUT B - A DEBRIEFING NOTE AND MINUTES FROM THE DEBRIEFING MEETING(S):**

(a) Prepare debriefing note, based on preliminary findings, conclusions and recommendations.

[17] All outputs from the consultancy are solely the property of UNESCO. E.g. UNESCO can distribute as widely as it finds appropriate.

[18] Depending on the preference of the Government of the Cook Islands, it might be required that the most optimal is to have three (3) separate power sector/feasibility study reports for Atiu, Mauke, and Mitiaro respectively.

(b) Discuss debriefing note with the Director, Energy Division (ED), Ministry of Works. Prepare minutes of the meeting. Present debriefing note to the Minister of Energy.

**REGARDING OUTPUT C - A POWER SECTOR/FEASIBILITY STUDY REPORT WITH REGARD TO ATIU, MAUKE, AND MITIARO:**

In general:

(a) Specify what improvements in the short term (i.e. 0-1 years) should be undertaken in the current diesel based power systems.

(b) Describe and assess the technical, socio-cultural, economic, financial and institutional/management feasibility in the medium term (i.e. 1-5 years) of supplementing the current diesel systems with renewable energy sources.

(c) Describe and assess the technical, socio-cultural, economic, financial and institutional/management feasibility in the long term (i.e. 5-10 years) of replacing 100% of the current diesel based power systems with renewable energy sources.

(d) Develop an overall, balanced and realistic power sector plan for the short, medium and long term for installation of new generation capacity in order to meet the requirements of load growth, reliability, operating costs and environmental sustainability.

(e) Consider appropriate Demand Side Management (DSM) strategies of all the supply options to be investigated.

(f) Undertake a preliminary Environment Impact Assessment (EIA) in line with the Government's EIA procedures/guidelines of the recommended supply option interventions.

(g) Consult during the whole process as appropriate with major stakeholders such as the Energy Division (ED), Ministry of Works; relevant Island Councils/mayors; Office of the Minister for Islands Administration (OMIA) and the Environment Service, Government of the Cook Islands.

(h) Ensure that all short, medium and long-term interventions proposed are consistent with the Cook Islands National Energy Policy (2003).

(i) Consult relevant sections of the Outer Island Power Development Study for the Cook Islands from 1998 (ADB, TA no. 2264-COO) in particular the sections on Atiu, Mauke and Mitiaro.

(j) Coordinate and collaborate to the extent possible with activities undertaken in the Cook Islands as part of the Pacific Islands Renewable Energy Project (PIREP) executed by the South Pacific Regional Environment Programme (SPREP).

In particular:

(k) *Briefly describe background and immediate objectives*. The description might include but not necessarily be limited to the following: 1) the project idea, its immediate objectives and beneficiaries; 2) dates of essential events; and 3) relevant studies and investigations already undertaken.

(l) *Briefly describe the socio-economic context*. The description might include but not necessarily be limited to the following: 1) geography, climate and main economic activities; 2) structure of local administration overall and more specifically how it relates to power supply services; 3) size of population, population density, 4) average income per capita; 5) income distribution; 6) occupational distribution; 7) economic growth and growth potentials; 8) willingness and ability of the concerned project beneficiaries to pay for the services; 9) relevant forecasts (e.g. extension of service area(s); population/target group(s); per capita income, etc.). As part of this task, briefly undertake an analysis of general development priorities for the island/village in question. An appropriate methodology could possibly be a qualitative survey technique such as Participatory Rural Appraisal (PRA). Among others this will enable island/village development problems to be ranked according to priority and gender (and/or other relevant variables).

(m) *Briefly describe the power sector*. The description might include but not necessarily be limited to the following: 1) the relevant public authorities for the sector at national and local levels, roles and responsibilities; 2) government policy and plans for the sector, objectives, strategies, programmes and activities; 3) sector national and local budgets in relevant details and measured in relation to total budgets and other sectors; 4) overall legislative framework for the sector; 5) the organisation of the sector itself, ownership within the sector, degree of organisational and financial autonomy of the power supply entities; 6) service sector coverage at national and local levels; and 7) national norms and standards for the sector (e.g. fuel, efficiency, emissions, treatment and disposal of waste oil, cooling water, etc.).

(n) *Describe and assess power/electricity demand, tariff structure and rates*. The description and assessment might include but not necessarily be limited to the following: 1) size and composition of present power/electricity demand; 2) demand projections (these are to be compared with the supply forecasts); 3) tariff structure and rates strategy and forecasted power/electricity rates in fixed prices; and 4) procedure to follow for changing of tariff structure and rates.

(o) *Undertake problem analysis*. The analysis might include but not necessarily be limited to the following: 1) the present power supply situation; 2) present and potential demand for power services; and 3) short, medium and long term problems to be

addressed (legislative, institutional, human resource, technical, environmental, financial, security of supply, etc.). A key here will be the load structure including peak and minimum power requirements, daily load curves and their variability, and forecasts of these parameters for a 5 and 10 years period respectively. Further, a survey of existing appliances being used in households and their daily use times and the inventory of other loads on the islands should be undertaken if needed.

(p) *Specify in detail what improvements in the short term (i.e. 0-1 years) should be undertaken in the current diesel based power systems*. Proposed interventions should look at generation as well as distribution.

(q) *Preliminary assess local energy resources*. The analysis might include but not necessarily be limited to the following: 1) describe the technical possible local energy resources that can be utilised presently and realistically in a 1-10 years period for power generation; and 2) recommend the most viable of the local energy resources. The resource assessments must include solar, wind and biomass (notably coconut oil).

(r) *Assess in detail, technology and project engineering*. This assessment might include but not necessarily be limited to the following: 1) present and forecast needed power supply capacities and characteristics; 2) proposed standards of power supply; 3) power plant technology options including merits and disadvantages and recommended option; 4) power supply network technology options including merits and disadvantages and recommended option; 5) infrastructure (e.g. site, wharf, access roads, etc; 6) overall plant lay out; 7) overall building, machinery and equipment specifications; 8) overall procurement and construction supervision model (foreign – local supplies); and 9) overall operation and maintenance engineering requirements (e.g. spare parts and after sales services).

