Atiu 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, or the many individuals who kindly provided information on which the study is based.

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ACRONYMS and ABBREVIATIONS

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
AIC	Atiu Island Council
Al	Aluminium
APS	Atiu Power Supply
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

min	Minute
mm	Millimetres
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 Atiu 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 Atiu Power Supply (APS) situation and would provide approximately 10% of Atiu's electricity requirements. With 40 to 50% capital cost subsidy through donor agencies the wind generated power is financially viable and will substitute over 7,000lt 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% brings these 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 Atiu Power Supply.

Table 1-1 Summary of Findings and Recommendations

	Findings	Short Term	Medium Term	Long Term
Power Station	Installed capacity marginal. Building in need of upgrade	New 60-70kW generator 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. Handling procedures lacking in areas	Upgrade handling facilities 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. HV switchgear requires attention. Areas of LV in need of replacement No transformer maintenance	HV switchgear upgrade LV distribution upgrade Consumer metering refurbishment Transforming servicing	Ongoing maintenance and upgrading	Ongoing maintenance and upgrading
Administration and Personnel	Officer in Charge position not filled Computerised billing system adequate Staff training required Only part time manning of power station	Implement staff training programme Improve workplace safety Increase power station manning 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, electric cooking appliances. Control of large consumer loads Street lighting using 5% of energy generated Limited use of solar hot water systems(SHS)	Promote energy efficiency Investigate means of encouraging use of fluorescent lighting Address cost and loading of street lights Encourage use of SHS	Continued development of energy efficiency initiatives and load management. Continued promotion of SHS	Continued development of energy efficiency initiatives and load management 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

	Findings	Short Term	Medium Term	Long Term
Tariff	Full Cost Recovery Tariff - $1.11/kWh	Billing of street lights	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	On-site wind monitoring Commence evaluation of biomass potential and financial viability	Installation of grid connected 20kW wind turbine. Possible battery hybrid or biofuel implementation to increase renewable energy input.	Displace all diesel fuel with renewable energy technologies.
Load Growth	Planned large boutique resort development Water supply upgrading may use electric pumping	Large resort developments to generate own power preferably with local renewable energy Consider use of renewable energy for water pumping Investigate repair of wind powered water pumps	Consideration whether to integrate resort developments with island power supply Monitoring of load growth and capacity planning	Distributed generation may become an option as new renewable technologies emerge and island develops economically 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 the 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 73% over the 1998 figures whilst the billed tariff has only increased 11% for domestic and 7% for commercial. 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 GoCI applies to the outer islands.

Whilst population has decreased approximately 35% power consumption has increased 18%. On a per capita basis consumption has increase by close to 80% showing 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	$0.64	$1.11	+73
Domestic Tariff	$/kWh	$0.36 + $5/month	$0.40 + $5/month	+11
Commercial Tariff	$/kWh	$0.58 + $5/month	$0.62 + $5/month	+7
Population[1]	No.	956 (1996)	623 (2001)	-35
Installed Capacity	kW	192	242	+26
Maximum Demand	kW	87	85 (100)[2]	-2(+15)[2]
Supply Hours	Hours	19	24	+26
Households with refrigeration	%	71	73	+2
Households with Electric Jug	%	76	84	+8
Households with Video	%	9	75	+66
Power Supply staff number	No.	4	4	0
Commercial Customers	No.	29	24	-17
Domestic Customers	No.	258	246	-5
Billed kWh p.a.	kWh	277,169	326,060	+18
Specific Fuel Consumption	kWh/litre	2.9	2.74	-6
Projected/Actual generation for 2004[3]	kWh	441,495	381,009	-14
Projected/Actual peak load 2004[3]	kW	109	100[4]	-8
Proposed LV distribution reconstruction	$	US$179,000	NZ$380,198	

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.

- 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

- 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.

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 EIA of the short, medium and long term power supply options will be carried out. The assessment will be based on ADB's 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,
- Atiu Island Profile, 2003

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 2004. Rarotonga, Mauke and Mitiaro

Mission 2: 17th July – 30th July 2004. Atiu and Rarotonga and delivering debriefing note.

2.3 National Background Information

2.3.1 Physical Description & Population[1]

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.

Map 2-1 – Cook Islands

Source – CIA Factbook 2004

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.

[1] The SPREP/UNDP/GEF 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

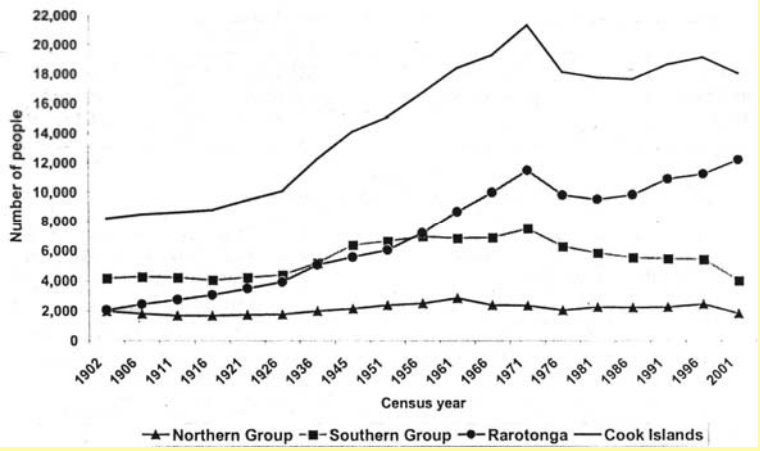
Island	Island Type	Area Sq Km	Maximum Elevation (meters)	Population (Dec 2001)	Principal Habitat
Southern					
Rarotonga	High Volcanic	67.1	652	12,188	Strand vegetation, extensively modified coastal forest & wetlands, fern lands, cloud forest, inland forest
Aitutaki	Volcanic & Coral	18.3	124	1,946	Strand 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.

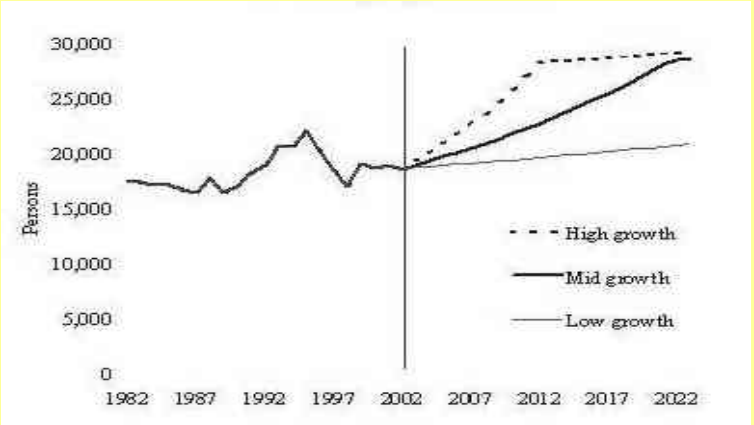
For the low growth scenario, the population's average annual growth rate (AAGR) over the next twenty-years is 0.8%; for the medium and high scenarios, it is about 1.6%. There are no projections by island or island group but outer island populations are expected to continue to decline. Assumptions regarding 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 Ratified Entered into force	25 Nov 87 9 Jul 89 22 Aug 90	 24 Jun 87 26 Jun 90	17 Sep 95 30 Oct 00 ?	06 Aug 85 28 Oct 85 11 Dec 86	16 Sep 98 27 Aug 01 n/a *	Acceded to Vienna Convention, 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	14 July 1980	18 Aug 2001	18 Aug 2001
Ratified	12 Nov 1980	28 Aug 2001	28 Aug 2001
Entered into force	01 Jan 1981	3 Oct 2002	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 – SPREP/UNDP/GEF Pacific Islands Renewable Energy Project (PIREP) Draft Cook Islands National Report May 2004' e = estimated; p = projected; BOP = balance of payments

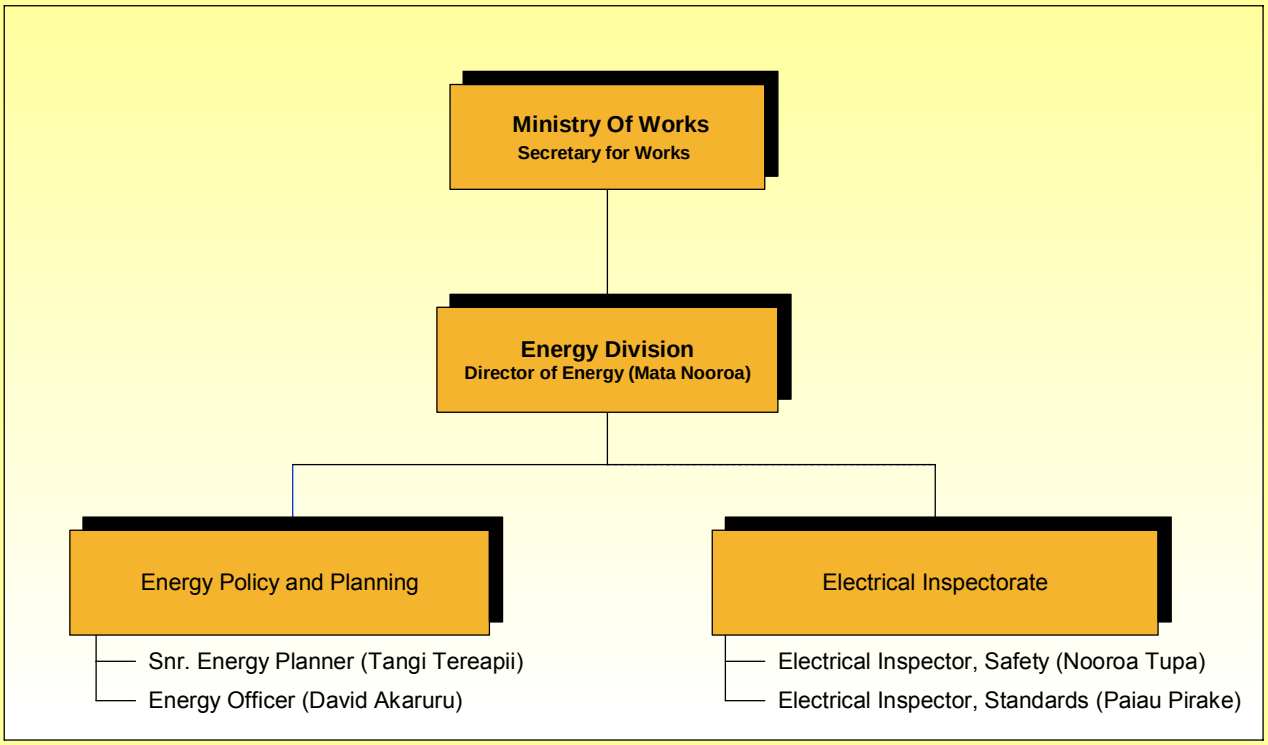
Reforms from the mid-1990s, including the sale of state assets, the strengthening of economic management, a dramatic reduction in public sector employment, the encouragement of tourism, and a debt restructuring agreement have collectively rekindled investment and growth.

