ENERGY MISSION TO THE COOK ISLANDS
01 – 12 November 2004

SUSTAINABLE UTILISATION OF RENEWABLE ENERGY
SUB-REGIONAL WORKSHOP ON WIND ENERGY
01 – 03 November 2004; Mangaia, Cook Islands

BIOMASS RESOURCE ASSESSMENT WORKSHOP
04 – 05 November 2004; Rarotonga, Cook Islands

WAVE GAUGE DEPLOYMENT & OTHER ENERGY ACTIVITIES
08 – 12 November 2004; Cook Islands

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SOPAC Miscellaneous Report 581
ACKNOWLEDGEMENT

Funding provided by the Australian, New Zealand and the Japanese Governments through the SOPAC Community Lifelines Programme is hereby acknowledged.

The assistance, logistical support and hospitality provided by the Cook Islands Energy Division, Mangaia Island Council, Mangaia Power Utility and the People of Mangaia is gratefully acknowledged and appreciated.

Appreciation also goes to Otheniel Tangianau\(^1\) and Mathilda Miria-Tairea\(^2\) for their presentations during the biomass resource assessment workshop.

\textit{Meitaki} to Mata Nooroo, Tangi Tereapii, David Akaruru of the Energy Division and Ian Bertram, Sani and Budley from the Marine Resources Department for their assistance in making the wave gauge deployment exercise possible.

Thank you also to the workshop participants from the Cook Islands, Fiji Islands, Samoa, Tonga and Vanuatu for their active cooperation and input to the discussions during the week.

The invaluable assistance and guidance provided by colleagues at SOPAC is much appreciated.

\(^1\) From the Office for Minister of Island Administration.
\(^2\) Project Manager, Waste Management Project, Ministry of Works, Cook Islands.
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THE COOK ISLANDS

Sprinkled over more than 2 million km$^2$ of the South Pacific Ocean lie the 15 islands that comprise the Cook Islands. Geographically, the Cook Islands have an interesting diversity of island landscapes from the high rugged island of Rarotonga (653 m) to the almost atoll-like Aitutaki and the unusual raised islands of Mangaia, Atiu, Mauke and Mitiaro.

The Cook Islands are divided into two groups, with a total land area of 240 km$^2$. Within the southern group lies Rarotonga, the largest with 67 km$^2$, home to about 8000 residents and the main township of Avarua. The southern group also includes Aitutaki, Mangaia, Atiu, Mauke, Mitiaro, Palmerston, Takutea and Manuae. The northern group is more scattered and consists of Pukapuka, Manihiki, Penrhyn, Rakahanga, Nasau and Suwarrow.

The island of Mangaia is the most southerly of the Cook Islands and the second largest. It has the distinction of being the oldest island in the Pacific. Analysis of its geology shows it dates from 18 million years ago, which is probably why it arouses keen interest among geologists. Roughly circular in shape, it rises 4750m above the ocean floor. It has a central volcanic plateau and like many of the southern islands in the Cook Islands, it is surrounded by a 60 m high ring of cliffs of fossilised coral, makatea.

These limestone battlements are honeycombed with caves featuring stalactites and stalagmites of extraordinary beauty. The largest and most spectacular cave is Teruarere. This was rediscovered in the mid 1930s by a native Mangaian in company with the celebrated American writer and Pacific exile, Robert Dean Frisbie. The high outer wall of makatea slopes into the interior and streams from it drain into a lake as well as some small swamps situated between the inner wall of the makatea and the remnants of the original volcanic cone in the centre which is the island's highest point, Rangimotia at 169 m.
EXECUTIVE SUMMARY

The objectives of the mission to the Cook Islands were as follows:
• To conduct a Sub-regional Workshop on Wind Energy in Mangaia;
• To provide an introduction to Biomass Resource Assessment;
• To deploy a wave gauge off the coast in the south-eastern side of Rarotonga;
• Discuss and assist the Energy Division in other energy related issues.

The following is a summary of details on the activities carried out during the mission.

The Sub-regional Workshop on Wind Energy in Mangaia, Cook Islands was made possible through the Sustainable Utilisation of Renewable Energy (SURE) Project. Six member country representatives attended the workshop. One of the objectives of the workshop was for participants to learn from the Mangaia experience with wind energy.

A 2-day training on Biomass Resource Assessment was convened in Rarotonga following the Mangaia workshop. The training is an extension of a regional initiative to address the lack of reliable data and guiding plans, policies and the absence of trained and experienced PIC nationals required to manage biomass energy resources in a sustainable manner. The training utilised the materials developed by SOPAC and Imperial College Centre for Energy Policy and Technology (ICCEPT).

A wave gauge was deployed off Muri Beach in Rarotonga to further substantiate the wave energy potential. This is a follow-on survey from the earlier Norwegian-funded pre-feasibility study. The Energy Division together with the Marine Resources Department will download the data on 2 cycles for a period of 6 months.

In addition to the above activities, discussions on energy matters were held with the following people:
• Mata Nooroa; Tangi Tereapii and David Akaruru – Energy Division
• Matthew Paterson, Deputy High Commissioner – New Zealand High Commission
• Apii Timoti, CEO – Te ao ponga (Rarotonga Power Utility)
• Secretary – Mangaia Island Council
• Anthony Whyte, General Manager – Mangaia Power Utility
• Keu Mataroa, Assistant Secretary – Ministry of Works
• Carl Hunter, Deputy Secretary – Ministry of Foreign Affairs
• Ian Bertram, Secretary – Marine Resources Department
SUSTAINABLE UTILISATION OF RENEWABLE ENERGY

The purpose of the Sustainable Utilisation of Renewable Energy (SURE) Project is to ensure that the four key projects\(^3\) implemented under the Pacific rural Renewable Energy France-Australia Common Endeavour (PREFACE) Project are provided with the necessary back up and support to assist in guaranteeing their sustainability in the future. In addition, it also provides a mechanism for the sharing of technical information in relation to the development and implementation of these renewable energy projects and allow for post-project monitoring to be made and experiences shared.

The island of Mangaia in the Cook Islands through the PREFACE Project installed two 20-kW grid-connected wind turbines. Following their commissioning in October 2003, the Mangaia Power Utility has been monitoring and evaluating the performance of the two turbines. The SURE Project made possible a sub-regional\(^4\) wind energy workshop to be convened in Mangaia from the 1\(^{st}\) to the 3\(^{rd}\) of November. The workshop focussed on the sharing of experiences to inspire decision makers on the opportunities of renewable energy, particularly wind energy systems.