(s) *Assess production, operation and maintenance of inputs*. The assessment might include but not necessarily be limited to the following: 1) overall supply programme for fuel, lubricants and cooling water; qualitative properties; quantities; source and origin; availability; unit costs; and 2) overall utilities; needs; availability; and unit costs.

(t) *Describe possible future project/power plant organisation*. The description might include but not necessarily be limited to the following: 1) project preparation organisation (e.g. involved parties, possible technical support and their roles and responsibilities); 2) project implementing organisation (e.g. implementing agency, other involved parties, their roles and responsibilities including construction and installation supervision), 3) power supply entity organisation (e.g. roles and responsibilities); and 4) job positions to be filled (e.g. recruitment needs, availability of relevant workforce within reasonable distance from the project).

(u) *Briefly outline needed training and technical assistance programme*. The outline might include but not necessarily be limited to the following: 1) specification of staff/positions to be trained and the training subjects; 2) training programme (e.g. content and duration of courses, participants, on-the-job or classroom; local, regional or overseas); and 3) technical assistance programme (e.g. specification of expertise needed, time schedule for inputs, placing and the role of expert(s) in the project/plant organisation).

(v) *Briefly undertake preliminary Environmental Impact Assessment (EIA) of current and recommended future supply option(s)*. The general framework for the assessment will be the Cook Islands Government's EIA procedures/guidelines, but since no specific procedures/guidelines are available with regard to power sector interventions, the Asian Development Bank (ADB) Environmental Guidelines for Selected Industrial and Power Development Projects (1993) will be applied. Thus, included will be a description of the actual and potential positive and negative environmental impacts during: i) construction and erection period; and ii) operations period (e.g. external and internal environment, occupational health and safety). The assessment under *the construction and erection period* might include but not necessarily be limited to the following: 1) social impacts due to employment creation; 2) social impacts due to population relocation; 3) noise impact from construction works; 4) disposal of excavated materials; 5) construction waste, dust and other pollution; 6) disruption of access to houses and business; 7) impacts on surface and groundwater sources; 8) use of and impact on other natural resources; 9) potential areas of conflict with: coastal/inland water, agriculture, forestry/uncultivated land, and other types of area. The assessment under the *operations period* might include but not necessarily be limited to the following: 1) social impacts due to improved living conditions; 2) reduced air pollution; 3) increased employment conditions; 4) impacts on surface and groundwater resources; 5) cooling water disposal; 6) fly ash and waste oil treatment and disposal; 7) social impacts, including public nuisance due to fuel transport; 8) noise impacts from the operation; 9) energy consumption; and 10) health and safety of workers and the public. Consult extensively among others with Environment Service, Government of the Cook Islands for this activity.

(w) *Outline the budget for different power supply options*. The outline might include but not necessarily be limited to the following: 1) investment budget and 2) operation budget.

(x) *Undertake economic analysis*. A 15-year term and 6% discount rate (when inflation is not considered) should be applied for the analysis.

(y) *Undertake financial analysis*. The analysis might include but not necessarily be limited to the following: 1) net present value (NPV) of the investment; 2) financial internal rate of return (FIRR); 3) a cost recovery analysis; and 4) relevant sensitivity analysis.

(z) *Briefly undertake assumptions and risks analysis*.

(aa) *Develop power sector plan*. Based on outcomes of the above mentioned activities develop an overall, balanced and realistic power sector plan for the short (0-1 years), medium (2-5 years) and long (6-10 years) term for installation of new generation capacity to meet the requirements of load growth, reliability, operating costs and environment sustainability.

**REGARDING OUTPUT D – A POWER RECOMMENDATION PAPER WITH REGARD TO PUKAPUKA**

In general:

(a) Undertake a desk study to be based primarily on available information, but if needed, additional information obtained through electronic means of communication (i.e. fax, email and telephone).

In particular:

(b) Using consumer bills and user data from an appropriate island in the Cook Islands having non-24 hour power estimate the number of Pukapuka households in the use ranges of less than 30 kWh/month, 31 to 50 kWh/month, 51-75 kWh/month, 76-100 kWh/month and greater than100 kWh/month.

(c) Prepare a preliminary PV Solar Home Systems (SHS) design suitable to provide 240V, 50Hz AC power at a level permitting operation of appliances typically used in rural households connected to non 24-hour diesel power systems in the Cook Islands. The base design should be based on the existing solar panels in place in Pukapuka with expansion designs for systems capable of 2 kWh/day and 4 kWh/day. Estimate the number of systems of each size that would be required on Pukapuka using the consumer profile estimated in (b).

(d) Compare upgrading of existing SHS - to the preliminary design determined in part (c) - to diesel grid electrification suitable for operation 6-8 hours per day at peak demand periods considering demand estimates of (b). This assessment should be undertaken respectively from the perspective of: i) the Government of Cook Islands, ii) Island Councils; and iii) the consumers. Consideration in the comparison should be given to: i) costs; ii) environmental impact; iii) relative value of 24-hour SHS power to part-time diesel power; iv) cost to consumers; and v) reliability of power regarding access to maintenance and fuel.

(e) Using the past 2 years shipping data for Pukapuka, estimate the size and cost of the diesel fuel storage facility necessary to maintain reliable 8-hour diesel power on Pukapuka. It has to be ensured that existing shipping systems can handle the fuel requirements for diesel power safely and that space is available for the quantity required.

(f) Preliminarily recommend the most optimal power solution (i.e. either to improve the existing PV SHS or to install (in addition) a new AC power system based on diesel generators).

(g) Outline for the recommended power solution, steps that need to be undertaken and issues that need further clarification.