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 ATIU

3.1 Background

3.1.1 Physical Description and Population

Atiu a raised volcanic island surrounded by steep makatea[2] cliffs lies 215km North East of Rarotonga. The island has an area of 2,693 hectares and rises to 72 meters above sea level. Atiu is the third largest island in the Cook Islands. The central plateau is characterised by red volcanic soils with surrounding areas of swamps and a small lake.

Map 3-1 Atiu

Source – New Zealand Department of Survey & Land Information

Atiu has five villages; Teenui, Ngatiarua, Areora, Tengatangi and Mapumai, concentrated on the central plateau and a population of 623 (Dec 2001 Census). A house survey in Jan 2004 indicated a population of 530. As with the other islands in the Southern Group migration has decreased the population of Atiu by around 30% over the last decade. 131 people are engaged in paid employment (Dec 2001 Census).

Atiu has the highest annual average rainfall in the Cook Islands (1,980mm) which has resulted in erosion of parts of the inland hills characterised by red volcanic soils. Table 3-1 list basic physical statistics for Atiu.

Table 3-1 Atiu Physical Statistics

Land Area			2,693 Ha
Arable soils	Class 1		469 Ha
	Class 2		1,370 Ha
Reef Circumference			21 km
Transport	Air		Daily
	Airstrip (length)		1.7 km
	Shipping		Monthly, Variable
	Roads	Sealed	8.9 km
	Roads	Unsealed	
Distance from Rarotonga			215 km
Distance from nearest inhabited islands			50 km (Mitiaro)

Source – Atiu Island Profile 2003

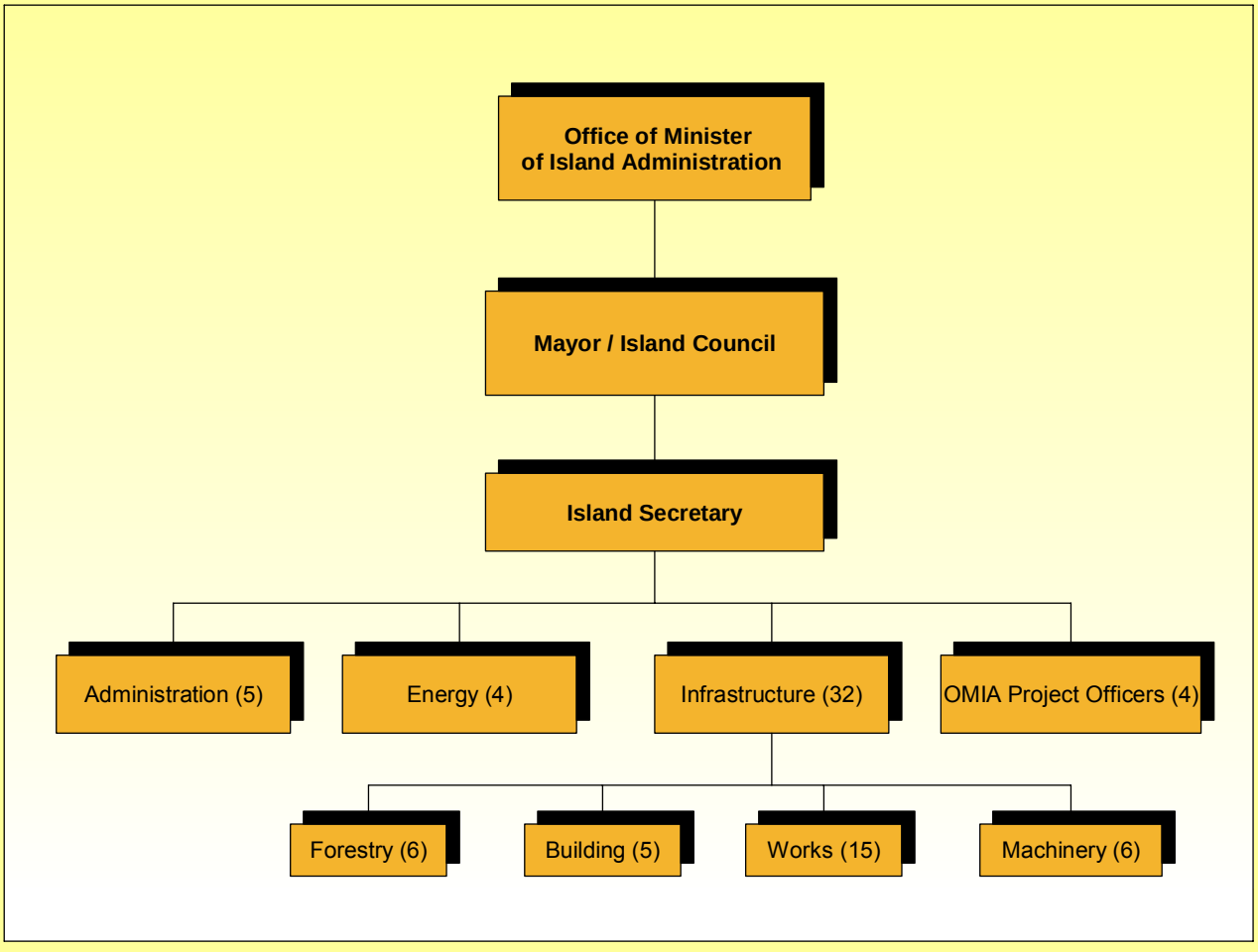
2 Makatea are high islands which have sunk to sea level, developed coral reefs, and then elevated by volcanic activity. Their central hills are surrounded by elevated dead coral

3.1.2 Local Government

The local governing body of the island is the Atiu Island Council (AIC). 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 Arikis, a representative of the Aronga Mana, 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 managing the functions of the Island Administration (IA) and works closely with the Mayor and Island Council for the benefit of the island community. Figure 3-1 shows the organisational structure of the IA.

Figure 3-1 Atiu Island Administration Structure



Source – Atiu Island Profile 2003

3.1.3 Atiu Integrated Development Plan 2000-2005

The need to put in place an integrated development framework for Atiu to address the high rate of migration of young people to Rarotonga and overseas had been identified by Atiu leaders, Government representatives and the Island Council. This plan identified the following goals and strategies as follows.

Atiu Development Goals

The Atiu Development Goals are integrated but are shown in four parts, as follows:

1) To halt mass exodus of the young people from Atiu to Rarotonga and Overseas.
2) To increase economic power to the people of Atiu to enable them to improve their standard of living.
3) To ensure that people of Atiu receive quality education and an, improved informative economy.
4) To improve the health standard of the people of Atiu and to live in harmony with their environment.

Atiu Development Strategies

These strategies must be implemented systematically in order to impact efficient development on the island. This must done by:

1) Funding the newly established nursery to support seedlings and propagation of economic plants, currently in existence and those that will be introduced in the near future, in support of farming to make Atiu a major agriculture export island.
2) Initiating the maintenance and improvement of all strategic infrastructures to support socio-economic developments and management functions on Atiu.
3) Providing sufficient and efficient water supply to the island:
    a. Relocate one windmill to pump water for residents;
    b. Immediately identify water wells in the valleys and develop these to support the existing water supply on the island; and,
    c. Establishing a revolving fund to encourage the purchase and construction of water tanks, and gutters to catch rain water.
4) Providing priority infrastructure to induce economic activities of scale conducive to the capacity of the island economy to make these activities successful.
5) Pncouraging economic growth on a scale competitive to Rarotonga and other outer islands to attract people of Atiu origin back to the island.
6) Devising an education system that supports the artisans as well as that which supports the academics. The type of education system that forms the basis to sustaining the islands economy.
7) Educating people in appropriate skills that will provide them to sustain their day to day living and gives them a sense of pride. This will encourage the population to be productive.

8) Providing incentives for Atiuans to manage the liquid and solid waste on the island without damaging their environment through careless disposal

9) Improving the welfare and health standards of the people in harmony with their environment.

10) Encouraging sustainable eco-tourism between Atiu, Aitutaki and Takutea.

11) Encouraging cultural activities that will support tourism in general as well as the specialized eco-tourism of Atiu and Takutea.

12) Ensuring that youth and women are fully involved in decision-making and positively supporting development on the island.

13) Encouraging the harvesting of marine resources for home consumption and selling excess to the developing tourism market to supplement house income.