The following is an overview of the areas covered during the 3 days in Mangaia:

- **Wind Energy Opportunities in the Pacific** – the session highlighted the wind energy potential in the region making reference to earlier resource assessment and feasibility studies. The presentation also looked at the issues and challenges from a regional perspective.

- **The Mangaia Grid-Connected Wind Turbines** – this session was conducted on-site. The turbine characteristics, logistics involved in getting the turbines to Mangaia and inputs / assistance provided by the donors, Cook Islands Government and the community of Mangaia were highlighted. The challenges / issues were also discussed.

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\(^3\) Mangaia in the Cook Islands; Namdrik Atoll in the Marshall Islands; Fonoifua, Fotuha’a, Kotu, Matuku, O’ua and Tungua in Tonga; and Mota, Mota Lava and Sola at the Torba Province, Vanuatu.

\(^4\) Participating Countries: Cook Islands, Fiji Islands, Niue, Samoa, Tonga & Vanuatu.
• Wind Energy Planning – the session introduced Strategic Planning and Management (SPM), Comprehensive Hazard and Risk Management (CHARM) and WA*P as planning tools that could be used in wind energy project planning.

• Practical Wind Energy Implementation – the presentation provided an exercise that enabled participants to go through a series of stages involved in a feasibility study. These included turbine selection, yield estimation, park set-up, logistics involved, etc.

• Country Presentations – the country presentations provided a feedback on the status of renewable energy in particular wind energy in each country. It also provided an avenue to share experience. The country presentations are available upon request from SOPAC.

• 20-kW Wind Turbine in Nabua, Suva – the session highlighted the performance of the turbine since commissioning. It also discussed some of the issues addressed during the course of acquiring a site and installation.

• Wind Energy Economics – the presentation introduced the skills and knowledge required to prepare financial and economic analyses for wind energy projects. A case study enabled participants to develop their own projects through an Excel template. The session also used the Excel template to analyse the Mangaia Project.

Additional details on the challenges and turbine performances are attached as Annex 1.
Biomass resources have been and remain a major source of energy for the people of the Pacific island countries (PICs). On average, biomass accounts for around 90% of the rural energy use and a quarter of the urban energy use. There has yet to be a comprehensive survey of the available biomass energy resources, the rate at which they are consumed and the possible socio-economic and environmental implications given different possible consumption scenarios, reforestation and conservation measures. Current available data are based on estimates dating as far back as 1987.

The PICs have identified biomass as a priority area in their respective energy sectors, however, the lack of reliable data and guiding plans and policies and the absence of trained and experienced PIC nationals are the major constraints to the sustainable management of their biomass energy resources.

The objectives of the biomass initiative are as follows:
• Develop a Sustainable Management Plan on the use of biomass resources in the PICs;
• Provide training on biomass resource assessment and policy formulation to the PICs;
• Update information on the current status and experiences with the biomass energy technologies that are relevant to the PICs; and
• Implement a demonstration project.

Using the materials developed by ICCEPT and SOPAC, a 2-day workshop was convened in Rarotonga to introduce the subject. The workshop addresses only one of the above-mentioned components, the Biomass Resource Assessment. It was anticipated that the participants would use the opportunity to develop their understanding of biomass resources and its applications as an energy source.

The following areas were covered during the workshop:
• A Global Perspective – the session introduced biomass as a major energy source worldwide including the technologies and use.
• Biomass Energy & Development – areas included are components and constraints of sustainability; role of biomass energy in an integrated approach to energy provision and development; links between energy, poverty and sustainable development; and the Millennium Development Goals.
• Climate Change – The presentation gave an overview of what is climate change / climate variability?; the future role of biomass energy & renewables; and funding opportunities.
• Biomass Production (the Cook Islands Experience) – provided details of an in-country initiative that looked at the feasibility of having fuel crops. This session was presented by Otheniel Tangianau from the Office for the Minister of Island Administration.
• Problem Solving Scenario – the exercise enabled participants to analyse the situation in 2 villages and then make suggestions for improvement.
• Biomass Resources – what are they? Issues & Characteristics.
• Methodologies – the session introduced participants to the basic understanding of biomass resource assessment; measuring biomass resources; and assessment of biomass consumption.
• Project Implementation Issues – discussions focussed on what is required for successful project planning & implementation? A case study from Vanuatu was also considered.
• Biofuels, Opportunities and Challenges – presented an overview of the concept, production, economics and supply of biofuels in the Pacific context. Emphasis was on coconut oil and biodiesel.
• Waste Treatment and Management – Mathilda Miria-Tairea, Project Manager, Waste Management Project, Ministry of Works presented the ADB-funded Cook Islands Waste Treatment and Management Initiative. Participants also had the opportunity to visit the site.

Landfill facility and Seepage Ponds in Rarotonga.
WAVE GAUGE DEPLOYMENT IN RAROTONGA

From 1986 to 1995 the Norwegian Government through the Norwegian Agency for International Development (NORAD) funded a pre-feasibility study for wave power in the South Pacific including a comprehensive ocean wave measurement programme for the South Pacific Applied Geoscience Commission (SOPAC). This culminated in the publication of a booklet “Ocean Wave Energy in the South Pacific, the Resource and its Utilisation”, SOPAC Miscellaneous Report 234.

In 2002, SOPAC and U.S Wave Energy\(^5\) signed a Memorandum of Understanding (MOU) with the primary objective of expanding the earlier work carried out by the NORAD-funded programme.

To date, U.S Wave Energy has reviewed the data from the earlier study and carried out analysis using their Wave Energy Module (WEM). One of the promising sites identified was the Cook Islands. The analysis by U.S Wave Energy showed an average power potential of 324 kW.

Given this potential it was considered appropriate to carry out a full feasibility study in the Cook Islands. The first phase of this study is to log data sets at a specific site (as marked in the picture above) near shore at 18m depths to further substantiate the wave energy potential.

The following is a summary of activities carried out in the deployment of the wave gauge:

**Testing the Wave Gauge**

The gauge was lowered at the Avarua wharf to test the data recording and downloading process. This also provided the opportunity for the Energy Division and the Marine Resources personnel to actually go through the data downloading procedure.

\(^5\) 65 Pioneer Drive, Longmeadow, MA, 01106 USA.
The importance of taking care in opening the wave gauge capsule removing the batteries so as to ensure that the batteries do not get disconnected before pressing the close-file button.

The batteries have been removed (but still connected). Note that prior to disconnecting the batteries and removing the 128 MB memory card there is a need to press the close-file button.