**5. INPUTS**

| **Organisation** | **Input** |
|---|---|

| | |
|---|---|
| Energy Division (ED), Ministry of Works, Government of the Cook Islands | a) Provide relevant background information and documentation to the consultant(s) regarding strategies, policies, programmes, plans, activities, projects; etc.; b) Assist with logistics concerning the field visits; c) If appropriate participate in the field visits; and d) Coordinate input from relevant national and local stakeholders on the draft documents. |
| UNESCO/UNDP-Apia | a) Organise the consultancy; b) Fund the consultancy; c) Provide consultant with copies of relevant documentary sources; d) If possible participate in the field visits; and e) Provide input on the draft documents. |

## Annex B - List of People Consulted[19]

- Ministry of Works Energy Division – Mata Nooroa; Director of Energy
- Ministry of Works Energy Division – Tangi Tereapi; Snr Energy Planner
- Ministry of Works Energy Division – David Akaruru; Energy Officer
- Environment Services - Vaitoti Tupa; Director of Environment
- Meteorological Office - Arona Ngari; Director of Meteorology
- Meteorological Office - Nga Rauraa; Support Services Manager
- Mauke Island Secretary - Tai Tura
- Mauke Island Council and Aronga Mana
- Mauke Member of Parliament - Hon Mapu Taia *(He was at meeting, and ex officio a member of Mauke Island Council and Aronga Mana)*
- Mauke Telecom Station Operator - -Marae Turaki
- Mauke Power - Ngatuaine Tutere; Officer in Charge
- Tua Trading, Mauke (largest consumer) – Patrick Tua; Owner
- Mitiaro Island Secretary - Tai Topa (Also acting Officer in Charge of Power)
- Mitiaro Island Council and Aronga Mana
- Patai Store, Mitiaro – Peter Van Dongen; Manager/Owner
- Mitiaro Member of Parliament - Hon Tangata Vavia
- Office of the Minister for Island Administrations – Nandi Glassie; CEO
- Ministry of Foreign Affairs & Immigration - Assistant to Secretary; Carl Hunter

[19] This list does not include the energy survey participants or details of all staff in the various administration consulted

- Ministry of Works – Ben Parakoti; Water Works, Vaipo Mataora; Survey Division, Timoti Tangiruaine; IT Manager
- Atiu Island Secretary - Charlie Koronui
- Atiu Island Council and Aronga Mana
- Atiu Member of Parliament – Hon Upoko Simpson
- Atiu Power Supply - Teura Kea; Acting Officer in Charge
- Atiu Villas & Central Store – Roger Malcolm; Manger/Owner
- Atiu Coffee – Jurgen Manske-Eimke; Manager/Owner
- Cook Islands Tourism Corporation - Chris Wong; CEO
- Ellena Tavioni; Tapuata Eco Retreat Developer, Atiu Is
- Ministry of Agriculture - Secretary Nga Mataio
- Te Aponga Uira (Rarotonga Electricity Authority) – Apii Timoti; CEO
- Te Aponga Uira (Rarotonga Electricity Authority) - John Christmas; Consultant/Engineer
- Minister of Energy & Finance – Hon Tapi Teremoana Taio
- Ministry of Finance & Economic Management, Aid Management Division - Temarama Anguna; Acting Manager

- Office of the Leader of the Opposition; George Turia, CEO

# Increasing Utilisation of Renewable Energy Technologies in the Cook Islands

Project CKI/03/009, UNESCO, Apia Samoa

# INCEPTION NOTE

Prepared by:
Bruce Clay
Herbert Wade

21st June 2004

## 1. Introduction

Renewable energy has been identified by the Cook Islands Government as having the potential to contribute significantly to the economy, environment and social development. The title of this project is the National Energy Policy 2003 goal for renewable energy.

The project aims to determine short-term improvements in the current diesel based power systems on Atiu, Mauke and Mitiaro in the Southern Group and asses the feasibility of utilising local renewable energy resources in the medium and long term to supplement or replace existing diesel power systems and to prepare draft project concept proposals for each island. Additionally the project will undertake a desk study to asses the options of either upgrading the PV systems or diesel grid electrification for the island of Pukapuka in the Northern Group. A draft project concept proposal will also be prepared for Pukapuka.

## 2. Key Stakeholders

The following have been identified as key stakeholders in the success of this project:

- Ministry of Works and in particular the Energy Division
- Office of the Minister for Islands Administration
- Atiu, Mauke, Mitiaro & Pukakpuka Island Councils and Aronga Mana
- Members of Parliament for Atiu, Mauke, Mitiaro & Pukapuka
- Ministry of Environment
- Tourism Corporation

## 3. Objectives and Methodologies

With regard to the islands of Atiu, Mauke and Mitiaro:

### (a) Determine short term improvement of existing power system

All three islands indicate in their respective 2004/2005 budget statements various degrees of improvement and upgrading of power systems. These include provision of 24hr power, upgrading of equipment, improved maintenance and energy efficiency.

During the field trips to the islands power system operational data will be collected, equipment listed and discussions had with power system operators, island administration and council. Based on data and feedback gathered recommendations will be made for short term improvements. Both generation and distribution will be addressed and suitable interventions developed.

### (b) Determine medium term feasibility of supplementing current diesel power systems with renewable energy

In line with the National Energy Policy of promoting the increased use of feasible renewable energy technologies, this project aims to determine medium term (1-5 years) options of supplementing the current diesel systems with local indigenous renewable energy sources. Assessment of the various intervention options will consider technical, socio-cultural, economic, financial and institutional/management feasibility as well as environmental impact.

Data and information gathered during missions including operational, load profiles and consultations with stakeholders will be combined with existing studies undertaken in the Cook Islands in developing feasibility options and developing an overall, balanced and realistic power sector plan. Existing relevant studies include the Pacific Islands Renewable Energy Project (PIREP), Outer Island Power Development Study (1998 ADB) plus statistical data from the 2001 Census.

Technically mature renewable energy technologies to be considered for supplementing the current diesel power systems include; solar thermal, solar photovoltaic, wind and biomass. Local energy resource assessment will be based on available resource data and field visit observations. Feasibility analysis will include civil, operational and maintenance requirements and the difficulties of operating and maintaining power systems in remote locations.