Of particular relevance to this project is the Sectoral Strategic Plan for Energy. The stated goal for the energy sector being; "To deliver to every consumer, electricity, at the least cost while maintaining a reliable and sustainable energy supply." Table 3-2 lists the objectives of the Strategic Plan for energy and status as of the time of the field visit to Atiu.

Table 3-2 Energy Sector Strategic Objectives and Current Status

Objectives	Status
To maintain the existing power supply	Ongoing
To hire a replacement Officer in Charge for the Australian volunteer.	Not completed
To complete reticulation of power supply including the installation of a sub-station in Areora and a link between the power station and Teenui.	Areora sub-station installed. Link to Teeuni to be completed
To complete the fencing of the power station and improve the fuel storage area.	Fencing completed. Fuel storage upgrade not completed
To replace all untreated wooden power poles with concrete poles.	Underway
To purchase a utility truck with a 'cherry picking' hoist installed.	Completed
To provide adequate street lighting in all villages	Main village areas completed.

Source – Atiu Island Profile 2003

3.1.4 Proceedings of Consultative Meetings on Atiu, 4-7 March 2003

A consultative meeting was held on Atiu from the 4th to 7th March 2003 to discuss the islands development and strategic plan. Following are the key energy sector comments from this meeting:

- Infrastructure needs and issues highlighted the need for alternative energy systems and in particular the use of wind power;
- Replacement of old power poles; and,.
- Upgrading of household meter boxes.

3.1.5 Infrastructure

An unsealed road circuit the island with the central settlement area linked by a network of roads to this coastal road. The central settlement area has nearly 9km of sealed roads.

The 1.7km unsealed airstrip on the Northern Coast has scheduled daily services to Rarotonga (45minutes) and neighbouring islands and is serviced by Air Rarotonga's Banderante and Saab turbo prop aircraft.

Water supply is from a combination of private and communal rainwater tanks and piped public supply sourced from bores in the centre of the island. Rainwater is the only potable supply with reticulated groundwater used for bathing and washing. Supply has been limited and works are under way to investigate new water sources.

Picture 3-1 Atiu Airport

Photo: Bruce Clay, 2004

The Atiu Island Water Supply & Sanitation Assessment Final Report from year 2003 recommends amongst other refurbishment and water gallery development the repairing of two windmill bore pumps and perhaps solar powered water pumping.

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. The surge at the wharf and shallow entrance to the landing is a concern. Dredging of the launching area and upgrading of facilities is required.

Picture 3-2 Water Reservoir and windmill

Photo: Bruce Clay, 2004

Picture 3-3 and 3-4 Taunganui Landing and 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 Atiu Energy's grid supplying backup power.

Picture 3-5 Telecom Facility

Photo: Bruce Clay, 2004

Agriculture is the principal productive sector of the Atiu economy. Most produce is for home consumption. Nono has developed as the major export of over 1000kg/month. A small amount of coffee is also exported to Rarotonga. Treated kikau (palm frond) has developed as a new industry.

Tourism has been steadily growing over recent years with close to a thousand visitors per annum. There is presently 5 motel/lodges in operation with a total of 47 beds. Any future tourism development will need to be managed particularly in regards to provision of water and power services.

Picture 3-6 and 3-7– Atiu Motel and Kopeka Lodge

Photo: Bruce Clay, 2004

3.2 Atiu Power Sector

3.2.1 Background

Atiu Power Supply (APS) is operated as a department of the Island Administration (IA). Power generation is by way of diesel powered gensets with underground high voltage (HV) distribution and overhead low voltage (LV) distribution. Power supply has been 24 hours since 1998.

Atiu Island Council (AIC) has requested Government to return APS to 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 AIC to assess the best method of implementation. Aitutaki Power Supply is also included in this Cabinet decision.

Picture 3-8 Atiu Power Station

Photo: Bruce Clay, 2004

APS is presently staffed by one Supervisor , directly responsible to the Island Secretary, full time linesman, full time Electrical Mechanic and one part time operator. The Linesman and Electrical Mechanic also act on a part time basis as operators. The station is not manned full time. The power station is located on the Western extremity of the central settlement. The Officer in Charge position is currently vacant pending the hiring of a suitably qualified staff or TAU taking over responsibility of APS.

Table 3-3 lists the installed generation plant and tariff structure.

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

Supply Hours	Generators	Installed Capacity (kW)	Base/Max Load (kW)*	Tariff	
				Domestic	Commercial
24	1 x Hino 110kW 2 x Deutz 45kW 1 x Lister 42kW	242	32/85	$0.40/kWh + $5/month service charge	$0.62/kWh + $5/month service charge

* Loads based on logged data during field visit

3.2.2 Generation

Peak loads are carried by the Hino whilst off peak loads by the smaller sets. The smaller Lister appears to be the older of the generators.

A capital expenditure has been approved in the Atiu Island 2004-2005 budget of $29,669 for purchasing of new alternators for the three smaller generators.

Picture 3-9 Lister and Deutz Generators

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 200kVA transformer and distributed via underground feeders to 1 x 200kVA, 2 x 75kVA and 1 x 30kVA transformers for overhead LV distribution.

Picture 3-10 Hino Generator

Photo: Bruce Clay, 2004

A capital expenditure has been approved in the Atiu Island 2004-2005 budget of $16,500 for upgrading of 3.3kV switchgear.

As of June 2004 there are 246 domestic, 24 commercial and 4 church consumers connected to the grid. Churches are metered but not billed.

31 x 150W High Pressure Sodium and 4 x 8W fluorescent street lights are installed and un-metered. Total unbilled power consumption of the street lights would be in the order of 20,000kWh per year and would account for 5% of delivered power.

3.2.4 Station Manning Hours

The Power Station is presently manned during peak loads from 5am – 8.30am and 5pm – 8pm. 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. The station is attended at 12:00 and 00:00 hours for swapping generators if required and to note electrical and fuel readings in the station log.

Picture 3-11 Street Light

Photo: Bruce Clay, 2004

3.2.5 Fuel Handling

Fuel is carried in hull tanks on the inter island vessels and discharged to 1600 lt mobile tanks on the islands lighter for transport to the landing where a Hyab truck lifts the tank out of the lighter and transports to the power station. The lighter can carry one mobile tank at a time. Fuel deliveries can be in the order of 20,000lt per shipment which is equivalent to around 2 months of requirements. 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.

Fuel is stored in the mobile tanks at the power house and pumped as required to the main bulk tank of approximately 7,000lt capacity. From the bulk tanks, fuel is manually pumped into 2 day tanks.

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 3-4.

Picture 3-12 Fuel Storage

Photo: Bruce Clay, 2004

Table 3-4 Logged Power Variables

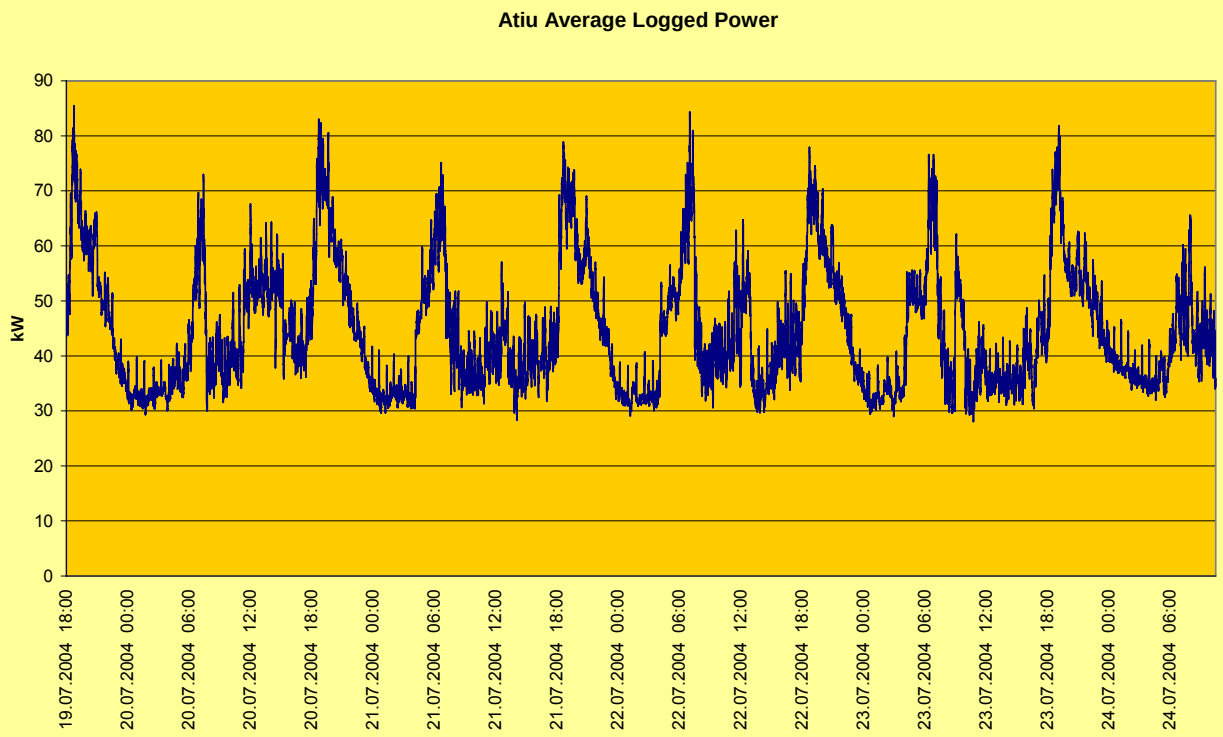
Phase Voltages; V1,V2,V3 in Volts (V)
Phase Currents; I1,I2,I3 in Amps (A)
Frequency in Hertz (Hz)
Phase and Total Power in kilo Volt Amps (kVA)
Reactive Power in kilo Volts Amps Reactive (kVAR)
Power Factor (0 – 1 inductive or reactive)
Current and Voltage Total Harmonic Distortion in % (THD)
3^{rd},5^{th}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

Logged data is analysed using Powerlink software

The installed generation capacity with 4 sets of an installed capacity of 244kW is adequate however is vulnerable to insufficient capacity should the Hino 110kW set break down. Should the 110kW set breakdown a maximum generation capacity of only 90kW would be available. Peak loads regularly reach 85kW.

