GREENHOUSE GAS MITIGATION

IN COUNTRIES PARTICIPATING IN THE PACIFIC ISLANDS CLIMATE CHANGE ASSISTANCE PROGRAMME (PICCAP)

South Pacific Regional Environment Programme (SPREP)

SPREP's Climate Change and Integrated Coastal Management Programme

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GEF

This report was prepared for the South Pacific Regional Environment Programme byMurray Ellis of Dialogue Consultants Ltd, and assistred by Solomone Fifita of the South Pacific Applied Geoscience Commission

PICCAP
our islands, our lives...

Contents

Executive Summary

This is a study of opportunities for the ten countries participating in the Pacific Islands Climate Change Assistance Programme (PICCAP) (Cook Islands, Federated States of Micronesia, Fiji, Kiribati, Marshall Islands, Nauru, Samoa, Solomon Islands, Tuvalu and Vanuatu) to mitigate their emissions of greenhouse gases cooperatively through a regional mitigation programme.

The countries are very modest producers of greenhouse gases, not only in total but also on a per capita basis. Nevertheless, they recognise the importance of greenhouse gas (GHG) mitigation and are committed to meeting their obligations under the United Nations Framework Convention on Climate Change (UNFCCC). Funded by the Global Environment Facility (GEF) and implemented by the South Pacific Regional Environment Programme (SPREP), PICCAP is designed to assist members to meet their UNFCCC reporting obligations.

The study included an assembly of the GHG inventories compiled by each country. This showed that the ten PICCAP countries emitted an estimated total of 2,152,000 tonnes of carbon dioxide from burning fossil fuels. A little over half of this is from Fiji, although Fiji's output is similar to the other countries on a per capita basis. Emissions of the minor GHGs were estimated by a number of countries, but the regional picture is incomplete. It is possible that the overall picture is of net absorption of carbon dioxide due to forest growth, but this cannot be confirmed.

Based on inputs gathered from visits to six of the ten PICCAP countries and a wide-ranging review of research and programmes related to energy efficiency and greenhouse gas mitigation, the study:

- evaluated a wide range of measures which could reduce greenhouse gas emissions in participating countries; and
- defined a set of criteria to select measures which might be included in a regional programme of greenhouse gas mitigation.

The measures that could potentially be employed are summarised in Table 1. This provided a wide range of options for consideration covering the sectors in which changes could be made, the different types of measures that could be taken and both renewable energy supply enhancement and efficiency improvements.

These options, criteria and the initial findings of the study were reviewed at a Regional Mitigation Meeting held in Port Vila, Vanuatu, from 30 November to 4 December 1998. Representatives of all participating countries, two additional South Pacific countries not members of PICCAP (Niue and Papua New Guinea) and the three regional organisations involved in this area—SPREP, South Pacific Applied Geoscience Commission (SOPAC) and the Secretariat of the Pacific Community (SPC)—attended this meeting. The meeting concluded that the programme should cover the three basic mitigation options. The programme's elements comprise:

- **demand-side** options covering labelling schemes, appliances designed for tropical islands, training and education programmes, and various measures directed at ground transport;
- **supply-side** options related to increasing efficiency in existing energy systems; the use of biomass for heat and electricity, coconut oil fuel, wind power, and photovoltaics (PV); and
- a **forestry** programme designed to develop a sustainable supply of fuel and disseminate information on opportunities (while not being used to allow other countries to avoid their mitigation responsibilities).

In selecting these elements the meeting considered a number of issues, particularly:

- how severe should mitigation efforts be, in view of interactions with growth in population and living standards, and demonstration effect on other countries;
- the availability and appropriate roles of donor funding;
- the appropriate allocation of projects to national or regional programmes;
- project effectiveness;
- project sustainability; and
- the extent to which work is already covered by other programmes or agencies.

Table 1: Options for Mitigating Greenhouse Gas Emmissions

	Power Generation	Power Distribution	Power Consumption	Ground Transport	Forest
Pricing/tax	• Carbon tax on all fossil fuels • Tax on ageing and inefficient gensets • Preferential tax/exemptions on non-fossil consuming technologies	• Preferential tax/ exemptions on supplies for upgrading the distribution systems network	• Tax on inefficient appliances • Preferential tax/ exemption on more efficient appliances • Tariff review	• Carbon tax on all petroleum fuels • Tax vehicles according to engine sizes • Preferential tax/exemptions on non-fuel consuming transport system	• Make forest establishment expenses tax deductible • Sell emissions offset rights
Subsidy	• Subsidise lighter fuels • Subsidise more efficient gensets • Subsidise emission control/monitoring instruments	• Subsidies for upgrading power distribution networks	• Subsidise more efficient appliances	• Subsidise the public transport sector • Subsidise more efficient cars • Subsidise non-fuel consuming transport systems	• Compensate for loss of stumpage revenue • Provide free seedlings • Provide improved roads
Regulation/ policy	• Emissions level • Fuel quality • Power mix • Efficiency of gensets • More use of renewables	• Levels of line losses • Power thefts	• Minimum equipment standards	• Engine sizes • Emission levels	• Tree planting obligation after harvesting
Information	• Renewable energy awareness and training programmes	• Technical assistance with loss identification	• Efficiency labelling schemes • Efficiency audits • Public awareness and training programmes	• Fuel consumption labelling schemes • Public education and maintenance training programmes	• Public awareness and training programmes
Equipment Supply	• Emissions control and monitoring instruments • More efficient gensets • Power from wind, hydro, biomass, PV, coconut oil, geothermal, waves, OTEC	• Cables • Transformers • Reliable metering equipment to detect losses	• Affordable and efficient appliances • Solar water heaters • Biomass for heat • PV	• Public transport vehicles	• Nurseries
Institutional	• Commercially oriented power sector	• Commercially oriented power sector	• Full costs of power supply recovered in the power tariff • Commercially oriented power sector	• Traffic control measures to smooth traffic flows • Establish a coordinating agency to improve public transport efficiency	• Create company, trust, or other structure to facilitate afforestation projects

The meeting also identified short-term measures for inclusion in parallel national programmes covering:

- **demand side**: education on air-conditioner and refrigerator installation and operation, and in-country assessment of ground transport; and
- **supply side**: wind energy assessment, sustainable PV management, and options for efficiency increase in power supply.

The recommendations from the meeting set out two major initiatives following the study. These are to:

- develop feasible management structures for renewable energy implementation; and
- design a package of mitigation options for submission to financial institutions.

The meeting chose the following programme options.

Demand side:

- efficiency labelling schemes;
- appliances designed for tropical islands;
- training and education programmes; and
- ground transport (noting that this requires a mixture of measures, which varies by country).

Supply side:

- efficiency increase in existing systems;
- biomass for heat and electricity;
- coconut oil fuel;
- wind power; and
- photovoltaic.

Forestry:

- sustainable supplies of fuel; and
- information on income opportunities.

In relation to the last option, the meeting was concerned that mitigation forestry not be developed under arrangements that would allow other countries to avoid their mitigation responsibilities.

No single implementing mechanism can be suited to such a wide range of measures. In determining the appropriate mechanism for each element, the criteria that need to be considered were determined by examining past projects, especially the unsuccessful ones. These are that the implementer:

- be, or represent, the beneficiaries;
- have a clear mandate for its programme;
- possess adequate technical and managerial skills;
- have, or have access to, adequate funding to complete the programme;
- be acceptable to all other parties involved;
- be free from confounding incentives; and
- be subject to effective external financial control.

On this basis, the suggested allocation of selected options to implementing bodies is:

(1) Electricity utilities, including independent power producers (IPPs):

- renewable electricity (wind and biomass) for central systems;
- efficiency improvements to electricity systems.

(2) Government energy departments:

- setting policy frameworks;
- appliance efficiency labelling programmes—local implementation;
- appliances designed for tropical islands—local coordination;
- training and education programmes—local implementation;
- advice to other departments on ground transport; and
- encouragement of commercialised renewable technologies.