### (c) Determine long term feasibility of replacing 100% of the current diesel power systems with renewable energy

Much of the background for the analysis of medium term feasibility for renewable energy will be utilised in the long term (5-10years) analysis.

Replacing 100% of the existing diesel power systems with renewable energy offers the best opportunity to meet the National Energy Policy Statement as a long term mission for the nation's energy sector.

Maturing technologies showing long term potential may be considered in this assessment. In general energy storage is a major issue for a 100% renewable energy power system. In the long term feasibility analysis the system design would differ from the medium term and subsequently so will the technical, economic, financial and environmental analysis.

### (d) Preliminary Environmental Impact Assessment

For each recommended supply option intervention a preliminary EIA will be undertaken. The EIA will be based on the ADB Environmental Guidelines for Selected Industrial and Power Development Projects 1993.

Data for the assessment will be gathered during the field visits to the islands and from local sources where available.

### (e) Power Sector Plan

A power sector plan addressing short, medium and long term will be developed. The plan will encompass a synthesis of project recommendations developed during the feasibility analysis. This plan will be consistent with the National Energy Policy 2003 and will examine various issues including:-

- Operational Costs and Budgets
- Capital Budgets
- Tariff Structure
- Demand Growth
- Organisational requirements
- Human resources development
- Environmental sustainability
- Demand side management strategies
- Reliability

With regard to the island of Pukapuka:

### (f) A Power Recommendation Paper for Pukapuka

A desk study will be carried out to recommend whether to upgrade existing PV systems or implement an AC diesel electric grid. Information will be gathered from existing reports and enhanced through communication with stakeholders including the Energy Division, OMIA and Island Councils.

The study will develop an estimated household power profile and appropriate PV systems. A comparative analysis would then be undertaken between the Solar Home Systems and diesel grid electrification. This comparison would be taken from the Government, Island Council and consumer's perspective.

The PIREP report on Pukapuka provides a collaboration of operational information on the SHS in use and provides insight into addresses the upgrading and sustainability of these systems. As per this report, organisational structure, tariffs and operational/maintenance procedures need to be developed and implemented to ensure the long term sustainability of any power system on this remote island.

### (g) Draft Project Concept Proposal

Progressing from the power sector/feasibility study for Atiu, Mauke and Mitiaro and the Pukapuka power recommendation paper, draft concept proposals will be developed for the four islands. The proposed interventions are to be agreed upon by the Cook Islands Energy Division and UNESCO Apia prior to drafting. Format will be agreed upon with UNESCO Apia and guided by AusAID's guideline for Preparing Project Design Documents, 20thJune 2003 version.

## 4. Comments on Critical Issues and the Terms of Reference

Following is a listing of several issues are critical to the effectiveness of this project :-

| **ISSUE** | **ACTION/COMMENT** |
|---|---|
| Quality Data and Information | Identification of required information and principal sources.<br>Power system logging to cover as long a time period as possible.<br>Information, observations and data from previous studies to be corroborated where ever possible.<br>Effective consultations with stakeholders. |
| Island Community Involvement in Consultations | Consultation with Energy Division, OMIA and Island Councils/Administrations to ensure consumer expectations are appraised accurately.<br>Where necessary carry out qualitative surveys. |
| Local Energy Resource Assessment | A lack of site specific resource data, particularly wind, will require estimation and sensitivity analysis |

## 5. Proposed Work Plan

Outlined below is the proposed schedule. Dates and activities for Mission 1 & 2 have been agreed by the Cook Islands Director of Energy, UNDP/UNESCO Apia and the consultants. Background material is currently being reviewed by the consultants and project preparation is well underway.

| **Activity or Milestone** | **Scheduled Date(s)** |
|---|---|
| Project Preparation: Mission Programs, Inception Note, Background material review | 6 – 25 June |
| Mission 1: Field visits to Mauke & Mitiaro, meetings with relevant stakeholders | 26 June – 9 July |
| Preliminary analysis, debriefing note preparation for Mauke & Mitiaro | 12 – 16 July |
| Mission 2a: Field visit to Atiu, meetings with relevant stakeholders.<br>Preliminary analysis, debriefing note preparation for Atiu | 17 – 28 July |
| Mission 2b: Debriefing Note presentation | 29 – 30 July |
| Detailed Analysis and report preparation | 2 – 19 August |
| Submission of Draft Report | 20 August |
| Review Period for Draft Report | 21 Aug – 14 September |
| Submission of Final Report | 15 September |

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Following over page is the activity programs for the 2 Missions.

## Mission Activity Programs

### Mission 1

| | Day | Activity |
|---|---|---|
| 26th June | Saturday | - Meet with Mata Nooroa, Director of Energy, to discuss arrangements for the Mission. |
| 27th June | Sunday | - Sunday Church |
| 28th June | Monday | **AM:** Meet with Mata Nooroa, Director of Energy to discuss the project activities and finalise activity details for Mission 1 visit and preliminary final activities for Mission 2 respectively (to be outlined in detailed programmes that will be forwarded to UNDP/UNESCO and included as part of the de-briefing notes and minutes). Discuss existing power system experience and other relevant issues.<br>- Meet with Minister of Energy/Member of Parliament for Mauke to brief on Mission.<br>- Meet with OMIA to discuss the project, island administrations, energy planning, current power supply situation and liaison with island councils and administration. Identify interested parties on each island that should be included in consultations.<br>**PM: Travel Rarotonga – Mauke**<br>- Meet with Mauke Island Secretary to brief on Mission<br>- Visit Mauke power station and install power logger and commence gathering power system data and equipment list. |
| 29th June | Tuesday | -Meet with Mauke Island Council and Aronga Mana to discuss current power supply situation (demand, tariff structure, operation), institutional/management issues, potential demand, infrastructure, socio-economics of the island and other pertinent issues.<br>- Information gathering continued including household and non-domestic energy data (may include energy auditing where required). |
| 30th June | Wednesday | - Investigate potential local energy resources, physical and institutional conditions (geographic conditions, infrastructure etc ) relating to power generation development.<br>- Gathering information for preliminary EIA |
| 1st July | Thursday | - Further investigation and information gathering |
| 2nd July | Friday | **AM:** Further investigation and information gathering<br>- Disconnect power logger<br>- Meet with Mauke Island Secretary for debriefing and discussions<br>**PM: Travel Mauke - Rarotonga** |
| 3rd July | Saturday | - Commence preliminary analysis and identify any further information required<br>- Work on Mauke debriefing notes |
| 4th July | Sunday | - Sunday Church |