The flashing of the LED, as in the picture, indicates that the data sets have been closed and saved into the memory card.

The memory card can now be removed from the data logger.
The 128 MB memory card, which has a storing capacity of up to 6 months.

The memory card is inserted into the laptop for downloading.

The data sets are presented with the following characteristics:
- Pressure (Bars)
- Temperature (°C)
- Timing & Interfacing (real time, frequency, serial baud rate, etc)

Deploying the Wave Gauge to 18 m depth

The anchor (an old engine block) and the marker buoy, all hooked-up and ready for mounting the wave gauge.

The wave gauge is then mounted on the block as shown here.

The Marine Resources Department boat that was used for deploying the wave gauge.
The gauge was deployed to a depth of 18 m at 12 noon on coordinates 21°14’ S and 159°42’ W with help from the Marine Resources Department divers.
**FOLLOW-UP ACTIVITIES**

Following the workshops on Wind Energy and Biomass Resource Assessment, the deployment of the wave gauge and discussions during the mission, the following have been highlighted as activities that require follow-up after the mission:

<table>
<thead>
<tr>
<th>Activities</th>
<th>Action Required</th>
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<tr>
<td>• Wind turbine performance and related issues in Mangaia.</td>
<td>SOPAC to share its analysis of the power system with the Mangaia Power Utility, Te ao ponga, Energy Division, Office of the Minister for Island Administration and other interested stakeholders. SOPAC will also make recommendations on the best approach to enable optimal performance by the turbines.</td>
</tr>
<tr>
<td>• Policy-related activities. The Energy Division would like to get assistance in the review of its Energy Act and Electricity Regulations. Assistance on the implementation of activities highlighted in its Energy Policy and Plan is also required.</td>
<td>SOPAC can address this through the PIEPSAP project. The Energy Division would like to further discuss this in REM 2004.</td>
</tr>
<tr>
<td>• Data downloading from the wave gauge.</td>
<td>The Energy Division together with the Marine Resources Department to organise for the first download by the end of January 2005. The Energy Division will then forward the data to SOPAC for analysis.</td>
</tr>
<tr>
<td>• Wind Resource Assessment at Aitutaki. The Energy Division would like SOPAC participation in this activity particularly with the data analysis and review of a project proposal to be prepared by Vergnet. This activity is funded by AusAID.</td>
<td>The Energy Division will forward additional documents relating to this activity.</td>
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</table>
Additional Details on the Performance of the Wind Turbines on Mangaia

Jan Cloin, Energy Adviser, South Pacific Applied Geoscience Commission, November 2004

Technical Observations and Recommendations on the Mangaia Wind Turbine site

Mangaia Island, one of the Southern Cook Islands, was beneficiary of the PREFACE (Pacific Renewable Energy France Australia Common Endeavour) Project, in which two wind turbines were installed. These turbines have been installed since January 2004. SOPAC organised a workshop on the island to assess the lessons learnt from the project. Below is a technical report on the findings, with some recommendations for future improvements.

The Island Electricity System set-up roughly looks like Figure 1 below:

A typical Load Profile of the village is given in the picture below. The power factor is dynamic, but has an average of 0.8.

8 March 2003 Power Curve

Figure 2. Typical Load Profile Mangaia Power System before Turbine Installation. Below are the most important challenges found and suggestions for improvement of the performance of the system.
(A) Yield below expectation

The figure below shows the inputs in terms of kWh from the turbines into the systems based on the files at Energy Division in Rarotonga.

![Wind Turbine Production Data Mangaia 2004](image)

The yield of the turbines in the feasibility study written by turbine manufacturer Vergnet has been estimated to be between 94,000 and 104,000 kWh per annum.

During July 2004, turbine 1 failed through the separation of its blades. Luckily nobody got hurt and no severe damage to the rest of the system was caused. The blades have been replaced in November 2004. The turbine is still not fully operational due to the requirement of replacement bolts for attaching the blades.

Apart from the above accident, no clear reason can be found why the yield is only 20-25% from the amount in the feasibility study.

**Observation 1:** The wind turbine yield is far below the estimated yield.

**Recommendation 1:** Vergnet to analyse and provide an action plan on how to achieve the yield as quoted in the feasibility study.
(B) Reactive Power Consumption

The figure below shows the influence of the wind turbine system on the island system, by sketching a x-y graph of the kW and kVAR of the system, before and after the installation of the turbines.

**Figure 4.** The kW versus the kVAR before turbine installation during 1.5 months period in 2003.

**Figure 5.** The kW versus the kVAR after turbine installation during 1.5 months in 2004.

**Observation 2:** The power factor in the original situation never reached unity, indicating a sub-optimal power grid configuration. In ideal circumstances the reactive power would minimised, however there seems to be a average reactive component of 35 kVAR in the system. This can also be seen in Figure 2, typical load profile.

**Recommendation 2:** The reactor placed in the generator-house should be re-considered, or replaced to the end of the power line. The long lines will make the total system capacitive, and the
The main purpose of the reactor is to compensate for this. Given system behaviour as found in Figure 4, this might be overcompensated, causing the system to be generally reactive.

**Observation 3:** After installation of the wind turbines, the kVAR as a function of the kW measured have reached new heights. This is the area of the upper circle Figure 5. This is caused by the reactive power demand by the wind turbines.

After the installation of the turbines another interesting area can be observed, where the power factor has reached new lows even sometimes capacitive, marked by the lower circle in Figure 5. This can only be caused by the capacitors that have been provided with the wind turbine system, each providing 10 kVAc.

**Recommendation 3:** Install a second three-phase logger at the turbine site, while continuing logging three phase at the generator-house. On various wind conditions, low wind, medium wind, high wind, experiment with the capacitors on and with one and two turbines on. Also, the disconnection of the reactors in the generator house (see recommendation 2) should be included in this experiment. On the basis of the three phase logging data, conclusions should be drawn with regard to the dynamic effects of the system at various stages. Table 1 below shows some suggested testing parameters.

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<tr>
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<th>Mild wind</th>
<th>Medium Wind</th>
<th>Hard Wind</th>
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<tbody>
<tr>
<td>Capacitor Bank</td>
<td>1 on / 2 on / off</td>
<td>1 on / 2 on / off</td>
<td>1 on / 2 on / off</td>
</tr>
<tr>
<td>Reactor</td>
<td>1 on / 2 on / off</td>
<td>1 on / 2 on / off</td>
<td>1 on / 2 on / off</td>
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<tr>
<td>Total Load</td>
<td>Low / Peak</td>
<td>Low / Peak</td>
<td>Low / Peak</td>
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<tr>
<td>Type of Genset</td>
<td>1, 2, type</td>
<td>1, 2, type</td>
<td>1, 2, type</td>
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It is expected based on the current data, that only 1 reactor and both capacitors will give the best configuration, assuming the capacitors are switched offline when the turbines do not work. The above tests should further indicate the best system configuration(s).