(3) Government forestry departments:

- fuel-wood supplies enhancement—local implementation; and
- advice to other departments on carbon offset forestry opportunities.

(4) Regional organisations:

- appliance efficiency labelling programmes—lead role;

- appliances designed for tropical islands—lead role;
- training and education programmes—lead role;
- coconut oil fuel, wind and PV—lead role;
- dissemination of information on carbon-offset forestry opportunities;
- execution of donor-funded programmes; and
- coordination of programmes.

(5) Private and cooperative sector:

- supply and promotion of energy-efficient appliances;
- own and operate large and small IPPs;
- construct and operate biomass schemes for heat and electricity;
- own and operate plant to extract coconut oil for use as fuel; and
- design and implement projects under contract.

(6) Special purpose utility business:

- small-scale PV systems.

The last agency cannot yet be fully specified. PV system management has not been fully sustainable in any of the countries, and a new form of organisation is needed. Two specific unresolved issues are financial sustainability and the safe disposal of failed batteries. Suggested elements of such a new form of organisation are that it:

(1) be a special purpose commercial utility, not distracted by other lines of business, or confounding objectives;

(2) be a multi-country operation to obtain economies of scale in building strong technical and managerial capabilities;

(3) operate under contract to a regional organisation, so that donor funding can be accessed for initial capital, and financial oversight and control provided;

(4) build up funds in a secure trust fund to meet replacement costs; and

(5) possibly have some private ownership to instil financial discipline.

A major current initiative is the proposed SOPAC/SPC Joint Regional Energy Programme. This is highly compatible with the chosen mitigation programme and if both proceed they should be integrated. Differences in membership will need to be recognised. The design for the joint programme indicates that funding from Australia and France will be directed to rural electrification with PV systems, wind and mini/micro hydro development, solar thermal and biomass. This presents few problems, although it is noted that the design suggests that private funding could cover "perhaps around 50 per cent" of the initial costs. This may create some difficulties in achieving financial sustainability.

Recommendations

Two specific matters need to be addressed in preparation for a regional greenhouse gas mitigation programme. These are to:

(1) find an effective answer to the issue of sustainable PV system management. Such an answer is likely to be within the utility model, but also incorporate strict financial oversight, be able to enforce adequate payments, have strong technical and managerial skills to provide effective service on an adequate scale to achieve economies and be funded over an extended period of years; and

(2) obtain funding for the next stage, which is the specific design and costing of each element of the programme, in a form suited to submission to funding institutions.

The content of the programme should include only technologies that are fully proven to be effective and sustainable, at least in larger countries. Those not proven in Pacific island countries (PICs) require significantly different formulation and funding arrangements. Those recommended by the Regional Mitigation Meeting are:

- a wind power demonstration project;
- a PV implementation project (once the issue of sustainable PV system management has been addressed) designed to demonstrate the ability of the purpose-designed organisation to achieve its goals. This will require a programme of substantial size in each host country, and for the supply of hardware to be progressive and sustained over several years; and
- coconut oil fuel extracted and used on small scales in remote areas.

The other selected options depend only on fully proven technologies. These are:

- efficiency labelling for appliances, including the necessary liaison with manufacturers, other governments and public education;
- exploration with manufacturers and suppliers of the potential for supply and promotion of high efficiency refrigerators and freezers optimised for PIC costs and climate;
- support for training and education by providing designs and materials for programmes;
- material and technical assistance to electricity utilities to design and install equipment to increase efficiency in diesel generation, and to identify, design and implement least cost measures to reduce losses in distribution systems;
- investigate utilising biomass for both heat and electricity on smaller scales than presently proven to be fully commercially viable, including specific feasibility studies and pilot implementation and monitoring;
- advise governments on a mix of measures to improve the energy efficiency of ground transport;
- wood-fuel resource assessment and demand forecasts for each country, and investigation of measures to achieve environmental sustainability of supplies; and
- advise governments on developments in the treatment of forests in greenhouse gas inventories, on the development of international carbon-offset trading agreements that permit the inclusion of forests as carbon sinks, and on other means to obtain funding for afforestation or forest preservation such as through the Clean Development Mechanism.

1. Introduction

The ten countries participating in the Pacific Islands Climate Change Assistance Programme (PICCAP)—Cook Islands, Federated States of Micronesia, Fiji, Kiribati, Marshall Islands, Nauru, Samoa, Solomon Islands, Tuvalu, Vanuatu recognise the importance of greenhouse gas mitigation and are committed to meeting their obligations under the United Nations Framework Convention on Climate Change (UNFCCC). This commitment has been expressed in a number of fora. These include the Roundtable of Pacific Island Ministers on Sustainable Development. At its meeting on 17 November 1998, the Roundtable agreed to *"*emphasise the critical importance of steps to reduce greenhouse gas emissions*"*. Ministers also noted the need to develop *"*comprehensive Pacific-wide renewables and energy efficiency adoption projects to achieve economies of scale*"*.

Funded by the Global Environment Facility (GEF) and implemented by the South Pacific Regional Environment Programme (SPREP), PICCAP is designed to assist members to meet their UNFCCC obligations. This study on mitigation options forms part of that programme.

Pacific island countries (PICs), even including those outside PICCAP, are tiny from a global perspective. Nevertheless, PICs have the responsibility of managing one of the world's largest marine ecosystems. That ecosystem, and the communities depending on it, is highly exposed to damage, and in some aspects even loss of viability, in the face of climate change.

Therefore, in order to actively seek to ameliorate the climate change problem, PICs need to be able to present their case to the larger countries of the world and be taken seriously. Although on a world scale the PICs net emissions are insignificant, or even negative, in order to achieve an impact on the countries responsible for large emissions, the PICs need to be jointly able to demonstrate that they are prepared to undertake the measures and activities that they are recommending to others.

In addition, technological advances, partly resulting from interest in climate change issues, have made some alternative sources of energy, and some means of using energy more efficiently, more available. The PICs should be able to gain benefits from these technologies being implemented in the Pacific. Individually, all but the largest PICs have little control over the application of these technologies. A combined regional approach to the issue is more likely to succeed.

Based on inputs gathered from visits to six of the ten PICCAP countries and a wide-ranging review of research and programmes related to energy efficiency and greenhouse gas mitigation, this study:

- evaluated a wide range of measures which could reduce greenhouse gas emissions in the participating countries; and
- defined a set of criteria to select measures which might be included in a regional programme of greenhouse gas mitigation.

These criteria and the findings of the study were reviewed at a Regional Mitigation Meeting held in Port Vila, Vanuatu, from 30 November to 4 December 1998 attended by representatives of all participating countries. Also attending were two additional South Pacific countries not members of PICCAP (Niue and Papua New Guinea) and the three regional organisations involved in this area (South Pacific Regional Environment Programme (SPREP), South Pacific Applied Geoscience Commission (SOPAC) and Secretariat of the Pacific Community (SPC)). This meeting concluded that the programme should comprise:

- **demand-side** options covering labelling schemes, appliances designed for tropical islands, training and education programmes, and various measures directed at ground transport;
- **supply-side** options related to increasing efficiency in existing energy systems; the use of biomass for heat and electricity, coconut oil fuel, wind power, and photovoltaics (PV); and
- a **forestry** programme designed to provide a sustainable supply of fuel, and to disseminate information on income opportunities through forestry (but not to allow forestry to be used to enable industrialised countries to avoid their mitigation responsibilities).

The majority of these measures are directed at non-transport energy. While transport as a sector is too

important to ignore, it is also very difficult to influence. The most effective measures involve taxation, and hence can only be implemented nationally. A regional programme can do little more than provide assistance with policy analysis and education programmes.

The meeting also identified short-term measures for inclusion in parallel national programmes covering:

- **demand side**: education on air-conditioner and refrigerator installation and operation, and in-country assessment of ground transport; and
- **supply side**: wind energy assessment, sustainable PV management, and options for efficiency increase in power supply.

The recommendations from the meeting set out two major initiatives following on from the study. These are to:

- develop feasible management structures for renewable energy implementation; and
- design a package of mitigation options for submission to financial institutions.