Mission 1 (cont)

| | | |
|---|---|---|
| 5th July | Monday | **AM:** Meet with Mata Nooroa, Director of Energy to discuss the project activities and finalise activity details for Mission 1 visit to Mitiaro (to be outlined in detailed programmes that will be forwarded to UNDP/UNESCO and included as part of the de-briefing notes and minutes). Discuss existing power system experience and other relevant issues.<br>- Meet with OMIA to discuss the project, island administrations, energy planning, current power supply situation and liaison with island councils and administration. Identify interested parties on each island that should be included in consultations.<br>- Meet with Member of Parliament for Mitiaro to brief on Mission<br>**PM: Travel Rarotonga – Mitiaro**<br>- Meet with Mitiaro Island Secretary to brief on Mission<br>- Visit Mitiaro power station and install power logger and commence gathering power system data and equipment list. |
| 6th July | Tuesday | - Meet with Mitiaro Island Council and Aronga Mana to discuss current power supply situation (demand, tariff structure, operation), institutional/management issues, potential demand, infrastructure, socio-economics of the island and other pertinent issues.<br>- Information gathering continued including household and non-domestic energy data (may include energy auditing where required). |
| 7th July | Wednesday | - Investigate potential local energy resources, physical and institutional conditions (geographic conditions, infrastructure etc ) relating to power generation development.<br>- Gathering information for preliminary EIA |
| 8th July | Thursday | - Further investigation and information gathering |
| 9th July | Friday | **AM:** Disconnect power logger<br>- Meet with Mitiaro Island Secretary for debriefing and discussions<br>**PM: Travel Mitiaro – Rarotonga**<br>**Late PM: Travel Rarotonga - Nadi** |

Mission 2

| | Day | Activity |
|---|---|---|
| 17th July | Saturday | - Meet with Mata Nooroa, Director of Energy, to discuss arrangements for the Mission. |
| 18th July | Sunday | - Sunday Church |
| 19th July | Monday | **AM:** Meet with Mata Nooroa, Director of Energy to discuss and finalise activity details for Mission 2 (to be outlined in a detailed programme that will be forwarded to UNDP/UNESCO and included as part of the de-briefing notes and minutes) Discuss existing power system experience and other relevant issues.<br>- Meet with Member of Parliament for Atiu to brief on Mission.<br>- Meet with OMIA to discuss project progress, Atiu energy planning, current power supply situation and island council and administration liaison. Identify interested parties on Atiu that should be included in consultations.<br>**PM: Travel Rarotonga – Atiu**<br>- Meet with Atiu Island Secretary to brief on Mission<br>- Visit Atiu power station and install power logger and commence gathering power system data and equipment list. |
| 20th July | Tuesday | - Meet with Atiu Island Council and Aronga Mana to discuss current power supply situation (demand, tariff structure, operation), institutional/management issues, potential demand, infrastructure, socio-economics of the island and other pertinent issues.<br>- Information gathering continued including household and non-domestic energy data (may include energy auditing where required). |
| 21st July | Wednesday | - Investigate potential local energy resources, physical and institutional conditions (geographic conditions, infrastructure etc) relating to power generation development.<br>- Gathering information for preliminary EIA. |
| 22nd July | Thursday | - Further investigation and information gathering |
| 23rd July | Friday | - Further investigation and information gathering.<br>- Meet with Atiu Island Secretary for debriefing and discussions |
| 24th July | Saturday | **AM:** Disconnect power logger<br>TRAVEL ATIU - RAROTONGA<br>**PM:** Commence preliminary analysis and identify any further information required<br>- Preparing debriefing notes |
| 25th July | Sunday | - Sunday Church |
| 26th July | Monday | - Meet with Director, Environment Services<br>- Preliminary analysis/Prepare debriefing note and gather any required information |
| 27th July | Tuesday | - Preliminary analysis/Prepare debriefing note and gather any required information |

Mission 2 (cont)

| | | |
|---|---|---|
| 28th July | Wednesday | - Meet with Mata to discuss Draft Concept Project Proposals and Pukapuka power system.<br>- Meet with Member of Parliament and Advisor to discuss issues relating to Pukapuka electricity requirements<br>- Debriefing note preparation |
| 29th July | Thursday | - Meet with Mata Nooroa to present debriefing note and discuss project outputs. Possibly meet with OMIA to debrief and discuss |
| 30th July | Friday | - Meet with Minister of Energy to discuss debriefing note and findings particularly in regard to the National Energy Policy.<br>**Late PM:** Travel Rarotonga - Nadi |