**Observation 4:** The wind turbines require a remote control from the generator house, in order to maximise the wind power input from the wind. This remote control is currently not used, causing sub-optimal wind turbine configuration.

**Recommendation 4:** A dedicated line with constant connection to the wind turbine site from the generator house. This requires re-programming of the system’s PLC and related communication components. It enables control, but also monitoring of the power output of the wind system in the generator house. This will further add to the understanding of the dynamics of the system.
(D) System Stability

In the feasibility study that was the foundation for the implementation of the wind turbines in Mangaia, it was mentioned that without any additional electronics, the system would be able to operate with up to 50% of wind energy component.

Observation 5: With the current configuration it has been difficult to operate two turbines at night, since the total demand is much lower than the potential supply by the turbines.

Recommendation 5: An automatic control should be considered to safeguard the existing diesel generators for not consuming the oversupply of electricity. In addition to this, a separate frequency control of the power grid should be considered. If the frequency trips over / below a certain value, the turbines automatically are switched off.

(E) Diesel Savings

Due to low yield of the wind turbines, (4.3% of total electricity supplied by the wind), no great savings are to be expected in terms of litres of diesel per kWh.

![Graph of Specific Fuel Use Mangaia Power System as a function of Wind Energy Contribution]

Figure 6. Litres of diesel used per kWh as a function of the wind energy penetration.

Based on the data at the Energy Division, a graph was produced from the past 9 months. Of this data, July was omitted due to exceptional fuel use during testing of a generator. It can be seen that there is a negative correlation between the percentage of wind in the system, and the litres of diesel per total kWh, as expected. The savings are not very significant, due to the low contribution of the wind. On the basis of the graph and the average use of diesel, it is estimated that diesel use has decreased by 3.09%, or roughly 3,500 litres up to and including September 2004.

It is expected that diesel savings will further materialise once the yield increases and the reactive power balance of the power grid improves.

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6 According to Manager Mangaia Power Corporation, personal communication
The goal of the project, Sustainable Use of Renewable Energy (SURE), is to contribute to the sustainability of wind energy projects in the region. This is done through sharing of experiences, replicate success and inspire decision makers on the opportunities of renewable energy.

The primary purpose of the Mangaia Workshop are to assist participants develop their own wind energy projects through a series of activities outlined below.

### Workshops Programmes

**RENEWABLE ENERGY TECHNOLOGY CAPACITY BUILDING WORKSHOP (WIND ENERGY)**  
Mangaia, Cook Islands

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<th>Activity</th>
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<td></td>
<td>0800</td>
<td>5</td>
<td>Prayer</td>
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|      | 0800  | 5       | Country Presentations  
Cook Islands; Fiji Islands; Niue; Samoa; Tonga; Vanuatu  
The country presentations are intended to provide a feedback on the status of wind energy in each country. It will also provide an avenue where discussions can provide solutions to a particular country’s problem.  
|      | 1000  | 6       | MORNING TEA |
|      | 1030  | 6       | Session 6 | 20kW Wind Turbine in Nabua, Suva  
This session will provide the opportunity to highlight the performance of the turbine since commissioning. It will also highlight some of the issues that had been addressed during the course of acquiring a site and construction.  
|      | 1130  | 7       | Session 7 | System Integration Issues  
How to make maximum use of the wind energy and save fuel.  
|      | 1230  | 8a      | Session 8a | Wind Energy Economics  
Will enable participants develop the skills and knowledge necessary to prepare financial and economic analyses for wind energy projects.  
|      | 1430  | 8b      | Session 8b | Wind Energy Project Economic Case Study  
Go through a case study from m/s to $ or calculate with own data.  
|      | 1545  |        | AFTERNOON TEA |
|      | 1545  |        | Plenary   |

PRAYER & END OF DAY 2 – Wind Energy

[SOPAC Miscellaneous Report 581 – Cloin & Mario]
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| DAY 1     | 1000 – 1100 | • Welcome (Opening Prayer - Orometua)  
• PREFACE Project Description  
• Address by the Mangaia Island Council & Aronga Mana  
• Address by SOPAC | Tangi Tereapii & Anthony Whyte  
Vavia Tangataataia – Deputy Mayor  
Jan Cloin |
|           | 1100 - 1130 | MORNING TEA                                                            | Jan Cloin                                                                                           |
| 1130 – 1200 | Session 1 | Wind Energy Opportunities in the Pacific  
The session will highlight the wind energy potential in the region referencing earlier resource assessment and feasibility studies. The presentation will also look at the issues and challenges from a regional perspective. | Rupeni Mario                                                                                       |
| 1200 – 1300 | Session 2 | The Mangaia Grid-Connected Wind Turbines  
• Turbine characteristics  
• The logistics involved in getting the turbine to Mangaia  
• Inputs / Assistance provided by the Cook Islands Govt., Community in Mangaia and donors.  
• Challenges / Issues  
Site Visit | Anthony Whyte  
(Manager, Mangaia Power Utility) |
| 1300 – 1400 |        | LUNCH                                                                  | Rupeni Mario                                                                                       |
| 1400 – 1500 | Session 3 | Wind Energy Planning  
The presentation will also look at wind energy resource assessment and the possible use of WASP. | Rupeni Mario                                                                                       |
| 1500 – 1515 |        | AFTERNOON TEA                                                         | Jan Cloin                                                                                           |
| 1515 – 1630 | Session 4 | Practical Wind Energy Implementation  
Turbine Selection, yield estimation, park setup. | Jan Cloin                                                                                           |

[21] [SOPAC Miscellaneous Report 581 – Cloin & Mario]
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| 0800 – 0900 | **Session 9**  
**Social Implications of Wind Energy**  
The social & environmental implications are areas that has to be considered in a feasibility study. It is envisaged that this session will provide the necessary background for participants to address the discussions that will follow. |
| 0900 – 1000 | **Group Work**  
This session will enable participants apply the concepts and knowledge learnt over the last 2 days and develop a terms of reference required for a feasibility study including the formulation of a funding proposal. |
| 1000 – 1030 | **MORNING TEA**                                                             |
| 1030 – 1300 | **Continue on Group Work and Group Presentations**                           |
| 1300 – 1400 | **LUNCH**                                                                 |
| 1400 – 1500 | **Plenary & End of Workshop**  
Jan Cloin / Rupeni Mario |
| 1500 – 1515 | **AFTERNOON TEA**                                                          |

**DAY 3 - Wednesday 03 November**

**PRAYER & END OF DAY 3 – Wind Energy**
Biomass energy resources have been and remain to be the major source of energy for the people in the Pacific Islands. On average, biomass accounts for around 90% of the rural energy use and a quarter of the urban energy use. There has yet to be any comprehensive survey of the available biomass energy resources, the rate in which they are utilised and the possible socio-economic and environmental implications, given differing scenarios of consumption, reforestation and conservation measures. Current available data are based on estimates dating as far back as 1987.