1.1 Background to this study

This study has been undertaken as a component of the Pacific Islands Climate Change Assistance Programme (PICCAP). The primary function of PICCAP is to enable the participating countries, through training, institutional strengthening, and planning activities, to meet their reporting obligations under the United Nations Framework Convention on Climate Change (UNFCCC). The project has six major objectives to achieve for each country:

(1) an inventory of greenhouse gas sources and sinks;

(2) an evaluation of mitigation options;

(3) national vulnerability assessments;

(4) an evaluation of adaptation options;

(5) a national implementation plan; and

(6) the first National Communication to the Conference of the Parties to the UNFCCC.

The specification for the present project springs from the Regional Planning Meeting for PICCAP National Coordinators held in Apia in January 1998, and the PICCAP Greenhouse Gas Inventory and Methodology Training Course in Suva in April 1998. These identified and prioritised the main sectors to be addressed in developing proposals for measures to be undertaken in the PICCAP countries to mitigate impacts toward climate change.

Many of the options are common across all or some of the PICCAP countries. Hence for each country to fully explore these options individually would result in a great deal of duplication of effort. The first PICCAP Multipartite Review, in May 1998, agreed that PICCAP should assist this process by undertaking a regional mitigation analysis. This report is the result of that analysis, and of the considerations of the Regional Mitigation Analysis Meeting held in Port Vila, Vanuatu, from 30 November to 4 December 1998. The Terms of Reference for this study are attached as Annex I.

The purpose of the Regional Meeting was to consider the outcomes of the regional analysis of mitigation options. The timetable for the section of the meeting devoted to this is attached as Annex IV.

2. The Present Emissions Situation

With the recent completion by all countries of inventories of greenhouse gas emissions it is possible for the first time to obtain an overall picture of Pacific island emissions in relation to the rest of the world. On inspection, all the country inventories proved to contain a number of problems, in terms of both significant errors and coverage. Wherever sufficient information was available errors have been corrected and gaps plugged. In a few cases reasonable estimates have been used to replace clearly incorrect ones, but outright guesses have been avoided in favour of omitting some estimates. A description of the problems found, and the actions taken is given in Hay and Sem (1999). This has enabled an almost complete set of information to be assembled for fossil fuels and industrial processes. The volumes of petroleum imported and consumed by each country are shown in Table 1. Note that the table does not show exports, hence the quantities do not balance for Fiji. The only known problems with this table are that:

- domestic consumption of fuels may be overstated for Fiji, as insufficient allowance appears to have been made for exports;
- no information is available for international aviation bunkers for Kiribati and the Marshall Islands. As a consequence consumption of kerosene within these countries is probably overstated;
- only two countries have been able to supply information on international marine bunkers. As a consequence consumption of diesel fuel within the other countries is probably overstated.

The templates included requests for information on the consumption of fuel by sector. The countries' ability to supply information at this level of detail was patchy. This is demonstrated in Table 2, which shows the information for the transport sectors and electricity generation. As can be seen, six countries provided useful information. The lack of data on fuel use for electricity generation may seem surprising, as this information will generally be quite easy to obtain from the generation authority. That so few countries have done so seems to be a consequence of the obscure manner in which the Intergovernmental Panel on Climate Change (IPCC) templates and instructions are worded. These are particularly poor in that they confuse electricity and energy. Misunderstanding has been the result.

The data on transport-fuel use is also useful in providing a consistency check on the consumption of gasoline and aviation kerosene, since these are used almost exclusively for transport. This demonstrates a significant problem only for Fiji. This may reflect the under-allowance for fuel exports referred to above. Perhaps surprisingly for countries so oriented toward the sea, only one country (Tuvalu) was able to provide an estimate of fuel use by inter-island shipping within the country.

The level of information on consumption by other sectors which countries have been able to provide is too thin to be worth presenting.

Table 3 shows the picture obtained for the solid fuels, coal and biomass. Only Fiji uses the former, mainly in its cement plant. The information supplied on biomass growth and use is of doubtful value, with not all countries attempting this section. The manner in which the template and guidelines have been interpreted is highly variable. Samoa provided estimates for forest growth, but these have been omitted as there are errors in the calculations without sufficient information to provide corrections.

The Cook Islands estimates have been modified to remove natural forest from the plantation growth calculations, since these are not managed for harvest and there is little reason to believe that they have a significant net annual increment. Similar problems seem likely to have affected the Fiji and Vanuatu calculations. The appropriateness of the Vanuatu calculations cannot be assessed since only the end result is available. The large Fiji estimate of growth comes primarily from the biomass increment of natural forest. Much of this has been harvested, and may be recovering some net growth. However, the growth rates assumed are as for plantations, which seems unrealistically optimistic. No attempt has been made to correct this.

Estimates of the impacts of forest expansion or contraction are not available for FSM, Kiribati or Tuvalu. Kiribati and Tuvalu are atoll countries with minimal forest and no significant programmes to change what they have. Consequently the missing figures would be very small. FSM has substantial land areas and is potentially much more significant. There is no large-

scale logging industry on FSM, but forests are subject to clearance for agricultural purposes. Hence there is likely to be a net emission of carbon dioxide from this source.

The resulting carbon dioxide emissions and absorptions are summarised in Table 4. The estimates of emissions from fossil fuels and cement are subject to the limitations described above, but are sufficiently accurate to be of value. Hence credence can be given to the resulting estimate of a total emission by the PICCAP countries of 2.2 million tonnes (2,200 Gg) of carbon dioxide from fossil fuels and cement, although significant uncertainty remains. The estimates for biomass suffer from both more serious uncertainties in the calculations and the omission of some possibly substantial items. Consequently the overall regional figure has little meaning.

The information collected for methane emissions is shown in **Error! Reference source not found.**. Many countries had a degree of difficulty in estimating these emissions, and a considerable number of estimates are missing. Consequently, little significance can be attached to the total emissions. The table is shown to demonstrate the present state of the inventories, rather than to present definitive regional results.

Table 6 shows the situation for nitrous oxide, and Table 7 that for oxides of nitrogen (NO_x). Countries had great difficulty in obtaining estimates for these gases, with the result that these tables are even sparser than that for methane. Only Samoa succeeded in obtaining estimates for all categories. Even there, a large correction factor needed to be applied, and the accuracy of the result is unclear. No PICCAP-wide totals are shown, since these would be meaningless.

There are a number of other gases with greenhouse effects that are emitted to the atmosphere. Included in the inventory template were carbon monoxide, volatile organocarbons, sulphur dioxide, sulphur hexafluoride and fluorocarbons. Tables for these gases are not presented here as too few countries attempted to estimate them to make comparisons or aggregates meaningful.

The overall effect of GHGs is an aggregate of the individual gases, combined using the relative Global Warming Potential of each gas. The result of this aggregation is shown in Table 8. All the caveats listed above need to be taken into account in considering this table, so that the overall scale of the emissions by PICCAP countries is highly uncertain, and is not necessarily negative as shown.