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

Figure 3-2 Average Logged Power



Logged power was in the range 29.2 – 84.3 kW with an average loading of 44.5kW. This compares well to the power station records for the past year showing an average of 43.5kW.

Peak loads were occurring from 6:00 – 8:00am and 18:00 – 23:00pm. The evening peak load being generally the larger and longer of the two peaks. The power station logs have noted peak loads of up to 100kW.

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

Phase 1	Phase 2	Phase 3
30%	37%	34%

Frequency was logged in the range of 49.6 – 53.4 Hz which is acceptable. The operators tend to run the frequency a little higher than 50Hz.

Power factor was in the range 0.69 – 0.95 which is acceptable. Power factor does not often fall below 0.75.

Voltage Total Harmonic distortion was a maximum of 4.3%, which is acceptable.

As of June 2004 there were 246 domestic, 24 commercial and 4 church connections. An energy survey was carried out with 206 households and 51 commercial, Island Administration Departments, schools, meeting houses and churches. The survey assessed electrical appliance usage and main energy used for cooking.

Extensive use of electric jugs, refrigeration and TV's was apparent with the electric jugs and irons appearing to factor significantly in the size of the morning and evening peak loads.

Key findings of the survey are shown in Tables 3-5 & 3-6

Table 3-5 Residential Electrical Appliance Usage

Lighting; incandescent: fluorescent ratio:	4.1:1
Refrigeration; % of households using:	73%
Electric Jugs; % of households using:	84%
Electric Frypans: % of households using:	44%
Electric Clothes Iron; % of households using:	84%
Electric Toaster; % of households using:	22%
Electric Washing Machine; % of households using:	17%
TV; % of households using:	75%
Electric Hot water Systems; No. of households using:	5

NB Limited use of solar hot water heating

Table 3-6 – Energy use for cooking (% of households)

Gas:	25%
Wood:	26%
Electric:	1%
Gas & Wood:	35%
Gas & Electric:	2%
No Response:	11%

Four of the households surveyed remarked that they thought the tariff was too high.

Picture 3-13 Settlement

Photo: Bruce Clay, 2004

Table 3-7 Commercial Survey Main Points

- Largest consumer averages 70kWh/day running two upright display chillers, several large chest freezers and a walk-in cool room.
- One Bakery uses wood fired oven with a 7,5kW dough mixer.
- Atiu Coffee works with the power station operators to ensure they operate their coffee roaster off-peak. This is generally around 9:00am twice a week and can operate for around 6 hours. The roaster can draw up to 17kW but operates intermittently as it maintains temperature. Other plant can run at over 10kW and is associated with preparing the coffee berries.
- Atiu Motel operates a water pump of around 5kW, which surges to 25kW on start up.
- Joinery Shop has several larger 3- phase machines.
- Kopeka Lodge uses solar hot water heating

Picture 3-14 & 3-15 Joinery Shop and Coffee Roaster

Photo: Bruce Clay, 2004

Developments and Load Growth

- A Boutique style Resort is planned for the Eastern coastal area of Atiu. The resort could have a total of 40 or more suites all with air-conditioning plus swimming pool and amenities. There is no transmission line to the area and it would be assumed that the resort would generate its own power.
- The Atiu Island Water Supply & Sanitation Assessment Final Report from year 2003 calls for the construction of a new water gallery toward the South West of the island and depending on final design may include electric water pumping. It has been suggested by consultants in this report to consider solar and perhaps wind power for the pumps.
- Load growth from domestic consumers is not considered to be significant unless island development progresses.
- Eco-tourism developments will not add significant load.
- Most anticipated load growth can be offset by encouraging energy efficiency.

3.2.7 Water System

Currently the two windmill pumps are inoperative and the two electric bore pumps at Teponui (6kW) and Maranou (4kW) have broken down and are awaiting repair. Carting water by truck from a ground water source is being used as an interim measure. The Atiu Island Water Supply & Sanitation Assessment Final Report from year 2003 provides a water development plan to address the water shortage on Atiu.

The two electric bore pumps consume around 30kWh per day whilst operating.

Two Southern Cross 1ZC 10' multi-blade (drag) wind turbines located in the main settlement appear to have been out of service for many years. Apparently the pump head may have fallen to the bottom of the bore and has not been repaired. The Atiu Island Water Supply & Sanitation Assessment Final Report from year 2003 suggests they could be put back in service.

3.2.8 Maintenance

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

Major engine overhauls are scheduled for every 12-14,000 hours with engines shipped to Rarotonga for service at the OMIA workshop. There is one spare Deutz engine presently in Rarotonga undergoing service.

The Hino 110kW generator had recently returned from a complete overhaul in Rarotonga.

Unscheduled maintenance is dealt with according to available parts, tools and personnel. Approved in the Atiu Island 2004-2005 capital budget is the replacement of the three 60kVA alternators on the two Deutz and one Lister generators.

3.2.9 Distribution

HV, 3.3 kV, underground distribution appears to be in reasonable condition. There is no record of service of the transformers in the last five or more years and would be worth considering. Some HV switchgear is lacking and in poor condition. A HV extension is planned to coincide with the water system upgrade.

LV overhead distribution using insulated aluminium conductors is in need of significant maintenance with replacement of 26 of the local wooden poles required urgently. The general state of the LV distribution is poor and serious consideration should be given to replacing the separate aerial cables with more durable and lower service Aerial Bundled Cable (ABC).

Picture 3-16 & 3-17 Wooden and Concrete Power Poles

Photo: Bruce Clay, 2004

3.2.10 Full Recovery Tariff

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

Atiu Full Cost Recovery Tariff $1.11/kWh

Results from system modelling with Homer[3] calculated a cost of generated energy of $0.93/kWh which equates to $1.09/kWh full cost recovery tariff based on the generated/sold kWh ratio as per Technical Report shown in Table 3-8. Homer results provided a reasonable validation of the calculated full cost recovery tariff.

If the non-metered street light consumption of 20,000kWh/year was to be billed the tariff would reduce to $1.07/kWh.

The following table 3-8 for the period July 2003 – June 2004 showing monthly power generation and fuel use was generated from the APS Technical Reports submitted to the Energy Division. This data was the most consistent of all technical reports reviewed (i.e. Atiu, Mauke, Mitiaro and Pukapuka).

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

Table 3-8 Atiu Technical Report

Period	Generated (kWh)	Sold (kWwh)	* Unbilled (kWh)	Loss (kWh)	Eff. (%)	S.F.C (kWh/l)	Fuel Use (litres)	S.O.C (kWh/l)	Oil Use (litres)
Jul-03	30460	25959	138	4363	85.7	2.81	10841	328	93
Aug-03	30920	24997	3701	2222	92.8	2.67	11600	468	66
Sep-03	30720	26278	2481	1961	93.6	2.93	10490	445	69
Oct-03	32150	26293	2481	3376	89.5	2.73	11770	473	68
Nov-03	31020	27018	1340	2662	91.4	2.81	11052	456	68
Dec-03	33864	25494	126	8244	75.7	2.77	12240	616	55
Jan-04	33840	30705	2798	337	99.0	2.82	12000	408	83
Feb-04	30261	26294	305	3662	87.9	2.51	12070	240	126
Mar-04	32361	25925	196	6240	80.7	2.89	11200	539	60
Apr-04	34752	29724	1151	3877	88.8	2.87	12098	511	68
May-04	28714	27601	136	977	96.6	2.41	11920	219	131
Jun-04	31947	29772	246	1929	94.0	2.70	11830	344	93
Total	***381009***	***326060***	***15099***	***39850***	***89.5***	***2.74***	***139111***	***421***	***980***

* NB. Non-metered street lighting is not included. Consumption estimated at 20,000kWh/year.

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

Fuel and Oil Costs were calculated as per table 3-9.

Table 3-9 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**	

Personnel, maintenance and other operating expense information were gathered from the IA accounting records as shown in table 3-10.

Table 3-10 Operating & Maintenance Costs

Cost	Amount	Source
Personnel	$ 39,800	June 2004 YTD Financials
Maintenance	$ 10,400	June 2004 YTD Financials
Admin Telecom & Consumables	$ 3,255	June 2004 YTD Financials
Est. share of office staff on IA payroll	$ 4,000	25% of $20,000 accounts salary
Total	***$ 57,455***	

Estimated current capital and recurrent costs for power station and distribution are listed in table 3-11.