## Annex D – Documentary Sources


| | |
|---|---|
| ADB | ADB Cook Islands Power Development Study 1998 |
| ADB | ADB EIA Guidelines for Power Projects 1993 |
| AIC | Atiu Island Profile, September 2003 |
| AIC | Water Supply and Sanitation Assessment Report prepared by Flotek Systems, Rarotonga 2003 |
| CIA | *World Factbook: Fiji chapter* 2004 |
| FED | Pacific-Danish Environmental Education and Action Program – Feasibility Study of Phase 1, prepared by COWI/Risoe, January 1998 |
| GoCI | Cook Islands National Energy Policy 2003 |
| GoCI | Environment Act 2003 |
| GoCI | Environment Service Environmental Significance Declaration |
| GoCI | Cook Islands 2001 Population Census |
| GoCI | Cook Islands Budget Policy Statement 2004-2005 |
| GoCI | Outer Island Budget Outputs 2003-2004 & 2004-2005 |
| GoCI | Record for Technical Data for the Outer Islands prepared by the Energy Division |
| GoCI | Mangaia AWS Wind Data 2001-2003 prepared by the Meteorological Office |
| GoCI | Mauke AWS Wind Data 2001-2003 prepared by the Meteorological Office |
| GoCI | Cook Islands 2000 Census of Agriculture & Fisheries |
| GoCI | The Climate and Weather of the Southern Cook Islands prepared by New Zealand Meteorological Service |
| PREFACE | Mangaia – Cook Islands Feasibility Study for a Wind Farm Connected on the Diesel Grid, prepared by Vergnet SA December 2001 |
| PREFACE | Pre-feasibility study of wind power projects on Rarotonga, Atiu & Mangaia – May 1999 – Prepared by Vergnet SA, Laurent Albuisson |
| SOPAC | Copra Oil as a Biofuel in Pacific Islands - Challenges and Opportunities prepared by Jan Cloin |
| UNDP | GEF/ UNDP Pacific Islands Renewable Energy Project (PIREP) Draft Cook Islands National Report May 2004 |

# ENERGY SURVEY QUESTIONAIRE MAUKE 2004

| | | | | |
|---|---|---|---|---|
| Surveyor's Name: | | | | Date: |
| **Consumer:** | | | | **Conn. No:** |
| Occupation: | No. of people in residence: | | | Village: |
| Type of Building - Exterior Walls: | | No. of Rooms | | |

| Details | Number | Watts/Amps | Hrs Used/Day | Comments |
|---|---|---|---|---|
| Light (Incandescent) | | | | |
| | | | | |
| Light (Fluorescent) | | | | |
| | | | | |
| | | | | |
| Fans (Celling/wall) | | | | |
| Power Points | | | | |
| Water Heating | | | | |
| Refrigerator | | | | |
| Freezer | | | | |
| Electric Fying Pan | | | | |
| Microwave | | | | |
| Rice Cooker | | | | |
| Electric Jug | | | | |
| Electric Iron | | | | |
| Electric Toaster | | | | |
| Washing Machine | | | | |
| Electric Drill | | | | |
| Electric Circular Saw | | | | |
| TV | | | | |
| Video | | | | |
| DVD Player | | | | |
| Radio | | | | |
| | | | | |
| | | | | |

# Increasing Utilisation of Renewable Energy Technologies in the Cook Islands

Project CKI/03/009, UNESCO, Apia Samoa

# DEBREIFING NOTE

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## INTRODUCTION

Renewable energy has been identified by the Cook Islands Government as having the potential to contribute significantly to the economy, environment and social development. The title of this project *is* the National Energy Policy 2003 goal for renewable energy.

The project aims to determine short-term improvements in the current diesel based power systems on Atiu, Mauke and Mitiaro in the Southern Group and assess the feasibility of utilising local renewable energy resources in the medium and long term to supplement or replace existing diesel power systems and to prepare draft project concept proposals for each island. Additionally the project will undertake a desk study to assess the options of either upgrading the PV systems or install a diesel grid electrification for the island of Pukapuka in the Northern Group. A draft project concept proposal will also be prepared for Pukapuka.

## KEY STAKEHOLDERS

The following have been identified as key stakeholders in the success of this project:

- Ministry of Works and in particular the Energy Division
- Office for the Minister of Island Administration
- Atiu, Mauke, Mitiaro & Pukakpuka Island Councils and Aronga Mana
- Atiu, Mauke, Mitiaro & Pukapuka Power Supplies
- Members of Parliament for Atiu, Mauke, Mitiaro & Pukapuka
- Environment Services
- Cook Islands Tourism Corporation
- Cook Islands Investment Corporation
- Ministry of Foreign Affairs and Immigration
- Aid Management Division, Ministry of Finance & Economic Management

## ACTIVITIES TO DATE

Activities carried out to date for Atiu, Mauke and Mitiaro are as listed in the following table:-

| **Activity or Milestone** | **Dates** |
|---|---|
| Project Preparation: Mission Programs, Inception Note, Background material review | 6 – 25 June 2004 |
| Mission 1: Field visits to Mauke & Mitiaro, meetings with relevant stakeholders | 26 June – 9 July 2004 |
| Mission 2: Field visit to Atiu, meetings with relevant stakeholders.<br>Preliminary analysis, debriefing note preparation | 17 – 28 July 2004 |

Over the last five weeks two missions have been carried out which have involved field visits to the three islands and consultations with relevant stakeholders and interested parties. During these missions extensive information has been gathered on existing power system infrastructure, both physical and operational, individual island administration operation, strategic plans and development aspirations plus national issues pertaining to this project.

Local energy resource data and information has been collected for each island during field visits and from previous studies. Information was also gathered for assessment of environmental impacts of existing and planned energy generation development.

Household energy surveys were carried out to assess present power usage and enabled feedback from the wider community.

A power quality analyser (data logger) was used during each island visit which stored information on the power system operation allowing assessment of power quality and quantity.

The desk study for Pukapuka is currently underway with the Island Administration presently carrying out an energy survey to assess the needs and expectations of the population in regards to electricity requirements. Once the survey results have been received assessment of appropriate interventions (diesel grid or solar upgrade) will be finalised.