Table 1: Petroleum Supply to PICCAP Countries (tonnes of fuel)

		Cook Islands	Federated States of Micronesia	Fiji	Kiribati	Marshall Islands	Nauru	Samoa	Solomon Islands	Tuvalu	Vanuatu	Total
Imports	Gasoline	3,206	12,561	83,228	1,616	6,042	2,926	17,536	12,423	359	4,137	144,035
	Jet kerosene	10,389	11,557	55,465	1,040	5,699	4,149	7,662	4,803	452	4,630	105,845
	Other kerosene	60	0	35,581	819	722	0	0	1,405	207	779	39,573
	Diesel oil	6,736	60,914	202,257	5,105	37,076	15,227	14,231	61,550	968	19,133	423,196
	Fuel Oil	0	0	23,444	13	0	0	0	0	0	0	23,457
	LPG	18	99	898	64	1	40	595	940	0	991	3,646
	Total fuels	20,409	85,132	400,873	8,656	49,540	22,342	40,024	81,121	1,985	29,669	739,751
	Non-fuels	141	1,033	6,068	184	428	160	1,000	2,276	0	495	11,785
	Total	**20,550**	**86,165**	**406,940**	**8,841**	**49,968**	**22,502**	**41,024**	**83,397**	**1,985**	**30,165**	**751,536**
Domestic	Gasoline	3,206	12,561	83,228	1,616	6,042	2,926	17,536	12,423	359	4,137	144,035
	Jet kerosene	631	578	46,780	1,040	5,699	0	1,037	3,303	0	0	59,068
	Other kerosene	60	0	35,581	819	722	0		1,405	207	779	39,573
	Diesel oil	6,356	60,914	188,528	5,105	37,076	15,227	14,231	61,550	968	19,133	409,087
	Fuel Oil	0	0	11,849	13	0	0	0	0	0	0	11,862
	LPG	18	99	898	64	1	40	595	940	0	991	3,646
	Total fuels	10,272	74,152	366,864	8,656	49,540	18,193	33,399	79,621	1,534	25,040	667,270
	Bitumen	0	0	1,318	0		0			0	88	1,406
	Lubricants	141	1,033	4,733	184	412	160	1,000	1,651	0	407	9,722
	Other	0	0	17	0	16	0		625	0	0	658
	Total	**10,413**	**75,186**	**372,915**	**8,841**	**49,952**	**18,353**	**34,399**	**81,272**	**1,534**	**25,535**	**678,398**
International	Jet kerosene	9,757	10,979	47,438			4,149	6,625	1,500	452	4,630	85,530
	Diesel oil	380	0	13,709			0	4,247		0	0	18,335
	Fuel Oil	0	0	11,595	0	0	0	0	0	0	0	11,595
	Total	**10,137**	**10,979**	**61,147**	**0**	**0**	**4,149**	**10,872**	**1,500**	**452**	**4,630**	**103,866**

Table 2: Sectoral Consumption of Fuel (tonnes)

		Cook Islands	Federated States of Micronesia	Fiji	Kiribati	Marshall Islands	Nauru	Samoa	Solomon Islands	Tuvalu[+]	Vanuatu	Total
Road transport	Gasoline	3,170	12,392	40,690					12,710		3,516	72,478
	Diesel oil	987		123,028					22,040		10,141	156,196
	Total	**4,157**	**12,392**	**163,718**					**34,750**	**139**	**13,657**	**228,813**
Air transport	Gasoline	6	169	1,240					511		206	2,132
	Jet kerosene	1,050	578	2,660					800		0	5,088
	Total	**1,056**	**747**	**3,900**					**1,311**	**79**	**206**	**7,300**
Sea transport							0			1,231		1,231
Electricity generation				10				2,767	236		7,961	10,974

[+]The totals for Tuvalu have not been divided into various categories of fuel and therefore appear as total consumption. Thus totals in bold do not include Tuvalu figures.

Table 3: Consumption of Solid Fuels (tonnes)

		Cook Islands	Federated States of Micronesia	Fiji	Kiribati	Marshall Islands	Nauru	Samoa	Solomon Islands	Tuvalu	Vanuatu	Total
Coal	Domestic	0	0	13,131	0	0	0	0	0	0	0	13,131
	Bunkers	0	0	101	0	0	0	0	0	0	0	101
	Total	**0**	**0**	**13,232**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**13,232**
Biomass												
(Carbon content)	Forest growth	11,159		2,724,300			804		54,001	0	2,778,055	5,568,319
	Forest clearing	0		531,000			0		2,092,812		314,550	2,938,362
	Use for fuel		16,095	1,044	500	5						17,644
	Total	**11,159**	**16,095**	**3,256,344**	**500**	**5**	**804**	**0**	**2,146,813**	**0**	**3,092,605**	

PS: The totals for different categories of solid fuel do not add up. These should be read as separate. The Total should be **8,524,325**

Table 4: Carbon Dioxide Emmissions (tonnes per 000)

		Cook Islands	Federated States of Micronesia	Fiji	Kiribati	Marshall Islands	Nauru	Samoa	Solomon Islands	Tuvalu	Vanuatu	Total
Petroleum	Domestic fuels	32	234	1,156	27	157	57	104	251	5	79	2,102
	non-fuels	0	1	6	0	1	0	1	3	0	0	12
	International bunkers	32	35	193	0	0	13	34	5	1	15	328
Coal	Domestic	0	0	36	0	0	0	0	0	0	0	36
	International bunkers	0	0	0	0	0	0	0	0	0	0	0
Total fossil fuels excl. bunkers		**32**	**235**	**1,198**	**27**	**158**	**57**	**105**	**254**	**5**	**79**	**2,150**
Cement		0	0	45	0	0	0	0	0	0	0	45
Biomass	Forest growth	-41	0	-9,989	0	0	-3	-198	0	0	-10,186	-20,417
	Forest clearing	0		1,947				7,674			1,153	10,774
	Biomass use for fuel		47	3	1	0	0	0	0	0	0	52
	Total biomass	-41	47	-8,039	1	0	-3	0	7,476	0	-9,033	-9,591
Total all sources		**56**	**553**	**-5,404**	**57**	**314**	**126**	**7,721**	**513**	**11**	**-8,859**	**-4,914**

Note: Biomass data is fairly sparse and is not divided into various activities; i.e., the figures appear as total emissions of carbon dioxide from biomass.

Table 5: Emmissions of Methane (tonnes)

	Cook Islands	Federated States of Micronesia	Fiji	Kiribati	Marshall Islands	Nauru	Samoa	Solomon Islands	Tuvalu	Vanuatu	Total
Fossil fuel burning							17	25			42
Enteric fermentation	72		15,081	11	160	11	899	136	202	8,519	25,091
Animal wastes	420		2,637	13	300	212	1,146	419	0	2,679	7,826
Biomass burning		198	8,772		20		96	16			9,102
Solid waste	13		3,430	425	616	101	109	632			5,326
Wastewater	-		37	15	10	11	1,037				1,110
	505	**198**	**29,957**	**464**	**1,106**	**335**	**3,304**	**1,228**	**202**	**11,198**	**48,497**

Table 6: Emmissions of Nitrous Oxide (tonnes)

	Cook Islands	Federated States of Micronesia	Fiji	Kiribati	Marshall Islands	Nauru	Samoa	Solomon Islands	Tuvalu	Vanuatu
Fossil fuel burning							1	2		
Animal wastes	2			8		0	1	36		
Biomass burning		2	132	1			2	0		
Wastewater	118					1	22			
Total	**120**	**2**	**132**	**9**		**1**	**26**	**38**		

Table 7: Emmissions of NOx (tonnes)

	Cook Islands	Federated States of Micronesia	Fiji	Kiribati	Marshall Islands	Nauru	Samoa	Solomon Islands	Tuvalu	Vanuatu
Fossil fuel burning							914	1,250		
Biomass burning		68	4,794	53	23		57	4		
Total		**68**	**4,794**	**53**	**23**		**971**	**1,254**		

Table 8: Global Warming Potential of Emmissions

		Cook Islands	Federated States of Micronesia	Fiji	Kiribati	Marshall Islands	Nauru	Samoa	Solomon Islands	Tuvalu	Vanuatu	Total
Carbon dioxide	Fossil fuel & cement	32	235	1,243	28	157	58	105	254	5	79	2,197
	Biomass	-41	47	-8,039	1	0	-3	0	7,476	0	-9,033	-9,591
	Total	**-9**	**282**	**-6,796**	**29**	**157**	**55**	**105**	**7,730**	**5**	**-8,953**	**-7,394**
Methane		12	5	734	11	27	8	81	30	5	274	1,188
Nitrous oxide		38	1	42	3		0	8	11			104
Total		**41**	**288**	**-6,020**	**43**	**184**	**63**	**194**	**7,771**	**10**	**-8,679**	**-6,102**