Table 3-11 Estimated Current Capital and Recurrent Costs[4]

Estimated Full Capital Cost for Current Power Station				
	qty	**unit**	**cost**	Total
Engineering/Civil Design	1	fee	$ 30,000	$ 30,000
Building cost	120	sqm	$ 1,000	$ 120,000
Switchboard incl. sync panel	1	at	$ 35,000	$ 35,000
HV Transformer 200kVA	1	at	$ 18,860	$ 18,860
Fuel & Electrical fitout incl. labour	1	at	$ 12,000	$ 12,000
Fuel Storage bulk tanks	1	7,000 litre	$ 7,000	$ 7,000
Mobile tank	14	1600 litre	$ 2,000	$ 28,000
Hino 110kW	1	each	$ 90,000	$ 90,000
Deutz gensets ~ 45kW	3	each	$ 37,000	$ 111,000
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	$ 15,000	$ 15,000
Billing Computer/Printer	1	at	$ 4,000	$ 4,000
Contingency	10%	of	$ 525,860	$ 52,586
			Total	***$ 578,446***

Estimated Costs for Current Power Distribution				
HV Distribution	**qty**	**unit**	**cost**	**Total**
25mm Cu underground cable	8000	meters	$ 17.05	$ 136,400
50mm HD PVC conduit	2000	lengths	$ 17.85	$ 35,700
HV Transformer 200kVA	1	at	$ 18,860	$ 18,860
HV Transformer 75kVA	2	at	$ 7,785	$ 15,570
HV Transformer 30kVA	1	at	$ 5,190	$ 5,190
Concrete & misc. items	1	each	$ 20,000	$ 20,000
Equipment Freight NZ to Atiu estimate	20%	of	$ 231,720	$ 46,344
Allow 350 man hours to install mains @ $20/hr	1000	each	$ 20	$ 20,000
Equipment allowance (ditch digger etc)	1	each	$ 15,000	$ 15,000
Contingency	10%	of	$ 313,064	$ 31,306
			Total	***$ 344,370***

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

LV Distribution (incl freight)	qty	unit	cost	Total
Arial Bundled Cable 95mm Al	14000	meters	$ 9.65	$ 135,100
Poles incl ABC fittings every 60meters	240		$ 385.00	$ 92,400
Supply feeder connection to the ABC & install	280	each	$ 100.00	$ 28,000
Installation priced per pole incl. labour & equipment	240		$ 220.00	$ 52,800
Contingency	10%	of	$ 718,977	$ 71,898
			Total	***$ 380,198***

Estimated Current Recurring Costs				
	Period	**Qty**	**Unit Cost**	**Cost**
Generator Major Overhauls @ 35% of initial cost	5 years	4	$ 13,200	$ 52,800
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

APS, as is the case for Mauke 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 *Atiu Integrated Development Plan 2000—2005 the goal for the energy/power sector is to "*To deliver to every consumer, electricity, at the least cost while maintaining a reliable and sustainable energy supply ". Whilst budget constraints are a limiting factor, the following areas should be considered to improve the operation of the existing diesel generation system and thereby assisting in reaching the current island goal for the power sector.

3.3.1 Power Station

Generation capacity is sufficient at present but does rely on the operation of the larger Hino generator during peak loads. Should the Hino be out of service two of the smaller 45 kW machines would be run very close to there rated output and not be able to provide any significant reserve. When funds allow replacement of the Lister HR6 should be considered. The new generator should be 60-70kW prime giving a capacity of just over 100kW operated with one of the Deutz 45kW sets.

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

A Power Station building upgrade and refurbishment would improve working conditions by way of improved ventilation, lighting, wiring, noise suppression in the operating room and general amenities would require an investment of approximately $15,000 - $25,000.

Fuel handling facilities should be upgraded with improved pumping and filtration, particular water separation, and spill containment. Present fuel and oil handling practises result in considerable contamination of the fuel storage ground area from spilt fuel and engine oil waste. Up to 20lt per week of water contaminated diesel fuel is spilt onto the ground. Estimated cost for upgrading works $10,000 - $15,000.

3.3.2 Distribution

HV switchgear upgrade is covered under the Atiu Island 2004-2005 capital budget and should bring the HV distribution up to a satisfactory standard. Servicing of transformers should be undertaken to ensure reliable operation.

Much of the LV distribution requires replacement. ABC as used on Rarotonga has proved to be more serviceable and with lower maintenance costs than the existing separated aerial cables. Estimated investment is shown in Table 3-12.

Table 3-12 – LV Distribution Upgrade Investment

LV Distribution (incl. freight)	Qty	Unit	Unit Cost	Total
Arial Bundled Cable 95mm Al.	14000	meters	$ 9.65	$ 135,100
Replacement poles incl. ABC fittings	240	each	$ 385.00	$ 92,400
Supply feeder connection to the ABC & install	280	each	$ 100.00	$ 28,000
Installation priced per pole incl. labour & equipment	240	each	$ 220.00	$ 52,800
Contingency	10%	of	$ 718,977	$ 71,898
			Total	***$ 380,198***

Security of metering in consumers premises needs to be tightened as does upgrading of consumer installations as the standards on some installations are well below the regulatory safety requirements.

3.3.3 Administration and Personnel

Implement a staff training program. Presently there is no formal training program. APS, 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 3-13.

Picture 3-18 Safety Concerns/Pole Replacement

Photo: Bruce Clay, 2004

Table 3-13 Training

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

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. Discuss with the Energy Division occupational health and safety practices pertaining to electrical generation and reticulation.

3.3.4 Demand Side Management (DSM)

Atiu has several larger intermittent loads that can and are being managed. The Atiu Coffee machinery is the largest load on the island and procedures are already in place to operate the loads off-peak. Other significant loads are the electric bore pumps for the community water supply which should be operated off-peak. At the time of the field visit Atiu Motel's electric water pump had a leaking valve which caused 25kW surges every 40 minutes as it cycled. Station operators can be attuned to these types of faults and encourage consumers to remedy the situation.

The detailed energy survey undertaken clearly document 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 being convenient will require a conscientious effort from the Island Council and Administration to encourage consumers to consider other methods of water heating such as gas or wood.

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 on Atiu however the cost appears relatively prohibitive for the majority of consumers. The high cost of shipping and margins required by the shop keepers contributes to their high retail price. APS 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

Fuel wood for cooking is being largely replaced by Liquefied Petroleum Gas (LPG) as a more convenient fuel. Fuel wood is now predominantly used by low income households and for the traditional "umu kai" (earth) oven. Survey results show 26% of households on Atiu use wood as their primary source of cooking fuel. As such fuel wood is still an important resource on Atiu. This could be due to the significant amount of reasonably accessible timber on Atiu as a result of tree planting in the past.

Fuel oil from coconuts offers the best biomass potential 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 Atiu has 105 households using 18,898 coconuts weekly for feeding livestock and 115 households using 1,563 coconuts weekly for consumption. The census shows approximately 2,100 "cultivated" coconut palm trees whilst the number of "wild" coconuts is not counted. 58.7 acres of tree crops are planted on Atiu and whilst the 2000 Census does not distinguish between crops it could be reasonably assumed most is used for coconut.

In the early 1980's a wood gasifier was installed under a US Peace Corp project.[5] The gasifier product was fed into the air intake of the diesel generator. This operated from around 1982 until 1986. It was dismantled in 1987 as it proved difficult to acquire enough timber and there were corrosion problems in the gasifier and its feed to the diesel generator. The Geisha plant was introduced in Atiu during this time to provide the energy resource for the gasifier and has since become problematic with it's rapid growth. Pine plantations were also introduced at this time for both timber production and control of erosion. There is now approximately 2,700 acres of maturing Pinus carribaea. Perhaps with more modern gasifier technology the use of the abundant Geisha and Pine may prove economical.

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 2,000 pigs and 600 goats on Atiu. 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.

[5] The consultants could find no documentary information on the gasifier project and relied on verbal accounts from Roger Malcolm and the Mayor which contradicted the GEF/ UNDP Pacific Islands Renewable Energy Project (PIREP) Draft Cook Islands National Report May 2004 information in the use of pine for fuel.

As is the current situation in Southern Islands many of the pigs are not contained in pens and waste collection would be difficult. The Island Council 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 Global solar radiation data on Atiu however data collected from the Meteorological Office adjacent Rarotonga Airport should be sufficient for design and analysis of solar power systems. Atiu and Rarotonga are of similar latitude whilst Rarotonga being mountainous in comparison. Due to Atiu's elevation and high rainfall it would be reasonable to assume that it is similar to that of Rarotonga.

Collected solar radiation data for Rarotonga is show in Table 3-14. 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 3-14 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 GEF/ UNDP Pacific Islands Renewable Energy Project (PIREP) Draft Cook Islands National Report May 2004

Sufficient vacant land area is available adjacent the power house to erect a PV array of close to 150kWp. Other areas that could be considered are the site of the original airport and roofs of public buildings for modular grid connect PV. These areas would appear to have minimum impact on current land use.

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 mast 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[6], and COWI/Risoe 1998[7], 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[8]. 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.

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

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

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

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

The old airport on the plateau to the South East of Areoa Village offers the most potential for wind development. It is well exposed to the trade winds and has little residential development within 200 meters. Trees to about 6 meter in height have grown on the site so some clearing will be required. As for the other islands in the Southern Group the South East coastal areas offer potential however distance to the grid and in Atiu's case, obstruction from the central plateau would reduce viability.

The old airport site should have some acceleration affect due to the surrounding terrain rising slowly to the plateau. Whilst this may not be as great as that in Mangaia it is expected to be more so than Mauke and Mitiaro. Vegetation may cause some deceleration which could be minimised with some clearing of the airstrip to the East.

Based on the monitored data from Mangaia the average wind speeds for the old airport site at Atiu have been estimated as shown in table 3-15. These estimates are strictly for preliminary analysis and the financial analysis will test the sensitivity of varying these figures.

Table 3-15 Atiu Estimated Average Wind Speed

Commencing with Managia annual average @ 30m a.g.l.	7.5 m/s
Decrease in wind speed due to less terrain effect	5%
Assumed wind shear ratio as per Mangaia	$\alpha = 0.25$
Then Atiu annual average @ 24m a.g.l.	7.0 m/s
and @ 30m a.g.l.	7.1 m/s

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 Atiu 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 Atiu 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 managed 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 3-16 lists the current Island Administration equipment which could be utilised for power system development and standard charge out rates for private use.