During the two missions meetings and consultations were had with the following stakeholders and involved parties:

- Ministry of Works Energy Division – Mata Nooroa; Director of Energy
- Ministry of Works Energy Division – Tangi Tereapi; Snr Energy Planner
- Ministry of Works Energy Division – David Akaruru; Energy Officer
- Environment Services - Vaitoti Tupa; Director of Environment
- Meteorological Office - Arona Ngari; Director of Meteorology
- Meteorological Office - Nga Rauraa; Support Services Manager
- Mauke Island Secretary - Tai Tura
- Mauke Island Council and Aronga Mana
- Mauke Member of Parliament - Hon Mapu Taia *(He was at meeting, and ex officio a member of Mauke Island Council and Aronga Mana)*
- Mauke Telecom Station Operator - -Marae Turaki
- Mauke Power - - Ngatuaine Tutere; Officer in Charge
- Tua Trading, Mauke (largest consumer) – Patrick Tua; Owner
- Mitiaro Island Secretary - Tai Topa (Also acting Officer in Charge of Power)
- Mitiaro Island Council and Aronga Mana

- Patai Store, Mitiaro – Peter Van Dongen; Manager/Owner
- Mitiaro Member of Parliament - Hon Tangata Vavia
- Office of the Minister for Island Administrations – Nandi Glassie; CEO
- Ministry of Foreign Affairs & Immigration - Assistant to Secretary; Carl Hunter
- Ministry of Works – Ben Parakoti; Water Works, Vaipo Mataora; Survey Division, Timoti Tangiruaine; IT Manager
- Atiu Island Secretary - Charlie Koronui
- Atiu Island Council and Aronga Mana
- Atiu Member of Parliament – Hon Upoko Simpson
- Atiu Power Supply - Teura Kea; Acting Officer in Charge
- Atiu Villas & Central Store – Roger Malcolm; Manger/Owner
- Atiu Coffee – Jurgen Manske-Eimke; Manager/Owner
- Cook Islands Tourism Corporation - Chris Wong; CEO
- Ellena Tavioni; Tapuata Eco Retreat Developer, Atiu Is
- Ministry of Agriculture - Secretary Nga Mataio
- Te Aponga Uira (Rarotonga Electricity Authority) – Apii Timoti; CEO
- Te Aponga Uira (Rarotonga Electricity Authority) - - - John Christmas; Consultant/Engineer
- Minister of Energy & Finance – Hon Tapi Teremoana Taio
- Ministry of Finance & Economic Management, Aid Management Division - Temarama Anguna; Acting Manager

- Office of the Leader of the Opposition; George Turia, CEO

### PRELIMINARY FINDINGS AND OBSERVATIONS

Detailed analysis is currently underway and as such at this stage most finding and observations relate to the existing power systems. The following table shows current installed capacity and tariff.

| | Supply Hours | Generators | Installed Capacity (kW) | Base/Max Load (kW)* | Tariff | |
|---|---|---|---|---|---|---|
| | | | | | Domestic | Commercial |
| **Atiu** | 24 | 1 x Hino 110kW<br>2 x Deutz 45kW<br>1 x Lister 42kW | 244 | 35 / 80 | $0.40/kWh + $5/month | $0.62/kWh + $5/month |
| **Mauke** | 24 | 4 x Lister 42kW | 168 | 25 / 78 | $0.36/kWh + $5/month | $0.58/kWh + $5/month |
| **Mitiaro** | 19 | 2 x Lister 28kw<br>1 x Lister 21kW | 77 | 9 / 26 | $0.36/kWh | $0.58/kWh + $5/month |

*These are based on preliminary analysis of data logged during field visits

As a general observation most islands power generation operations suffer from limited resources, both physical and human, for the sustainable and reliable operation of the power generation and distribution systems.

Preliminary analysis would indicate medium and long term potential for local renewable energy sources to substitute imported diesel. Whilst wind power generation appears to be the most feasible medium term renewable energy technology solar and perhaps biomass may have a significant role in diesel substitution.

Following is an island by island synopsis of preliminary findings and observations made during the two recent missions. These were communicated to the stakeholders during debriefing meetings.

### 4a. Atiu

Atiu Island Council has requested Government to return Atiu Power Supply to Te Aponga Uira (TAU) to operate. In a Cabinet Memorandum dated 4th May 2004, the request was approved and TAU was instructed accordingly. Presently the Board of TAU has asked for power, financial and operational, information from Atiu Island Council to assess the best method of implementation. Although not part of this project it should be noted that Aitutaki Power is also included in this Cabinet decision.

#### Existing Diesel System;

- Generation capacity with 4 sets of an installed capacity is adequate however is vulnerable to insufficient capacity should the Hino 110kW break down.
- Power quality is reasonable with relatively stable line voltage and frequency at power house.
- Power station only manned during peak load periods.
- Age of generating sets will continue to tax the already limited maintenance budget.
- LV distribution and switchgear requires considerable maintenance and in certain areas replacement. Consideration should be given to replacement of ageing overhead LV 4 wire configuration with aerial bundled cables.
- No suitably qualified Officer in Charge of power.
- No organised training and upskilling program in place for power personnel, in particular for electrical engineering.
- Mechanics in the Infrastructure department appear competent for general engine maintenance.
- Lack of electrical and engine maintenance tools, test instruments and safety equipments.
- Fuel and oil handling facilities and procedure causing considerable fuel and oil contamination of environment, particularly in and around power station.
- Power house building has poor sound level suppression and ventilation. Building requires maintenance.

- Street lighting is a significant non-metered power consumer with no budgetary allocation.
- Existing tariff is below full recovery tariff. (Final report to quantify)
- Existing energy budget only covers fuel, oil, personal and generator set maintenance. No allocation for training, distribution maintenance and equipment.
- Meter reading and billing system reasonably thorough and adequate.
- Security of metering on consumers premises need to be tightened.
- Ageing consumer installations require upgrading, and on some installations the standards are well below the regulatory safety requirement.

#### Renewable Energy and DSM;

- Potential wind sites identified in area of old airport and South East coast. Old airport site is adjacent the existing HV distribution line whilst the South East coastal area would require grid extension.
- Appears to be considerable land area available for solar power including area within power station compound.
- Extensive pine and Gaisher plantings and to a lesser extent coconut plantations may offer biomass opportunities.
- DSM, in particular implementation of energy efficiency program, could contribute to significant reduction in diesel consumption. Household survey results will assist in calculation of potential energy efficiency measures.
- DSM could reduce peak loads and improve system reliability.