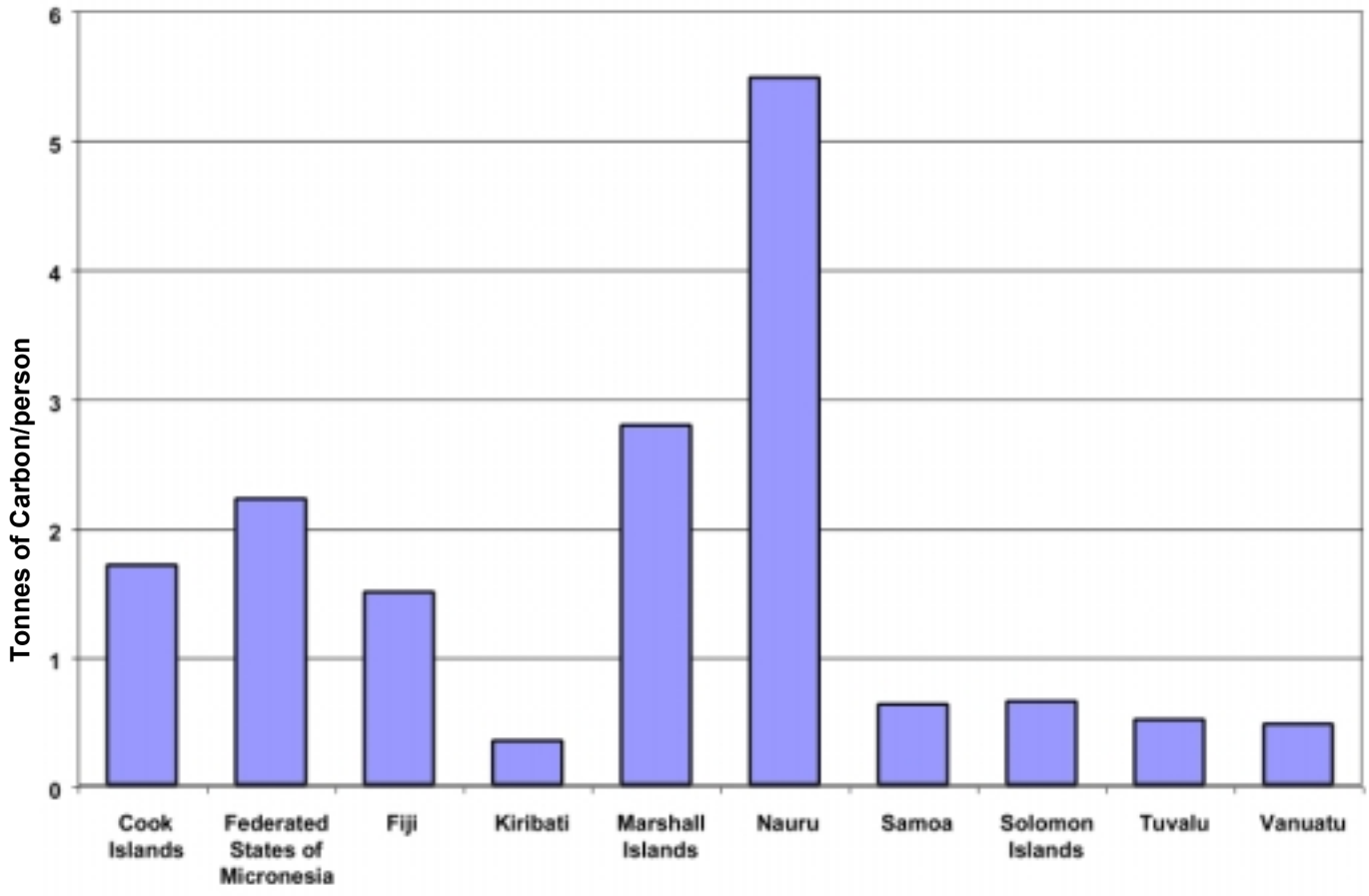
The components of GHG emissions for which estimates are reasonably reliable are carbon dioxide from fossil fuels and from limestone in cement manufacture. For these a comparison between countries is worthwhile and interesting, when placed on a per capita basis. This comparison is shown in Figure 1.

Notable in this chart are the relatively high per capita emissions from Nauru, a reflection of its energy intensive mining industry, and the very low emissions of the atoll country of Kiribati and large Melanesian countries.

It is of some interest to compare the results of the inventory with the situation recorded in 1990. Johnson (1995) includes data on outputs and effects from Pacific Regional Energy Assessment (PREA) (World Bank 1992). This information is summarised in Table 9.

The available data for 1990 enables a comparison only for emissions from petroleum combustion, which is equivalent to all fossil fuels, except for Fiji. The 1990 emissions are calculated from petroleum consumption as shown in Table 9, and compared in the final column with the corresponding emissions from the 1994 inventories.

Figure 1: Per person Emmissions of Carbon Dioxide from Fossil Fuels and Cement-making



It is not clear that the two years are on entirely the same basis, but some changes are likely to be genuine. Samoa shows the effects of commissioning a substantial new hydro station in that period, while a major gold mining operation commenced in the Solomon Islands. Both FSM and the Marshall Islands show large increases, although inadequate allowances for international bunkers in 1994 may have influenced this. It is not clear why the Cook Islands shows a large decrease.

The relatively modest scale of the PIC emissions can be seen when they are compared with world total carbon dioxide emissions in 1994 of 22,884 million tonnes, Table 10. This level of emissions is still progressively rising as shown in Figure 2. The PIC emissions represented about 0.02 per cent of total world carbon emissions in 1990. The PICCAP countries' emissions were 0.01 per cent of total world carbon dioxide emissions in 1994. The average per person annual production of 1.17 tonnes compares with a world average of 4.2 tonnes per person and a US average of 20 tonnes per person.

It is worth considering which parts of the various economies are responsible for consuming this fuel. As noted above, the inventories do not provide a satisfactory breakdown by sector. However, sectoral information is available for most countries, excluding Nauru, for 1990. This is demonstrated in Table 11.

Overall the reported pattern of petroleum demand is dominated by transport and electricity. However, note that there are significant missing data and no final conclusions can be drawn.

The unusual case in this table is the Solomon Islands, with only 26.5 per cent reported used for transport. From the inventory it is clear that the correct proportion is over 44 per cent, without including inter-island shipping. In addition, the other country with a low proportion used for transport is PNG, which is not a PICCAP country. On the other hand, Nauru, not included in Table 11, will have a low proportion used for transport. Hence in the PICCAP countries the proportion of petroleum used for transport is well over 50 per cent, and likely to exceed 60 per cent.

Given this uncertainty over the major use, the proportions used for electricity generation and other uses are, unfortunately, also quite uncertain.

Table 9: PIC Petroleum Consumption and Carbon Dioxide Emmissions, 1990 (adapted from Johnson 1995) and 1994

Country	Oil consumption (million tonnes)	Carbon dioxide emissions (million Tonnes)	1990 Carbon dioxide emissions (tonnes/ person)	1994 Carbon dioxide emissions (tonnes/ person)
Cook Islands	0.014	0.044	2.46	1.72
Federated States Micronesia	0.050	0.156	1.58	2.23
Fiji	0.323	1.007	1.39	1.41
Kiribati	0.010	0.031	0.44	0.36
Marshall Islands	0.029	0.090	1.98	2.81
Nauru				5.49
Palau	0.027	0.084	5.54	
Papua New Guinea	0.809	2.521	0.66	
Samoa	0.037	0.115	0.73	0.49
Solomon Islands	0.059	0.184	0.48	0.64
Tonga	0.024	0.075	0.77	
Tuvalu	0.002	0.006	0.77	0.66
Vanuatu	0.027	0.084	0.59	0.52
Total	**1.411**	**4.397**	**17.39**	**16.33**

Table 10: World Total Carbon Dioxide Emmissions 1990–2015 (millions of tonnes) US Department of Energy 1997