Table 3-16 Atiu Island Administration Equipment

Type and Description	Current Status	Charge out Rate
5 tonne hydraulic hoist truck (Hyab). Used for unloading barge and general lifting/carting works on island	Operative but in poor condition	$40/hr
JCB brand loader/backhoe (JCB)	Has engine problems and in generally poor condition	$20/hr
6 tonne tip truck	Reasonable condition	$40/hr
2 tonne Mitsubishi Forklift	Reasonable condition	N.A.
Komatsu Grader	Requires steering rod replacement	N.A.
Sakai Roller	serviceable condition	N.A..
Tar Sealing trailer with tar heating element (10kW)	serviceable condition	N.A.
D3 Komatsu bulldozer	serviceable condition	$50/hr
3 x Tractors	Working condition	$20/hr
Various cement mixers (engine driven)	Working condition	N.A.
2 x Rock crushing plants	One in use	N.A.
4 tonne barge powered by a two Yamaha 40 outboards	Good condition	~$30/$m^3$

Picture 3-19 Equipment

Photo: Bruce Clay, 2004

Both a new Hyab truck and JCB are planned to be procured to be used in the water supply development and could be used for any renewable energy development.

The airport site is characterised by red friable soil and should not hinder foundation excavation or trenching which could be carried out by the JCB backhoe.

Distance to the closest HV feeder would be less than 300m and poses no serious engineering problems in trenching.

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 staffs already have experience in diesel station operation, training would not need to be extensive.

Telecom has been successfully operating a 7.8kWp 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 Atiu's limited power station manning 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 Resources 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:

Atiu Specific Fuel Consumption 2.74 kWh/lt (average for period July 2003 – June 2004)

Present Landed Fuel Cost $1.069/lt (see Table 3-9)

Avoided Cost of Energy 1.069/2.74 = $0.39/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. In Atiu's case the battery bank required would be in the order of 3,000 kWh.

3.7.1 Option 1 Grid Connect Solar PV

Atiu's midday loading is in the order of 40kW which should allow the inclusion of around 8kWp (i.e. 20%) of solar. The array could be mounted on the roof of the power station building or ground mounted adjacent. Modelling of grid connected PV was carried out using both RETScreen[9] 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 table3-17.

Results were tested for sensitivity to installed cost and the avoided cost of energy as shown in tables 3-18,19 & 20.

[9] 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

Table 3-17 Grid Connect PV Specifications, Cost and Financial Parameters

PV Array	8.64 kWp
Array Area	80 m^2
Grid Inverter	7.5kW
Annual energy production	13,000 kWh
RE Fraction of total energy production	3.4%
Diesel Fuel Substituted	2337 litres p.a.
Installed Total Cost	$133,770
Installed Cost/Wp	$15.48
O&M/year	$990
System Life	25 years
Discount	6%
Project life	15years

Table 3-18 Capital Cost Sensitivity

Installed Cost ($)	Variation	RE Production Cost ($/kWh)
66,885	-50%	0.53
100,328	-25%	0.80
133,770	0%	1.07
167,212	25%	1.33

Table 3-19 Net Present Value (NPV)[10]

		Avoided Cost of Energy ($/kWh)			
Installed Cost		0.31	**0.39**	0.49	0.59
($)	Variation	-20%	**0%**	25%	50%
66,885	-50%	-28162	**-18094**	-5509	7076
100,328	-25%	-61646	**-51578**	-38993	-26408
133,770	**0%**	**-95065**	**-84997**	**-72412**	**-59827**
167,212	25%	-128614	**-118546**	-105961	-93376

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Table 3-20 – Internal Rate of Return (IRR)[11]

		Avoided Cost of Energy ($/kWh)			
Installed Cost		0.31	**0.39**	0.49	0.59
($)	Variation	-20%	**0%**	25%	50%
66,885	-50%	0.1%	**2.3%**	4.9%	7.4%
100,328	-25%	-3.6%	**-1.8%**	0.2%	2.2%
133,770	**0%**	**-6.0%**	**-4.5%**	**-2.7%**	**-1.0%**
167,212	25%	-7.8%	**-6.4%**	-4.7%	-3.2%

At present avoided cost of energy the solar PV would only be financially viable with capital costs reduced by around 60%. With an increase of around 50% in avoided cost of energy (i.e. diesel fuel cost) and PV capital costs reduced 50% the system would be financially viable.

The incremental cost of energy increase over the 100% diesel system is $0.03/kWh or around 3%.

[10] 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%.

[11] 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.

3.7.2 Option 2 Grid Connect Wind

A 20kW wind turbine would be the maximum feasible size to connect to Atius's grid. At an average wind speed of 7.0m/s the 20kW wind turbine should be able to deliver 96% of its output to the grid with 4% excess. Some demand side management could be considered to utilise the excess.

Assumed system nominal specifications and estimated costs and financial parameters are listed in Table 3-21.

Financial sensitivity is tested as per the following Tables 3-22,23&24.

Table 3-21 Grid Connect Wind Specifications, Cost and Financial Parameters

Wind Turbine Generator	20kW
Hub Height	24m
Average wind speed at hub height	7.0m/s
Weibull k factor	2.8
Annual RE production	39,500kWh
Annual Excess RE	1,600kWh
RE fraction of total production	10.3%
Diesel Fuel Substituted	7419 litres
Installed Total Cost	$202,430
O&M/year	$5,830
System Life	20 years
Discount	6%
Project life	15years

Table 3-22 Capital Cost Sensitivity

Installed Cost ($)	Variation	RE Production Cost ($/kWh)
101,215	-50%	**0.37**
151,823	-25%	**0.50**
202,430	0%	**0.64**
253,038	25%	**0.78**

Table 3-23 – Net Present Value (NPV)

		Avoided Cost of Energy ($/kWh)				
RE delivered		0.20	0.29	**0.39**	0.49	0.59
(MWh)	Variation	-50%	-25%	**0%**	25%	50%
19	-50%	-201,699	-183,580	-165,461	-147,342	-129,223
29	-25%	-183,580	-156,401	-129,223	-102,045	-74,867
38	**0%**	-165,461	-129,223	**-92,985**	-56,748	-20,510
48	25%	-147,342	-102,045	-56,748	-11,451	33,847
57	50%	-129,223	-74,867	-20,510	33,847	88,203
Installed Cost						
($)	Variation					
101,215	-50%	-64,246	-28,008	8,230	44,467	80,705
151,823	-25%	-114,853	-78,616	-42,378	-6,140	30,098
202,430	**0%**	-165,461	-129,223	**-92,985**	-56,748	-20,510
253,038	25%	-216,068	-179,831	-143,593	-107,355	-71,118
303,646	50%	-266,676	-230,438	-194,201	-157,963	-121,725
Annual costs						
($)	Variation					
2,915	-50%	-137,150	-100,912	-64,674	-28,437	7,801
4,373	-25%	-151,305	-115,068	-78,830	-42,592	-6,354
5,830	**0%**	-165,461	-129,223	**-92,985**	-56,748	-20,510
7,288	25%	-179,616	-143,379	-107,141	-70,903	-34,666
8,745	50%	-193,772	-157,534	-121,297	-85,059	-48,821

Table 3-24 IRR

		Avoided Cost of Energy ($/kWh)				
RE delivered		0.20	0.29	**0.39**	0.49	0.59
(MWh)	Variation	-50%	-25%	**0%**	25%	50%
19	-50%	-11.1%	-9.1%	-7.2%	-5.5%	-3.8%
29	-25%	-9.1%	-6.3%	-3.8%	-1.5%	0.6%
38	**0%**	-7.2%	-3.8%	**-0.8%**	2.0%	4.6%
48	25%	-5.5%	-1.5%	2.0%	5.2%	8.2%
57	50%	-3.8%	0.6%	4.6%	8.2%	11.6%
Installed Cost						
($)	Variation					
101,215	-50%	-2.3%	2.5%	7.0%	11.2%	15.3%
151,823	-25%	-5.2%	-1.3%	2.2%	5.5%	8.6%
202,430	**0%**	-7.2%	-3.8%	**-0.8%**	2.0%	4.6%
253,038	25%	-8.7%	-5.6%	-2.9%	-0.4%	1.9%
303,646	50%	-9.9%	-7.1%	-4.5%	-2.3%	-0.2%
Annual costs						
($)	Variation					
2,915	-50%	-4.5%	-1.4%	1.4%	4.0%	6.5%
4,373	-25%	-5.8%	-2.6%	0.3%	3.0%	5.6%
5,830	**0%**	-7.2%	-3.8%	**-0.8%**	2.0%	4.6%
7,288	25%	-8.7%	-5.1%	-1.9%	0.9%	3.6%
8,745	50%	-10.2%	-6.4%	-3.1%	-0.2%	2.6%