The Pacific Islands have identified biomass as a priority area in their respective energy sectors, however, the lack of reliable data and guiding plans and policies and the absence of trained and experienced nationals are the major constraints to the sustainable management of their biomass energy resources.

The objectives of the biomass initiative are as follows:
• Develop a Sustainable Management Plan on the use of biomass resources in the PICs;
• Provide training on biomass resource assessment and policy formulation to the PICs;
• Update information on the current status and experiences with the biomass energy technologies that are relevant to the PICs; and
• Implement a demonstration project.

This workshop addresses one of these components, the Biomass Resource Assessment. It is anticipated that the participants will use this opportunity to develop their understanding of biomass resources and its applications as an energy source.

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<tr>
<td>Return from Mangaia</td>
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<td>1100 - 1145</td>
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<tr>
<td>(i) Prayer</td>
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<td>(ii) Welcome &amp; Opening Remarks</td>
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<td>(iii) Setting the Scene (SOPAC)</td>
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<tr>
<td>• An overview of the Biomass Resource Assessment Workshop (what will be covered including a general introduction to biomass as a source of energy)</td>
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<tr>
<td>Jan Cloin</td>
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| DAY 1 - Thursday 04 November |
| 1145 – 1230 |
| Session 1 |
| A Global Perspective |
| Biomass as a major energy source worldwide including the technologies and use. |
| Biomass Energy & Development |
| Areas included are components and constraints of sustainable; role of biomass energy in an integrated approach to energy provision and development; links between energy, poverty and sustainable development; and the Millennium Development Goals. |
| Rupeni Mario |

| 1230 – 1330 |
| LUNCH |

<p>| 1330 – 1430 |
| Session 2 |
| Climate Change |
| What is climate change / climate variability? The future: role of biomass energy &amp; renewables. Climate Change funding opportunities. |
| Jan Cloin |</p>
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<th>DATE</th>
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<tr>
<td></td>
<td>1430 – 1530</td>
<td>Biomass Production – The Cook Islands Experience</td>
<td>Otheniel Tangianau,</td>
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<td>Session 3</td>
<td>(Office for Minister for Island Administration)</td>
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<td>1530 – 1545</td>
<td>AFTERNOON TEA</td>
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<td>1545 – 1630</td>
<td>Discussions (Problem Solving Scenario) Participants to analyse the situation in 2 villages and then make suggestions for improvement.</td>
<td>Rupeni Mario</td>
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<td><strong>END OF DAY 1 – Biomass Resource Assessment</strong></td>
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<td></td>
<td>0800 – 0900</td>
<td>Biomass Resources</td>
<td>Jan Cloin</td>
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<td>Session 5</td>
<td>What are they? Issues &amp; Characteristics.</td>
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<td><strong>Methodologies</strong></td>
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<td>The session will introduce participants to the basic understanding of biomass resource assessment; measuring biomass resources; and a brief look at assessment of biomass consumption.</td>
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<td>0900 – 1000</td>
<td>Project Implementation Issues</td>
<td>Rupeni Mario</td>
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<td></td>
<td>Session 6</td>
<td>What is required for successful project planning &amp; implementation? Brainstorm! Case study from Vanuatu.</td>
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<td>1000 – 1030</td>
<td>MORNING TEA</td>
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<td></td>
<td>1030 – 1200</td>
<td>Biofuels, Opportunities and Challenges</td>
<td>Jan Cloin</td>
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<td>Session 7</td>
<td>Present an overview of the concept, production, economics and supply of biofuels in the Pacific context. Emphasis on Coconut Oil and Biodiesel, but will also expand on other biofuels such as Ethanol.</td>
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<td>1200 – 1300</td>
<td>Waste Treatment and Management</td>
<td>Mathilda Miria-Tairea</td>
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<td>Session 8</td>
<td>• Cook Islands Initiative</td>
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<td></td>
<td>(Project Manager, Waste Management Project Cook Islands, Ministry of Works)</td>
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<td>1300 – 1400</td>
<td>LUNCH</td>
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<td>1400 – 1500</td>
<td>Site Visit</td>
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<td>1500 – 1515</td>
<td>AFTERNOON TEA</td>
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<td>1515 – 1545</td>
<td>Discussions and Round up</td>
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<td><strong>PRAYER &amp; END OF DAY 2 – Biomass Resource Assessment</strong></td>
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### ANNEX 3