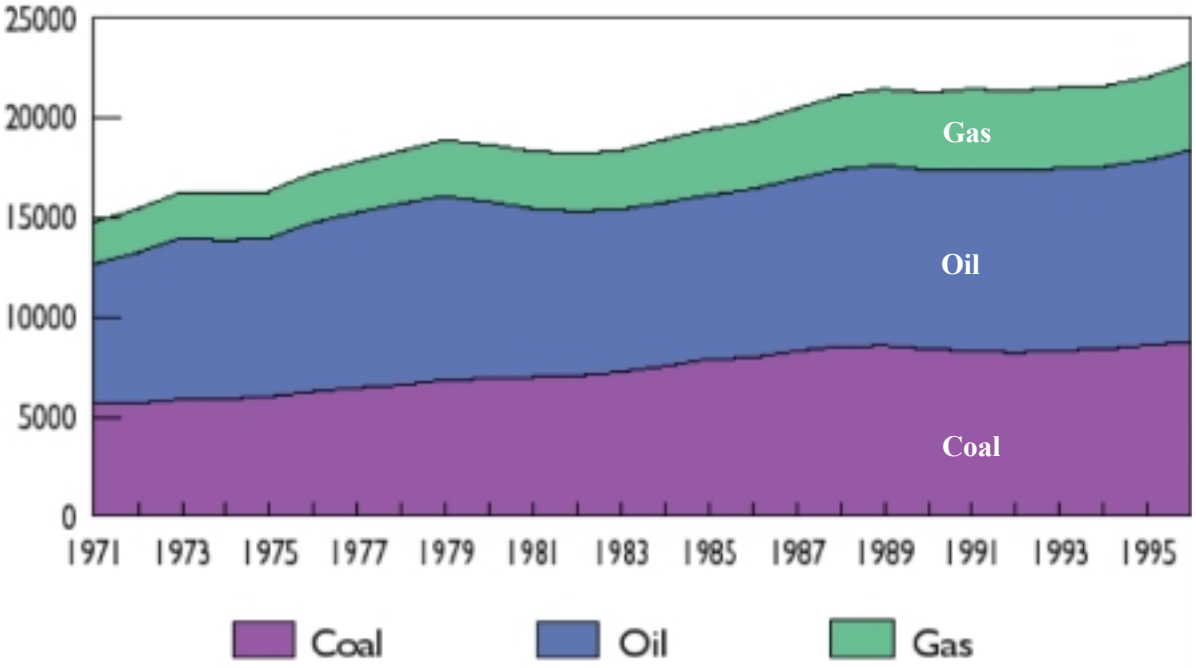
Country	1990	1995	2000	2005	2010	2015	%/yr, 1995-2015
North America	5,724	6,098	6,695	7,172	7,575	7,957	1.3
Western Europe	3,725	3,718	3,964	4,206	4,429	4,690	1.2
Industrialised Asia	1,496	1,734	1,885	2,028	2,174	2,292	1.4
EU/FSU	4,910	3,274	3,711	4,015	4,319	4,587	1.7
Developing Asia	4,004	5,408	6,838	8,415	10,028	11,851	4.0
Middle East	744	931	972	1,067	1,155	1,261	1.5
Africa	752	909	979	1,078	1,181	1,291	1.8
C & S America	693	807	964	1,170	1,401	1,657	3.7
Total World	22,048	22,879	26,007	29,151	32,262	35,586	2.2

Table 11: PIC Petroleum Demand by Sector, 1990 (Per cent of Total Petroleum Demand) Johnson 1995

Country	Transport	Electricity	House-hold	Govt., Industry (includes agro-industry), Commerce	Other
Cook Islands	70.6	26.2	3.1	n.a.	n.a.
Federated States of Micronesia	62.0	36.0	2.0	n.a.	n.a.
Fiji	75.8	4.4	7.2	12.5	0.0
Kiribati	71.0	19.4	9.7	n.a.	n.a.
Marshall Island	40.7	53.4	1.4	3.8	0.7
Palau	53.1	39.4	0.7	6.8	0.0
Papua New Guinea	34.4	52.6	1.5	11.5	0.0
Samoa	79.9	15.7	4.5	n.a.	n.a.
Solomon Islands	26.5	17.1	3.4	47.9	5.1
Tonga	72.0	23.1	4.9	n.a.	n.a.
Tuvalu	74.0	18.5	7.5	0.0	0.0
Vanuatu	70.9	23.2	5.8	n.a.	n.a.
Weighted Average	48.3	36.7	3.2	11.7	0.2

n.a. data not available

Figure 2: World Emmissions of Carbon Dioxide (millions of tonnes)



3. Mitigation Processes

There are three basic policy options available for the mitigation of greenhouse gases:

(1) **demand-side** options: reduce energy consumption while maintaining the level of service desired by the user;

(2) **supply-side** options: increase energy conversion efficiencies, or replace fossil fuels with renewable energy; and

3) development of **sinks** to remove greenhouse gases from the atmosphere.

Within this framework there are a range of measures that can be adopted:

- hardware supply;
- administrative measures;
- information;
- enforcement;
- fiscal measures;
- training; and
- forestry expansion.

A very large number of specific options can be identified that could potentially be employed. Those relevant to PICs are summarised in Table 12.

Obvious objections can be raised to a number of the options listed in Table 12, and those options are not discussed further. Those more worthy of consideration are discussed below.

3.1 Overview of demand-side options

A range of effective methods for increasing the efficiency with which energy is used have been developed and implemented in larger countries. These include:

- labelling schemes;
- regulation;
- purpose-built appliances for tropical islands;
- education and training programmes; and
- fiscal measures.

Individual measures are reviewed in the following section.

3.1.1 Electricity

All five types of demand-side measures can be applied to electricity demand, one of the two major components driving the use of petroleum fuels and the resultant greenhouse gas emissions. There are a number of potential programmes with that could reduce appliance energy use without loss of economic benefits. The crucial decision is the selection of the appliance at the time of purchase.

The buyers choose from the range available based on their preferences and the information available to them. Since energy efficiency is not visible, it tends to be ignored. The principal ways in which sales can be diverted toward more efficient models are:

- providing consumers with information about the efficiencies of the different models, and educating them to make use of it. This is generally known as a “labelling scheme”, although attaching labels to appliances is not the only means of doing this; and
- prohibiting the sale of appliances which fail to meet a specified efficiency level. This is called “minimum energy performance standards”, or MEPS.

Both methods work by not only changing what consumers buy, but by encouraging manufacturers and importers to provide more efficient models. The effect of these measures on GHG emissions is subject to wide uncertainty, since not only is the impact of any of these measures on electricity consumption uncertain, but accurate data on fuel use for electricity generation is not available. Future fuel use will also be highly influenced by choices of energy sources for additional power generation capacity. To the extent that requirements for additional capacity are met from non-fossil fuelled sources, changes in electricity consumption will not be reflected in changes in GHG emissions.

Table 12: Options for Mitigating Greenhouse Gas Emmissions

	Power Generation	Power Distribution	Power Consumption	Ground Transport	Forest
Pricing/tax	• Carbon tax on all fossil fuels • Tax on ageing and inefficient gensets • Preferential tax/exemptions of non-fossil consuming technologies	• Preferential tax/ exemptions on supplies for upgrading the distribution systems network	• Tax on inefficient appliances • Preferential tax/ exemption on more efficient appliances • Tariff review	• Carbon tax on all petroleum fuels • Tax vehicles according to engine sizes • Preferential tax/exemptions on non-fuel consuming transport system	• Make forest establishment expenses tax deductible • Sell emissions offset rights
Subsidy	• Subsidise lighter fuels • Subsidise more efficient gensets • Subsidise emission control/monitoring instruments	• Subsidies for upgrading power distribution networks	• Subsidise more efficient appliances	• Subsidise the public transport sector • Subsidise more efficient cars • Subsidise non-fuel consuming transport systems	• Compensate for loss of stumpage revenue • Provide free seedlings • Provide improved roads
Regulation/ policy	• Emissions level • Fuel quality • Power mix • Efficiency of gensets • More use of renewables	• Levels of line losses • Power thefts	• Minimum equipment standards	• Engine sizes • Emission levels	• Tree planting obligation after harvesting
Information	• Renewable energy awareness and training programmes	• Technical assistance with loss identification	• Efficiency labelling schemes • Efficiency audits • Public awareness and training programmes	• Fuel consumption labelling schemes • Public education and maintenance training programmes	• Public awareness and training programmes
Equipment supply	• Emissions control and monitoring instruments • More efficient gensets • Power from wind, hydro, biomass, PV, coconut oil, geothermal, waves, OTEC	• Cables • Transformers • Reliable metering equipment to detect losses	• Affordable and efficient appliances • Solar water heaters • Biomass for heat • PV	• Public transport vehicles	• Nurseries
Institutional	• Commercially oriented power sector	• Commercially oriented power sector	• Full costs of power supply recovered in the power tariff • Commercially oriented power sector	• Traffic control measures to smooth traffic flows • Establish a coordinating agency to improve public transport efficiency	• Create company, trust, or other structure to facilitate afforestation projects