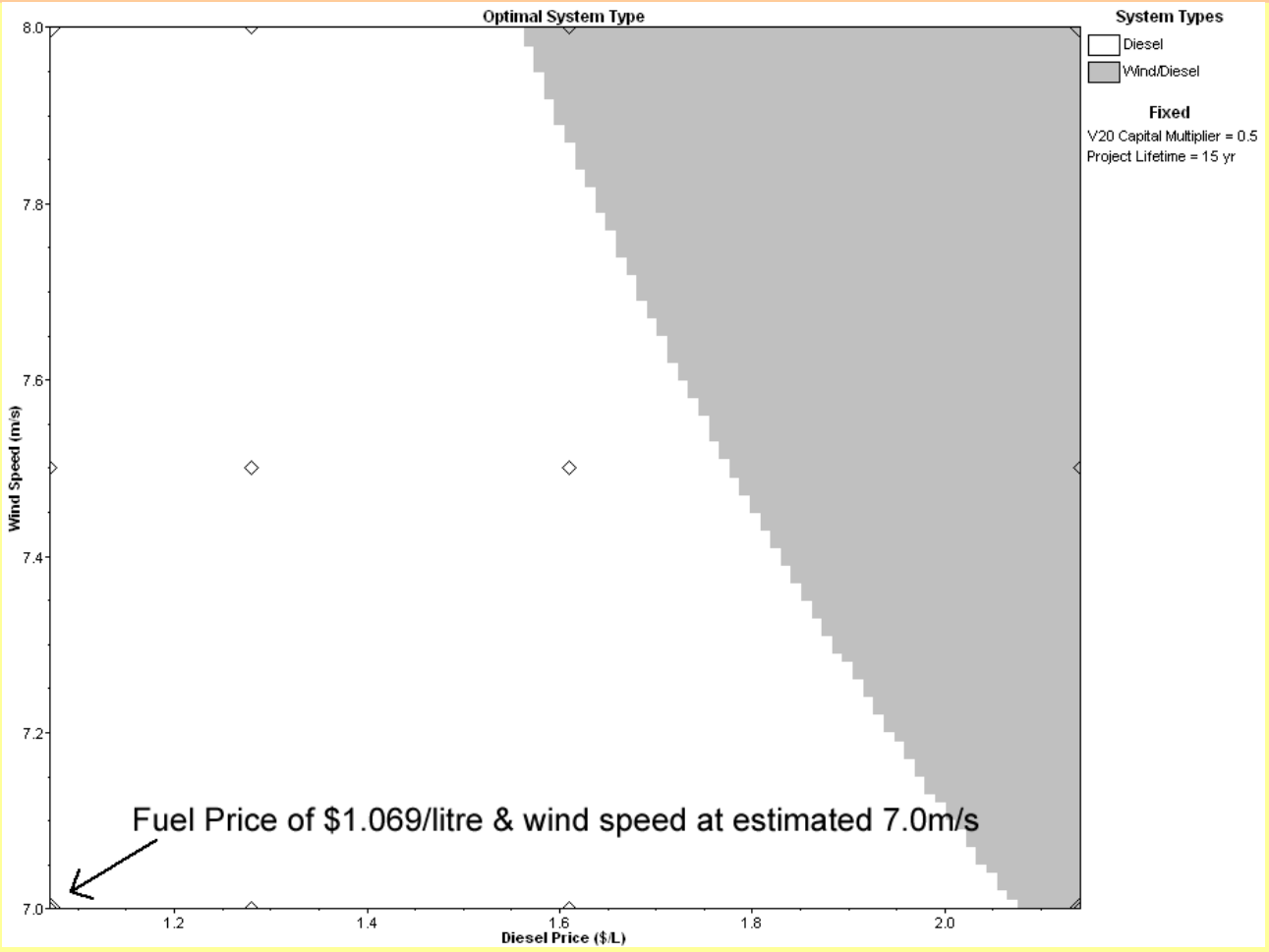
Grid connect wind is both economically and financially more viable than solar PV and would contribute a higher amount of renewable energy to the system. Economic and financial viability is dependent on effectively reducing capital costs through some form of grant funding.

System modelling with Homer investigated the financial viability of wind considering varying Capital Cost multipliers. Figure 3-3 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 $2.10/l 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 $1.55 for the wind turbine to be financially viable.

Figure 3-4 shows graphically the financial sensitivity to varying capital and fuel costs with a fixed wind speed of 7m/s (the estimated average for Atiu). Here the grey areas represent diesel only as

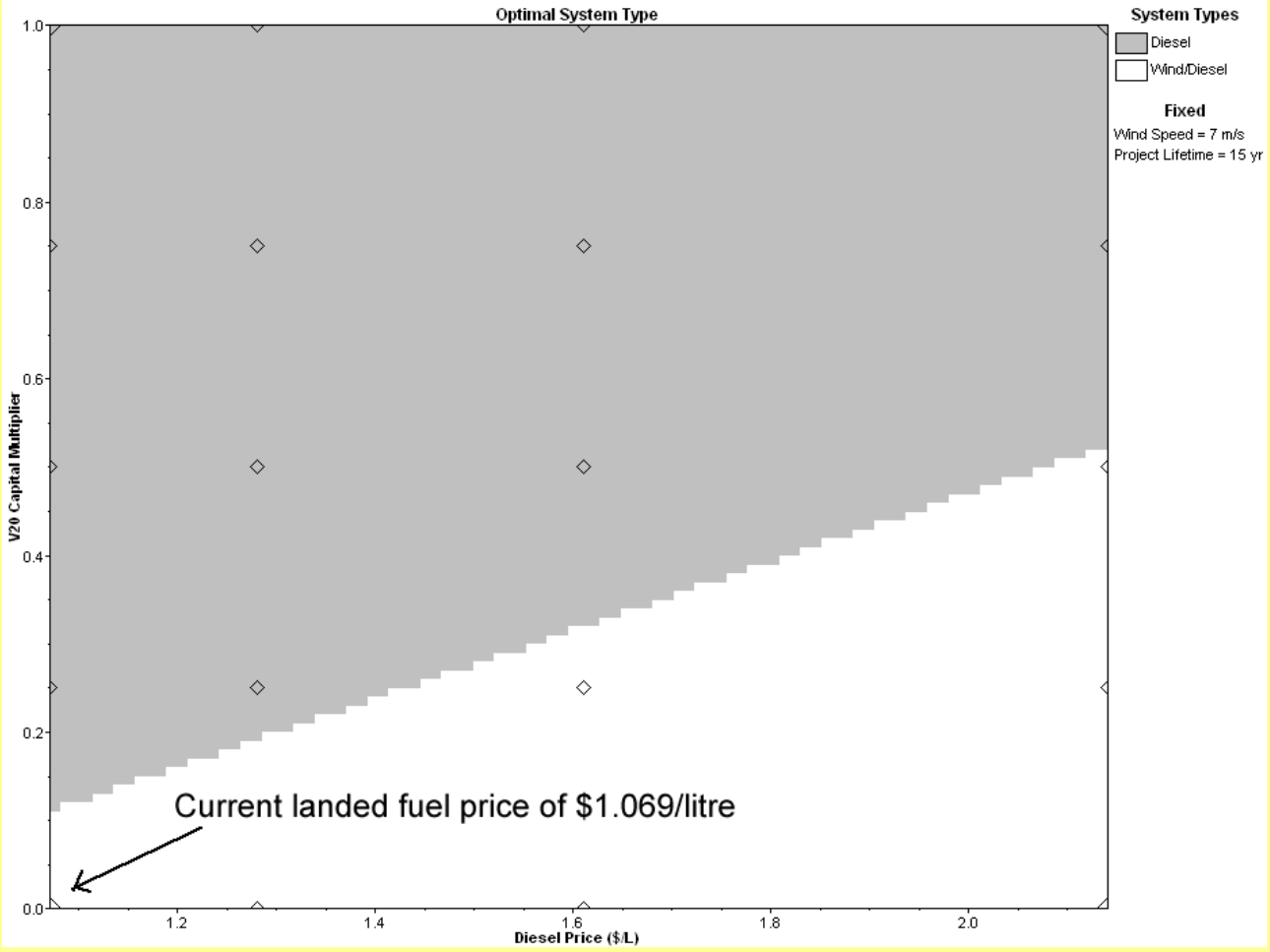
optimal whilst white areas are wind/diesel. At present fuel cost of $1.069/lt (where the x and y axis intersect) the required capital cost for wind to be financially viable is approximately 0.1 (10%) of the "real" cost.

Figure 3-3 Optimal System Type with 50% capital cost



Source – Homer

Figure 3-4 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 produced by the system. For wind turbine modelling a Westwind 20kW DC battery charging WTG was selected as being the most economical commercial proven model. This WTG comes standard from Westwind in Australia on a 30m tilt-up tower.

Table 3-25 shows the Cost of Energy (COE) at wind speed of 7.1m/s at 30m a.g.l., fuel at $1.069/lt and full capital costs. Diesel only generation is $0.19/kWh less than any renewable energy option.

Table 3-25 COE of Diesel and Diesel Hybrid Systems

	PV Array (kW)	WTG (kW)	Total Capital	COE ($/kWh)	RE Fraction	Diesel (litres)	Diesel (hours)
Diesel Only			$1,303,014	**0.93**	0	139,206	8,760
Diesel/Battery			$1,980,214	**1.11**	0	121,015	5,923
Wind/Diesel/Battery		60	$2,326,635	**1.12**	0.32	84,527	4,547
PV/Diesel/Battery	100		$3,137,214	**1.27**	0.33	83,727	4,547
Wind/PV/Diesel/Battery	100	60	$3,548,635	**1.27**	0.65	42,313	2,060