#### Medium and Long Term Considerations;

- Tourism considered the major priority in the medium to long term economic development by the Island Council, Tourism Corporation and Government.
- Eco tourism development planned for South East coast with up to 42 rooms/suites.
- Provision of reliable electricity and infrastructure a requirement for island development.
- Interruption to diesel supply, due to external circumstances, identified as a significant issue.

### 4b. Mauke

#### Existing Diesel System;

- Generation capacity with 4 sets of an installed capacity of 168kW is adequate however is vulnerable to insufficient capacity should one generating set break down.
- Power quality is reasonable with relatively stable line voltage and frequency at power house.
- Power station only manned during peak load periods.

- Age of generating sets will continue to tax the already limited maintenance budget.
- LV & HV distribution and switchgear requires considerable maintenance/upgrade and in certain areas replacement. Consideration should be given to replacement of aging overhead LV 4 wire configuration with aerial bundled cables.
- New 50kVA transformer and associated cabling to be installed in Oiretumu village to alleviate low voltage at grid extremities to the East.
- No organised training and up skilling program in place for power personnel.
- Lack of electrical maintenance tools, test instruments and safety equipments.
- Fuel and oil handling facilities and procedure can be improved to reduce fuel and oil contamination of environment, particularly in and around power station.
- Power house building has poor sound level suppression and ventilation. Building require some maintenance.
- Existing tariff is below full recovery tariff. (Final report to quantify)
- Existing energy budget only covers fuel, oil, personal and generator set maintenance. No allocation for training, distribution maintenance and equipment.
- Meter reading and billing system could be improved by utilising accounts computers to calculate and print monthly bills rather than manually as is done presently.
- Individual diesel powered water bore pumps presently in use are consuming considerable diesel (~400lt/month) and contaminating ground adjacent pumps with fuel and oil.
- Security of metering on consumers premises need to be tightened.
- Ageing consumer installations require upgrading, and on some installations the standards are well below the regulatory safety requirement.

### Renewable Energy and DSM;

- Potential wind sites identified in Nooangatua and South East coast. Nooangatua site is in the centre of the island on the raised plateaux within 300mtr of the existing HV distribution line whilst the South East coastal area would require almost 3 km of transmission line.
- Wind powered water bore pumps have performed well in the past but are presently requiring maintenance. Parts for repair of the wind pumps are currently awaiting shipment from Rarotonga.
- Considerable land area available for solar power particularly on the Nooangatua site.
- Coconut plantations may offer biomass opportunities.
- DSM, in particular implementation of energy efficiency program, could contribute to significant reduction in diesel consumption. Household survey results will assist in calculation of potential energy efficiency measures.
- DSM could reduce peak loads and improve system reliability.

### Medium and Long Term Considerations;

- Tourism considered by Island Council and Government to be a significant contributor to the medium to long term economic development of Mauke.
- Several smaller tourism accommodation developments under construction.

- Provision of reliable electricity and infrastructure a requirement for island development.
- Interruption to diesel supply, due to external circumstances, identified as a significant issue.

### 4c. Mitiaro

#### Existing Diesel System;

- Generation capacity with 3 sets of an installed capacity of 77kW is not adequate to provide reliable power of reasonable quality.
- Lack of ability to synchronise and run 2 generators to carry peak loads causes large power fluctuations.
- Out off balance phase loadings need to be rectified.
- Power station only manned during peak load periods.
- Age of generating sets will continue to tax the already limited maintenance budget.
- Power Station building is in a poor state of repair and inadequate for any future expansion.
- Location of Power Station within 100mtr of dwellings poses health and safety risks.
- LV distribution and switchgear requires considerable maintenance/upgrade and in certain areas replacement.
- Island Secretary presently acting as Officer in Charge of power.
- Island Secretary is the only licensed electrical tradesman on Mitiaro.
- No organised training and up skilling program in place for power personnel apart from that given by the Island Secretary
- Lack of electrical maintenance tools, test instruments and safety equipments.
- Fuel and oil handling facilities and procedure require improvement to reduce considerable fuel and oil contamination of environment, particularly in and around power station. (Capex approved in current budget)
- Existing tariff is below full recovery tariff. (Final report to quantify)
- Existing energy budget only covers fuel, oil, personal and generator set maintenance. No allocation for training, distribution maintenance and equipment.
- Meter reading and billing system could be improved by utilising accounts computers to calculate and print monthly bills rather than manually as is done presently.
- Security of metering on consumers premises need to be tightened.
- Ageing consumer installations require upgrading, and on some installations the standards are well below the regulatory safety requirement.

### Renewable Energy and DSM;

- Potential wind and solar site identified 200-300 metres East of existing power station.
- Potential wind site on South East Coast would require a transmission line of approximately 4km.
- Given the need to upgrade power station building, fuel handling and generation capacity the potential wind/solar site East of existing power station could also incorporate a new power station. This site would reduce present safety and environmental concerns.
- Coconut plantations may offer biomass opportunities.
- DSM, in particular implementation of energy efficiency program, could contribute to significant reduction in diesel consumption. Household survey results will assist in calculation of potential energy efficiency measures.
- DSM could reduce peak loads and improve system reliability and should be considered immediately to address lack of generator capacity during peak load periods.
- Present 3 phase submersible water supply pump is drawing around 1.5kW and should, if possible, only be run during off peak. Solar or wind powered pumping could be considered.

### Medium and Long Term Considerations;

- Power system including fuel storage, generation and distribution will need upgrading to cater for any further growth in power demand.
- Tourism considered by Island Council and Government to be a significant contributor to the medium to long term economic development of Mitiaro.
- Island Strategic Plan identifies low impact tourism including homestays as a starting point for tourism development.
- Provision of reliable electricity and infrastructure a requirement for island development.
- Interruption to diesel supply, due to external circumstances, identified as a significant issue.