The key issues that arise with **labelling schemes** are that:

- a programme needs to be large to justify the costs of setting it up and making it effective;
- they require reliable information and enforcement;
- they require extensive public education;
- it is very difficult to create a different scheme for PICs;
- the existing Australian scheme has some problems; and
- existing appliances are not designed for PIC climate or energy costs.

Notwithstanding these issues, labelling schemes have proven to be effective and offer large potential energy and economic benefits. The most important, but not the only, application will be to refrigerators and freezers. These account for over half of domestic electricity consumption in most PICs, and a 10 per cent improvement in efficiency, over a period of years, could be achievable.

Banning low efficiency appliances also has substantial potential energy and economic benefits. The downside is that such bans require reliable information and enforcement and they create conflict between governments and suppliers.

The potential for the development of **purpose-built appliances** for tropical islands lies mainly in refrigerators and possibly freezers. Implementation will require a labelling scheme designed to demonstrate the benefit of very high efficiencies. This option also has the potential for large economic and mitigation benefits.

Education and training programmes are similarly mainly applicable to refrigeration and air-conditioners. Such programmes have proven to be effective elsewhere. They would aim at:

- correct installation and cleaning ensuring that condensers are well ventilated and clean, and for air-conditioners that filters are cleaned;
- controls, such as timers or occupancy sensors, to minimise the operation of air-conditioners while rooms are unoccupied; and
- choice of correct appliance.

The potential of education programmes and attaching controls was established in the Air-conditioner Efficiency Project in the Solomon Islands.

Computer rooms are a potential specialised application for education. These are often air-conditioned to protect the computers. Improvements in both energy consumption and the life of the computers could be achieved by encouraging the use of dehumidifiers rather than air-conditioners.

There are three main types of **fiscal measure** that can be applied in promoting the efficient use of electricity:

(1) import duties which vary with appliance efficiency;

(2) duty concession for high efficiency appliances; and

(3) taxes on energy.

3.1.2 Ground transport

In nearly all PICCAP countries ground transport is the largest, and in many cases by far the largest, internal use of fossil energy. It is also a large expenditure and import cost. Hence reductions in fuel usage, if they can be achieved without losses in benefits to users, may have significant economic benefits as well as reducing greenhouse gas emissions. Unfortunately this sector is known for its resistance to efforts to improve its efficiency. However, this does not mean that nothing can, or is worth, doing. Even only a five per cent improvement in efficiency would reduce carbon dioxide emissions by 63,000 tonnes per year.

The issue of fossil fuel use in ground transport is characterised by:

- being relevant in all countries;
- being a large and fast growing source of greenhouse gases;
- having low potential for non-fossil substitutes;
- having potential for large reductions in greenhouse gas emissions;
- having large numbers of small users;
- a high resistance to change;
- experiencing rapid technical change in vehicles; and
- having significant government revenue implications.

Many measures intended to improve the efficiency of ground transport require regulatory or fiscal actions. These include:

- **Bans on large-engined/low-efficiency cars.** While it is superficially attractive to ban vehicles over a certain engine size, in practice exceptions will be needed for a variety of uses where a larger vehicle is needed. Cars with large bodies but smaller engines are difficult to obtain. The need to set up a regulatory authority with discretionary powers to issue exemptions also creates difficulties;
- **Fuel efficiency performance standards.** The USA has applied a falling lid to the average fuel consumption of the overall fleet of cars sold by each manufacturer. This requires extensive and constantly updated data on vehicle efficiencies for all makes and models of vehicles in each country, and vehicle efficiency testing equipment of a quality that cannot be challenged by aggrieved vehicle sellers and owners. The costs and technical difficulties of this have discouraged all but the largest countries from adopting this method. Even in the USA, which has adopted these standards, results have been mixed. The average new car in the USA has become smaller and more efficient, but a boom in sales of light trucks (in the form of pick-ups, recreational vehicles, and sports utilities) has offset this benefit. The trucks are outside the efficiency regulation, and have high fuel consumption;
- **High taxes on large-engined vehicles through scaled import duties and/or scaled annual fees.** Taxation rates that vary with the capacity of the vehicle engine have been used on and off by many countries for almost as long as there have been motor vehicles. Unfortunately there is not a direct link between engine size and efficiency. Capacity-based taxes have encouraged reactions like turbochargers on small engines, and running at high rpm, to get around the tax. Taxes based on measured efficiency would be much better in principle, but are not practicable in small markets—the required information is too difficult to obtain;
- **Tax company cars.** This is attractive as companies have access to taxation advantages that allow them to provide expensive cars at lower costs. Australia and New Zealand have dealt with this by introducing fringe benefits taxes to equalise tax rates. Unfortunately these are difficult and expensive to administer;
- **Reduced duty on spares.** Avoiding high duties on spare parts may have a small useful effect. This would need to be set in the context of each government's policy on duties. (More frequent tyre replacement may have safety advantages, but will not reduce greenhouse gas emissions.) Reducing import duties on vehicle diagnostic and tyre balancing equipment could also have a small effect in reducing the cost of providing vehicle maintenance services;
- **High fuel taxes.** The obvious incentive to minimise vehicle use is fuel taxation, although even this has not been found to be a strong influence anywhere. All PICs are experiencing rapid growth in traffic volumes in spite of a wide diversity of fuel prices; and
- **Different taxes on gasoline and diesel used for transport.** Many countries tax fuels to raise revenues to fund road maintenance. This also provides an incentive to minimise fuel use. Indeed this is the simplest and most direct means to penalise excess fuel use. There is more potential in moving consumption from diesel to petrol-fuelled engines. Since banning petrol vehicles would not be practicable, taxation measures are the main available incentive to encourage fuel switching.

There is a range of other measures that can contribute to the reduction of greenhouse gas production from ground transport:

- **Efficiency labelling.** Giving purchasers information about the fuel efficiency of vehicles is a good idea in theory but one which has proven very difficult to implement. New Zealand, for instance, has abandoned trying to make such a scheme compulsory, the required information on efficiencies was found to be too contentious, and too difficult to obtain. To establish such a scheme would be a hopeless proposition on the scale of the PICs especially in light of the significant imports of second hand cars from Japan;
- **Emissions standards and testing.** This could be effective in the short term, but its potential effectiveness is reducing as most new vehicles have computer controls on their engines. The drawback is that it involves considerable expense on testing and enforcement. The measure could be effective in reducing emissions of smoke and other local pollutants resulting from incomplete fuel combustion. However, the effects on greenhouse gas emissions would be minor at best;