**Participants List**

<table>
<thead>
<tr>
<th>Name</th>
<th>Designation</th>
<th>Island, Country</th>
<th>Email</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jan Cloin</td>
<td>Resource Person, SOPAC</td>
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<tr>
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<td>CTA/PIREP</td>
<td>Samoa</td>
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<tr>
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</tr>
<tr>
<td>Mataora Harry</td>
<td>Aronga Marnac</td>
<td>Cook Islands</td>
<td></td>
</tr>
<tr>
<td>Hetututama (Speedo)</td>
<td>General Manager</td>
<td>Niue</td>
<td>gm@<a href="mailto:npc@mail.gov.nu">npc@mail.gov.nu</a></td>
</tr>
<tr>
<td>Moli Janjea</td>
<td>Act. Senior Energy Officer</td>
<td>Vanuatu</td>
<td><a href="mailto:mjanje@hotmail.com">mjanje@hotmail.com</a></td>
</tr>
<tr>
<td>Ian Karika</td>
<td>Raro Environment Authority</td>
<td>Cook Islands</td>
<td></td>
</tr>
<tr>
<td>C. Koronui</td>
<td>Island Secretary</td>
<td>Atiu, Cook Islands</td>
<td><a href="mailto:ckoronui@atiu.gov.ck">ckoronui@atiu.gov.ck</a></td>
</tr>
<tr>
<td>Jan Kristensson</td>
<td>Electrical Engineer</td>
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<tr>
<td>Rupeni Mario</td>
<td>Resource Person, SOPAC</td>
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</tr>
<tr>
<td>Mata Nooroa</td>
<td>Director of Energy</td>
<td>Cook Islands</td>
<td><a href="mailto:punanga@energy.gov.ck">punanga@energy.gov.ck</a></td>
</tr>
<tr>
<td>Heremoni Suapaia</td>
<td>Energy Officer</td>
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<td><a href="mailto:Heremoni.suapaia@mof.gov.ws">Heremoni.suapaia@mof.gov.ws</a></td>
</tr>
<tr>
<td>Vavia Tanataataia</td>
<td>Acting Mayor</td>
<td>Cook Islands, Mangaia</td>
<td>Providing valid email for Cook Islands is not possible without error.</td>
</tr>
<tr>
<td>Teokotai (Tai) Topa</td>
<td>Island Secretary</td>
<td>Cook Islands, Mangaia</td>
<td>Providing valid email for Cook Islands is not possible without error.</td>
</tr>
<tr>
<td>Tevita Tukanga</td>
<td>Energy Planner</td>
<td>Tonga</td>
<td><a href="mailto:tukunga@lands.gov.to">tukunga@lands.gov.to</a></td>
</tr>
<tr>
<td>Tai Tura</td>
<td>Island Secretary</td>
<td>Mauke, Cook Islands</td>
<td><a href="mailto:issector@oyster.net.ck">issector@oyster.net.ck</a></td>
</tr>
<tr>
<td>Anthony White</td>
<td>Manager Mangaia Power Authority</td>
<td>Mangaia, Cook Islands</td>
<td>Providing valid email for Cook Islands is not possible without error.</td>
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ANNEX 4
Minutes of Discussions during the Workshops

Sustainable Utilisation of Renewable Energy Sub-Regional Workshop, 1-3 November

Day 1:
- Sent around a Participants list.
- Start at 11.00 at the Hall on Mangaia.
- 17 people including Rupeni and myself.
- Address by Mata Nooroa (energy division).
- Minister to lead the prayer.
- Address by Deputy Mayor; first time to have international workshop on the Island; benefits obtained from wind power; problems that have been experienced; appreciate donors for pilot project.
- Welcome word from SOPAC (Jan Cloin).
- Round of introduction for the participants.
- Rupeni to explain on the objectives of the workshop and the build up of the programme.
- Participants were asked what they want out of the workshop. Write the questions down that you want to be solved. [see below]
- Rupeni presented on regional opportunities for wind energy.
- Rupeni on Wind Energy Planning and WAŚP.
- Lunch.
- Continue Presentation on WAŚP
- Participants went through the things they would like to be covered. These were presented and an indication was given on what the workshop would cover.

Below are the Participants wishes:

General:
- The opportunity to venture into Wind Energy [covered]
- Educating people about Renewable Energy [covered]
- Update of the wind power in Fiji at Mead Road [covered]
- Positive and negative Experiences w/t Mangaia Wind Power Project/ good thup/bad thup [covered]
- The advantage and disadvantage of wind energy [covered]
- Would like to know the good and the bad effects of wind turbine with the experiences in Mangaia [covered]
- To know all about wind power on Mangaia: Transport, Cost allocation, Connection onto the grid, The problems encountered [covered]

Technical:
- How do you best overcome the problem of wind and demand variability on a small island where wind provides a large portion of the electricity supplied? [Will be covered]
- The advantage and disadvantage of a Hybrid System? [Will be covered]
- How do you best protect the turbines from hurricanes? [covered]
- [rephr] What are the maintenance requirements for wind energy? [covered]
- Learn something about that is compatible with the existing utility system/feed into grid [covered]
- Technical Capability for the wind data [analysis] assessment [Will be covered]
- Reactive Power Issue and how to solve it? [Will be covered]

Resource Assessment:
- To learn about the method of collecting wind data with all its aspects [Discuss]
- [rephr] Is funding possible for monitoring equipment? [covered]
• Without the [wind measuring equipment] wind power will not be implemented as a subsidiary / options for power production [Discuss]
• Proposed Sites for monitoring stations? [Discuss]

**Economics:**
• Costs involved in running: Fuel generator (purchasing fuel, etc.) Wind Power (Cost of erecting, maintenance) [covered]
• Tariff Structure for Renewable Energy [discuss]
• Will the Wind Power Project reduce the cost and [...] Electricity produced [Discuss]
• Is [wind energy] more economical than fossil fuel generation? [Covered]
• At what wind speeds would be appropriate to implement such projects? [Covered]

**Environment:**
• Are there any impacts of wind generation on the environment? (Noise, Birds Casualties, Erosion, +/- Visual Impact, + Clean Air, -Physical Danger, -+ Reduced Waste Oil Disposal, Shadow Effect) [discuss]

These points were discussed in terms of how they were going to be covered by the workshop. [end at 16.30 hrs ]

**Day 2**
• Opening by Rupeni
• Prayer by Arieta Gonelevu
• Country presentations:
  • **Fiji – Arieta Gonelevu;** explanation of the DoE Programme activities; 50 pre-feasibility studies carried by means of visiting villages; outreach on wind energy potential and technology; Wind Energy Mapping; Currently two wind measuring sites: Gau and Yasawas; Currently 10 sites with more than 3 years of data, only 2 are promising according to DoE; Fiji DoE aims to create hybrid systems on outer islands instead of Diesel-powered supply; currently two independent power producers: Tropik Hardwood and FSC.
  • **Niue – Speedo Hetutu;** explanation of the energy situation after the cyclone expectation of setting up an energy office on the island next to the utility; ACP country assistance on RE; Will be under supervision of utility; proposed wind on the eastern part of the island, where Heta has done least damage and also is good wind potential; average 6 m/s and standard deviation 0.7 m/s; 1) operation in salty air 2) cyclone-prone area 3) able to operate in low capacity power grid; 100% Renewable Energy aim for the future, looking at storage by means of REDOX Vanadium cells as batteries.; currently Niue Power corporation pays NZD 0.96 per liter of diesel; On Mangaia they pay NZD 1,50 per liter of diesel. (tax?)
  • **Samoa – Heremoni Suapaia;** overview of energy sector in Samoa; excerpts from PIREP report; discussion on fuel terminals and ownership plus risks involved.
  • **Tonga – Tevita Tukunga;** overview of the energy sector; focus on the wind energy study carried out by the Japanese; conclusion of 1-year wind measurements on two sites was that the potential was too small due to low average wind speeds. For sustainable wind energy it is not recommended to implement. For donor projects, it is proposed to go to masts of 50 meters.
  • **Vanuatu – Moli Janjea;** Overview of energy sector; monopoly of UNELCO; customers pay US$0.38 cents per kWh; has recently ventured into two outer islands; 80% of the islands still have no access to grid electricity; typical SHS (JICA) 2*50 Wp system, 120 Ah battery, 4 lights, (3*8, 1* 18W) and option of inverter, with regulator of 10 Amp; 45 systems on schools and health centres as part of PREFACE Project; Very difficult to access the sites. Reasons for failure include no technical capacity and donated hardware that does not fit the real needs of the population; wind measuring systems found 4.8 m/s averages on different islands.
Anthony Whyte – Cook Islands; Emphasise that the Project is pilot. 7 m/s on average over the year; some months no wind. Power factor considerations, furthermore no significant savings; community involvement through local chiefs and schools / issues: communication costs of the remote control misunderstanding between Vergnet and MPC. Constant line required; power factor and no significant savings; erosion; public expectations were high, but the savings are not materialising; safety concerns were raised during the falling of the blades; tourists want to see the site -> benefits; economic viability has to be sorted out.