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

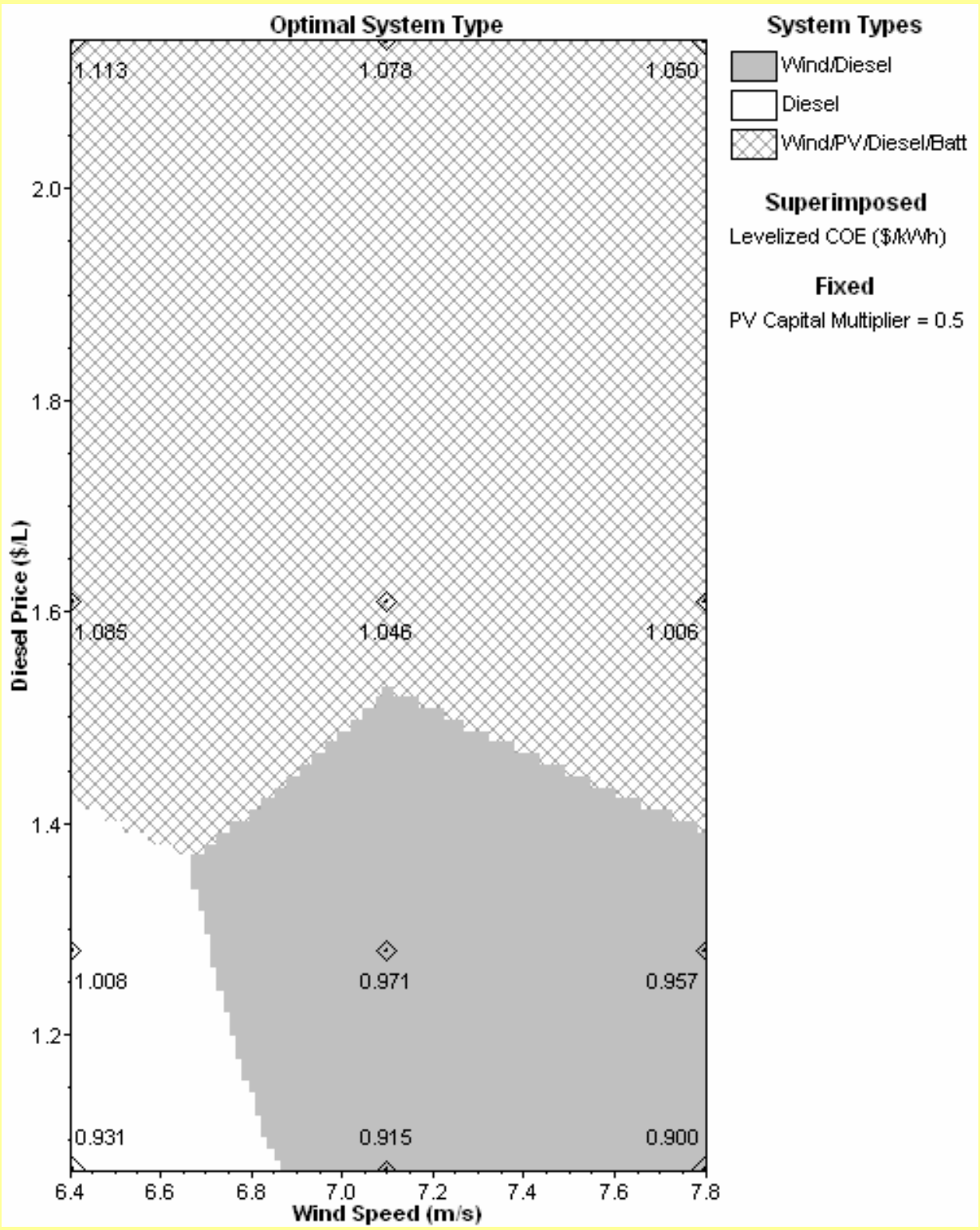
With capital cost reduced by 50% and wind speed of 7.1m/s at 30m a.g.l. and fuel at $1.069/lt renewable energy systems are within 4% of the COE of the diesel based system. This is shown in Table 3-26.

Table 3-26 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			$1,303,014	**0.931**	0	139,206	8,760
Diesel/Battery			$1,641,614	**1.006**	0	120,904	5,904
Wind/Diesel/Battery		60	$1,847,325	**0.965**	0.31	81,024	3,725
PV/Diesel/Battery	100		$2,252,614	**1.027**	0.33	79,957	3,692
Wind/PV/Diesel/Battery	100	60	$2,425,825	**0.986**	0.65	42,336	2,064

Figure 3-5 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 6.83 m/s and that the wind/PV/diesel/battery hybrids are financially feasible once fuel prices reach close to $1.40/lt.

Figure 3-5 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 10% 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 close to 10% of Atiu's power requirements and save over 7,000 litres of diesel fuel annually.

Estimated costs of implementation are shown in Table 3-27.

Table 3-27 – 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 3-20 20kW Wind Turbine as Recommended for Atiu

Photo: Bruce Clay, 2004

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

Biofuel from coconut oil and timber resources offers long term potential to provide all power generation from renewable energy resources available on Atiu. This can be in conjunction with the use of other 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 Atiu Power Supply 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 as the predominant fuel. Investigation into the practical and financial aspects of biofuel production can commence in the short to medium term while wind and solar commence the journey to energy independence.

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 will 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.

The Atiu Island Integrated Development Plan 2000-2005 states the goal: To prevent further degradation of the environment while in the pursuit of economic development. The establishment of any new renewable energy power systems should follow this goal and comply with the new Environment Act 2003.

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 Atiu 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 significant 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. Spilled waste oil was visible on the ground during the site visit.

Picture 3-21 Waste Oil handling

Photo: Bruce Clay, 2004

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 at the rear of the power house to the compound fence is noticeable. There is no grass and the plants at the boundary show signs of dying off. Outside of the compound and to the areas not directly behind the powerhouse the plant life did not appear significantly affected. Due to the porosity of the red volcanic soil on the plateau it would be expected that the fuel and oil would make its way through to the groundwater and onward to the coast. In the Atiu Island Water Supply & Sanitation Assessment Final Report from year 2003 there was no mention of oil contamination. 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 1,000 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.

Daily 6-10lt of fuel is drained from the bottom of the day tanks and allowed to settle in containers to separate water. After separation the diesel from the top of the container is put back in the tanks and the remaining water/diesel mix is discarded potentially on the ground. This water is contaminated with fuel.

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 respiratory 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. There is one dwelling adjacent the power station compound at a distance of around 60m which would be considerably affected by noise. Fortunately the next closest dwelling is more than 100m distant and would not be adversely affected to the point of interference to speech or sleep.

Public Safety

Atiu's's electrical distribution operates at voltages up to 3,300V and consumer connections at 230V. These voltages are particularly hazardous and life threatening. Both 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.

3.9.2 PEIA for Recommended Renewable Energy Option

As documented above the most optimal local energy resource in the short/medium term for Atiu 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 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 and ferrous and non-ferrous metals and fibre reinforced plastic pose 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. A reasonable amount of vegetation clearance would take place however the vegetation is not native and has grown since the closure of the old airport.

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 100 metres from the nearest residence impact of noise will be insignificant;
- Visual – Windmills have been used on Atiu 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; and,
- 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 7,400lt of diesel per year. This corresponds to a net greenhouse gas reduction of ~ 34 t_{C02}/year plus the 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 [12]

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.

(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.

[12] 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.

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 [13]

(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.[14]

(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.

(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.

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

[14] 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.

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[15]

- 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

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

- 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. Power system logging to cover as long a time period as possible. Information, observations and data from previous studies to be corroborated where ever possible. 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. 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. 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

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. - Meet with Minister of Energy/Member of Parliament for Mauke to brief on Mission. - 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. **PM: Travel Rarotonga – Mauke** - Meet with Mauke Island Secretary to brief on Mission - 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. - 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. - Gathering information for preliminary EIA
1st July	Thursday	- Further investigation and information gathering
2nd July	Friday	**AM:** Further investigation and information gathering - Disconnect power logger - Meet with Mauke Island Secretary for debriefing and discussions **PM: Travel Mauke - Rarotonga**
3rd July	Saturday	- Commence preliminary analysis and identify any further information required - Work on Mauke debriefing notes
4th July	Sunday	- Sunday Church

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. - 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. - Meet with Member of Parliament for Mitiaro to brief on Mission **PM: Travel Rarotonga – Mitiaro** - Meet with Mitiaro Island Secretary to brief on Mission - 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. - 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. - Gathering information for preliminary EIA
8th July	Thursday	- Further investigation and information gathering
9th July	Friday	**AM:** Disconnect power logger - Meet with Mitiaro Island Secretary for debriefing and discussions **PM: Travel Mitiaro – Rarotonga** **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. - Meet with Member of Parliament for Atiu to brief on Mission. - 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. **PM: Travel Rarotonga – Atiu** - Meet with Atiu Island Secretary to brief on Mission - 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. - 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. - Gathering information for preliminary EIA.
22nd July	Thursday	- Further investigation and information gathering
23rd July	Friday	- Further investigation and information gathering. - Meet with Atiu Island Secretary for debriefing and discussions
24th July	Saturday	**AM:** Disconnect power logger TRAVEL ATIU - RAROTONGA **PM:** Commence preliminary analysis and identify any further information required - Preparing debriefing notes
25th July	Sunday	- Sunday Church
26th July	Monday	- Meet with Director, Environment Services - Preliminary analysis/Prepare debriefing note and gather any required information
27th July	Tuesday	- Preliminary analysis/Prepare debriefing note and gather any required information

28th July	Wednesday	- Meet with Mata to discuss Draft Concept Project Proposals and Pukapuka power system. - Meet with Member of Parliament and Advisor to discuss issues relating to Pukapuka electricity requirements - 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. **Late PM:** Travel Rarotonga - Nadi

Annex D – Documentary Sources

ADB	Cook Islands Power Development Study 1998
ADB	EIA Guidelines for Power Projects 1993
AIC	Atiu Island Profile, September 2003
AIC	Water Supply and Sanitation Assessmnet Report prepared by Flotek Systems, Rarotonga 2003
CIA	*World Factbook: Cook Island 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
SPREP	Pacific Islands Renewable Energy Project (PIREP) Draft Cook Islands National Report May 2004, SPREP/UNDP/GEF
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

ENERGY SURVEY QUESTIONAIRE ATIU 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				
What is your main method of cooking? Wood / Gas / Electricity				

Increasing Utilisation of Renewable Energy Technologies in the Cook Islands

Project CKI/03/009, UNESCO, Apia Samoa

DEBREIFING NOTE

Prepared by:
Bruce Clay
Herbert Wade

28th July 2004

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. 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 2 x Deutz 45kW 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 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.