Tangi – Cook Islands 1998 the project was initiated, shows the throughtime of the RE project. Diesel delivery time including installation is about 6 months. Why it takes so long? Started with Patrice Courty in 1998 where he was researching c/nut oil on Mangaia. Started with Prefeasibility study executed by Vergnet, done in Mangaia, Atiu and Rarotonga; based on rurutu experience, Mangaia was chosen as a good site. 6 month data monitoring on three sites, including the current site. Vergnet managed to secure an MoU with the landowners, to agree with the concept. Project document was prepared. Another 6 months went over the proposal. Tender was called for the supply, two companies bid, Bruce Clay and Vergnet. Vergnet won the tender and installed the turbines. Technical issues covered by Anthony. Local training would have been a good investment, starting with the wind data analysis. The shipments of the materials was up to Rarotonga port, but not to the site. The costs were large and did not cover the current benefits. Furthermore, the prefeasibility study was carried out three times with different consultants. Repeating the same work – too many studies, no hardware.; positive side: project benefits CI, stepped into the learning curve, new to CI. Secondly, learning experience for young people, during clearing the site the school was involved and were keen to learn about the project, hope Mangaia will be extended; community involvement: no landfees (yet). Did the monitoring near the beach for NZD 300 and building of a road. Thanks to local community leaders and MPC. There is space for more turbines for extension. Creates a separate option for electricity generation.

Solomone – background on the PREFACE Project. Implemented at SPC. Put A$3 million for 3 years, with possibility of extension. Termination after 3 years. Time constraints resulted in quick transfer of project responsibilities;

Chief – Another project on the same piece of land will be acceptable, no land fees will be charged.

Arieta – Patrice Courty came here for c/nut oil, there was a study here, but there were not enough coconuts for fuel generation. Extractor plus labour would result in $4 per liter. Assumption of 40 cents per coconut.

SF – Tries to resolve the issues with outstanding telephone bill ($5,000) and power-factor compensation.

Speedo – training needs for local counterparts to be a productive counterpart; Important role of utilities; try to look for niches of wind power, water pumping, streetlight.

Rupeni – training is necessary, is a prime objective. Tangi mentioned the wind data analysis, transport issues, laying out responsibilities (strategic action planning), community involvement. What are the problems? How to solve it? Then we achieve the objectives of the workshop.

Tevita – Would it be an idea to invite Vergnet to this workshop? (Were invited)

Anthony – They stuck to their contract: put two wind turbines up and that’s it. Communication problem: may require another visit for a technician to solve the problem, they are pretty hesitant.

Mata – Power factor problem seems to be unresolvable for Vergnet; one of the components of the project was on-site training. Has this happened?

Anthony – Language has been a great problem; technical areas is quite difficult to communicate; is an issue that needs to be considered. The actual programming of the PLC is in French and Anthony can’t cope with that. Requires Michel from France to resolve this.

Solomone – Training: was anticipated to send Mangaia people to other sites. Did not happen.
Day 3:

- 8.30 hrs: Opening by Rupeni
- Opening Prayer by Moli Janjea
- Jan Cloin: Wind Energy Economics presentation
- Participants work in groups of 2 – 3 with laptops and go through their own case study. They first selected a site, analyse wind data, and on basis of this select an amount of electricity to be yielded out of the wind. On the basis of that, a turbine is selected from a wind turbine catalogue (German). This is the basis for the cost of the project, that are entered into an excel sheet. After that, the power curve is entered into the excel sheet. At the same page, the average wind power that resulted from the wind turbine analysis is entered into the weibull distribution for the site. This, combined with the power curve, gives us the yield of one wind turbine. The eventual yield takes into account the amount of turbines, losses, park effect.
- With the cost, yield and price per kWh (or sometimes the avoided costs for price of diesel), the yearly benefits were assessed. With this data, financial indicators of the project were assessed. This included the payback time, the net present value and the internal rate of return. The participants developed 6 different case studies using their own data.
- As an example, the Mangaia wind power project was entered as a separate project, during a plenary session. The participants including Anthony Whyte (Mangaia Power Utility) helped to find all the data to calculate the real costs and benefits to the community. Included were new investments for cabling (wind turbine distance control) and the benefits that would increase after year 2, through gaining of experience. The conclusion was that up to now, the project has not created positive benefits but has the potential to become given the right attention to the challenges that the wind turbine park poses (KVAR problem, distance control of turbines, system stability, hardware problems (bolts)).
- The last portion of the day guided the participants through a Multi-Criteria Analysis. Every participant around the table was able to mention a cause of the wind turbine to the community. Secondly, they were all asked to assess the importance of that criterion to the community. Thirdly, the participants were asked to mention the impact on a scale from – 5 (very negative) to 5 (very positive).

[end at 14.30 for a late lunch and then guided tour through the island]
BIOMASS WORKSHOP RAROTONGA, 4 November

Day 1:
4 November 2004

11 participants, 2 resource persons (Rupeni and Jan)

- 11.15 hrs: Opening by Mata
- Opening SOPAC by Jan Cloin
- Opening and Prayer by CEO, Ministry of Works
- Brunch with Coffee / tea
- 11.50 hrs: Rupeni “Setting the scene”; (SF) Biomass Definition? : all organic matter that can be used for energy.
- 12.03 hrs: Rupeni “Biomass Energy and Development”
  Main indicators of sustainable development?
  - GDP per capita
  - User fees in project
  - No subsidy in a project
  - Having enough technical expertise to sustain a development
  - Urban/Rural development
  - Social Cohesiveness / Gender issues

Main obstructions of sustainable development
- certain old cultural practices

Three pillars: economic, social and environmental development; long term: don’t compromise the future possibilities with current decision.

12.18 hrs questions. Blending of biomass with regular petroleum resources? (Speedo) – will be subject to a separate session. How do you relate biomass to poverty? Biomass is the fuel of the poor. That will count for traditional biomass. Is easy to get to, unless you’re in urban areas.

12.25 : (Jan) “Climate Change and the role of Renewable Energy (in particular Biomass)”.

Discussions on Climate Change Mitigation with a focus on the energy sector. (Speedo) Is there a star-rating for diesel gensets in terms of efficiency?

13.45 : Break for Lunch / Relaxation

15.00 : Presentation on Biomass resources in Cook Islands; What is the most interesting type of wood to use in the Cook Islands for use of biomass. Test different (imported) species on various types of soil. What are the opportunities and challenges in terms of plantation feasibility and sustainability in terms of yield, environmental effects and quality. Findings included that the growing of biomass in CI for energy was not feasible.

15.47 : Plenary discussion, close at 16.00 hrs
Day 2:
Opening at 8.45 hrs (Rupeni)
Opening Prayer (Rupeni)
- (Jan) Biomass Resources
- (Jan) Resource Assessment Methodologies
- Brunch
- 10.25 hrs (Rupeni) Project Implementation Issues
- (Jan) Copra Oil as a biofuel
- 11.45 hrs (Mathilda Miria-Tairea) Waste Management in Cook Islands
- 12.05 hrs (Tani) Build of Aitutaki Land Fill site and Rarotonga Site
- Excursion to Waste Management Site in Cook Islands
- Lunch from 1.15 hrs
- Recap at 2.37 hrs: Overview of the programme for the last two days, presentation of the CD with the work files, pictures, presentations for the workshop week;
- Roundtable where participants react to the programme and evaluate the programme:
  - **Mr Koronui**: Missed the first part on wind energy, really impressed at the biomass workshop; especially about the methodologies; discussion on the presentation by OD on biomass. Hope that Aitutaki Wind Power Potential will be assessed so that it can contribute to the RE potential of Atiu. Experiences from Mangaia are very valuable, so the implementation at Atiu can benefit in the future.
  - **Manfred**: Biomass is a new subject, very interesting indeed.
  - **Arieta**: Thanks to the training, esp. Jan in a different culture, disagreements are not part of the public speeches, was useful. Where to from here? We have to be passionate on the subject. Two trainers might come back to us.
  - **Mata**: 1) Is Mangaia successful? Is every project we start a success? How do we measure this? In that class, the Mangaia project a success. 2) Ownership is a key to a successful project, in the same direction as Atiu. Maybe Biomass is not feasible in CI, that is a useful conclusion. Let it be known that Aitutaki is only an assessment. In the islands in the Cooks this is an important development. Thanks to Rupeni and Jan for also looking at the social aspects as well as the technical aspects. Thanks to SOPAC for getting us here. Colleagues at Energy for their help setting up the local content.
  - **Heremoni**: Thanks Rupeni and Jan; Good experience, socially and on energy. Three days in Mangaia it was my first turbine, going through the exercise was useful even though I was a day sick. Biomass as well, Waste to management… Thanks to the hosts.
  - **Moli**: Thank SOPAC, Rupeni and Jan and to gather us all here. This is the best time ever that the course that also goes to the project site. That is valuable. Seeing the social side of it, technical challenges. Most workshop we stay inside, but this one we see and being on the actual site, good experience for the participating countries. Our utility company on wind farm, similar size as in NC. Good foundation through the wind park. Hope that similar workshops will be organised, thanks to the participants for sharing their experiences, till we meet again.
  - **Tevita**: This workshop is a success. 1) Thank to SOPAC that they committed resources for keeping it in our interests. Both Mangaia and in Rarotonga. Mata has made history in the regional energy sector. Normally we meet when we commence a project, or when we implement a project. This is new, we are here to see the outcome of the project and that is very interesting. The reason why is that verse in the Bible: Israel came to a spot and the Egyptians Mozes was crying; Tell your people to go forward and don’t be afraid. Everything was right, reception, food, transport. That is the
message that we take from here. CI is advanced, with energy policy, energy act. Not only that we move forward, despite the barriers, lighting example. Also SOPAC: go to the sites where the projects are, so that we learn from each other. Invite all to Kingdom of Tonga (agree all?).

- **Speedo**: Before I came here Niue was seriously looking at installing windpower. Now I have learnt a lot from it, practically and theory and comments from Pacific island countries. I will be responsible for implementation for RE in our island system. From my observations, Thanks you very much for the good work that has been done in CI. There are lots of things that Niue has to catch up with. Carry out data logging for wind power. I will have to do it in Niue. Thanks for SOPAC all information, assistance, never tired of whatever questions. Thanks for hospitality, know that this is a burden for the hosts, including their families. Thanks Rupeni and Jan, Sol.

- **Solomone**: Good to see the workshop Training of the PREFACE Project. It is through the PREFACE Project and his proposals that this is happening. The more organisations involved, the better. There is so much out there to be done, it will make a difference. Support that it is good to have training on the ground, just like PIGGAREP is envisioning to do. Thanks Mata for hosting, and also for moving ahead. Lastly, Rupeni and Jan for the excellent work done.

- **Jan**: Thanks for hosts, Rupeni, happy that SOPAC was able to fund the project, looking forward to continuing the next workshop on PV.

- **Keu**: Closing down the workshop: We had the opportunity to meet during the last two days; thanks for coming to the CI and sharing your views to development of energy in the CI. Next to energy, we have most of the infrastructure, water supply, survey, IT work. 1996 amalgamated from different departments. Thanks to sponsors. Hope you enjoyed Mangaia, on behalf of the Minister of Works, thanks for being a good audience. Always welcome to hop by at MoW. Thanks to Jan and Rupeni and representative from SPREP, Solomone Fifita. Let the flame of unity be with us all. –

Prayer

- Closing Remarks by Keu.

[Closing 3.30 hrs]