- **Education programmes.** Education, for both private and commercial **drivers**, could be expected to improve driving behaviour and with it fuel efficiency. Incentives could be provided through lower insurance rates for those passing approved courses. This would necessitate a level of government involvement in insurance premium setting that would be difficult to justify. In addition, many Pacific drivers do not insure their vehicles, and vehicles may have several drivers. Other incentives, such as a reduced fee for renewing drivers' licences, could be more workable. Maintaining the effectiveness of the education will remain a problem;
- The level of education of **mechanics** is a common problem. Most technical institutes are able to provide the courses. However, there is insufficient incentive for mechanics to undertake training. This could require a publicity campaign to create an awareness of the advantages of having one's vehicle maintained by a trained mechanic;
- A further option is to introduce public awareness programmes on the relative fuel economy and running costs of different vehicles. However, applied on its own, this would be unlikely to be effective. Its role would be to back up the other education courses to sustain their effectiveness;
- **Road construction and maintenance improvements.** Smoother and straighter roads require less energy to travel over, and numerous other traffic engineering improvements can reduce fuel use; and increase vehicle life. Hence the economics of this are highly attractive on roads with moderate or heavy traffic volumes. However, it is not clear that any less fuel use results, as users are likely to increase their travel if this becomes faster, cheaper and more comfortable. One important effect of better road surfaces, particularly if safety is improved by also increasing road widths, can be an increase in the use of bicycles and motorbikes in place of cars. Improved road design can provide large increases in road capacity, but requires substantial investments in road construction, e.g. to provide turning lanes near intersections;
- **Traffic management improvements.** Traffic congestion is a significant source of fuel wastage. Options include to:
  - make more use of traffic officers at busy locations or during peak periods. This is effective, but requires that the officers be available and trained. It may be possible to train people specifically for this task, rather than use fully trained police officers;
  - introduce better traffic light and management systems. Extra traffic lights have been installed in some countries to good effect. Greater benefits could be obtained by moving toward area-wide traffic light management to coordinate a succession of lights;
  - encourage better bus fleets through preferential duties on buses, local assembly, etc. Some of the larger countries have encouraged local industry by providing protection from imported buses. This has achieved local production, but at some cost in terms of the quality of the resulting buses. Use of buses could be made more attractive, and switching to cars slowed, by permitting the free import of buses;
  - construct more and better designed bus pull-over lanes in busy areas. These work well when used. The remaining problem appears to be to persuade bus drivers to use them. This may be more a matter of enforcement than education.
- **Encouragement for public transport.** With growing affluence, the shift to private vehicles is a well established trend. Vehicle drivers are notoriously difficult to shift onto other forms of transport;
- **Promote bicycle usage.** For low and small islands generally, encourage bicycles through low duty, local assembly, etc. The effect of financial measures will be small, given the low price of bicycles compared to cars. Targeting bicycle promotions, including riding instruction, to children may prove more useful in the long term than trying to persuade adults; and
- **Develop a long-term land-use/traffic plan to better accommodate future traffic growth.** This has great theoretical potential, but is a major operation, the difficulties of which have largely defeated attempts by larger counties. A road development plan may be as much as Pacific island countries can realistically achieve.

Despite the extensive portfolio of options, energy efficiency in ground transport has received much less attention than electricity. Many countries around the world have attempted to achieve reductions in transport

fuel use, and all have found this difficult. Vehicle users have proved highly resistant to attempts to reduce their use of vehicles. They have also resisted attempts to reduce vehicle size. It is clear that people place a high value on mobility, regarding this as much more important than environmental benefits, or even appreciable financial benefits to themselves. Pacific islanders do not appear to be different to other people in this respect. As a result transport is a difficult sector in which to achieve greenhouse gas mitigation.

3.2 Overview of supply-side options

Supply-side options are those that have received the most attention in the past. Renewable energy projects have the dual attraction of offering reduced consumption of fossil fuels while at the same time providing increased energy supplies. However, in the context of the present programme it is important to avoid exacerbating energy and greenhouse gas problems by stimulating energy consumption through promoting energy projects (especially electrification) for people who have higher priorities in other areas, such as health and education;

Renewable and efficient technologies are in a range of states of development and need to be provided for PIC conditions. Their current status in the PICs can be classified as:

- **well proven**
  - industrial biomass;
  - household biomass;
  - solar water heating;
  - large hydro;
  - diesel generation efficiency increase; and
  - power distribution efficiency increase.
- **successful with some remaining problems**
  - photovoltaic (PV) for remote areas; and
  - small scale hydro.
- **tried but found not yet ready for widespread use**
  - small scale biomass to electricity;
  - biomass to transport fuel;
  - photovoltaic (PV) for grid supply; and
  - coconut oil as a fuel.
- **developed but little experience in Pacific islands**
  - wind energy;
  - geothermal;
  - urban waste to energy; and
  - nuclear.
- **not yet developed**
  - wave power; and
  - ocean thermal energy conversion (OTEC).

This classification is by no means rigid as developments are underway in a number of technologies that currently are not widely used in the PICs.

3.2.1 Supply-side measures

Industrial biomass is a fully proven technology that has good economics on the medium-to-large scale. It can yield large reductions in greenhouse gases and it is possible to generate electricity efficiently by co-generation. The main application is as an industrial boiler fuel. This raises steam for the industrial processes and often to generate electricity. In the Pacific this is done on both a large scale, e.g. at the sugar mills in Fiji, and on a smaller scale at coconut oil plants in several countries.

Further development of biomass as a boiler fuel is limited only by the need for industrial heat at locations able to provide a supply of fuel. The economics are most favourable when the biomass is produced as a by-product of the industrial process. There are some situations where an excess of biomass is produced over the industry's requirements. This creates an opportunity for additional electricity generation. The major difficulty is often the seasonal nature of the fuel supply. A successful project requires securing an alternative fuel for the remainder of the year.

Household biomass is both traditional and sustainable in the PICs. The key issue is the maintenance of a fuel-wood supply.

Solar water heating is similarly proven and sustainable, with good economics. However, the technology is only relevant to consumers of relatively large volumes of heated water. This restricts their use to commercial establishments and high-income houses. There is a commercial supply industry already established in most countries, and the Pacific Regional Energy Assessment Overview Report recommends against government

intervention. The only reason to make changes would seem to be if there is found to be a disparity in taxation levels between electricity and solar water heaters that is discouraging installations.

Biomass fuels, suitable for use in transport, are still at fairly early stages of exploitation. Bavaria, for example, now sells some 40,000 tonnes per annum of "biodiesel" made from rapeseed oil (Sims 1998). However, all these schemes still require heavy subsidies, and are far from commercial. These, and the cereal-based projects in North America, owe their existence more to agricultural policies that result in embarrassing agricultural surpluses, rather than to energy supply issues. They have little relevance to the Pacific islands.

Hydro is a fully proven technology adopted worldwide. However, technical problems are common on very small schemes. Hydro is already used extensively by Fiji and Samoa, and further hydro development in Fiji, Solomon Islands, Samoa and possibly Vanuatu provides the region's largest potential for greenhouse gas mitigation. Each of these is a substantial investment project in its own right, and needs to be advanced as a specific national project.

Each of these countries also has smaller scale hydro potential. Unfortunately the economics and institutional issues of small-scale hydro frequently make these much less attractive than large schemes. Substantial efforts have been put into identifying potential schemes, and the need is now more in working up particular development proposals. The other PICCAP countries have little or no hydro potential.

Efficiency improvements in power systems in **the efficiency of diesel generation** and **power distribution** both involve fully proven technology and also have good economics. A five per cent average generation efficiency improvement would reduce carbon dioxide emissions by some 30,000 tonnes per annum, while a reduction in distribution losses by five per cent would reduce emissions even more.

Diesel generation has provided the majority of electricity in all PICCAP countries except Fiji, and remains significant even there. In the atoll countries diesel generation accounts for more than half of all fossil fuel use.

The efficiency of this generation varies considerably around the PICs, and is nowhere optimal. Even well-maintained powerhouses leave opportunity to make further gains by means such as fuel centrifuging and waste oil disposal by blending into fuel. These would have other environmental and cost benefits as well as reducing greenhouse gas emissions.

The now completed United Nations Development Programme (UNDP) Power Sector Project provided some assistance with efficiency improvements through the Pacific Power Association. However, much improvement work remains to be done, and most utilities need assistance in carrying it through.

It will be important that any programme developed in this field does not become involved in basic maintenance of large generating sets. This is a subject of continuing concern in some countries, but is more appropriately a national responsibility. The maintenance of smaller scale generating sets is a difficult and widespread problem in most countries. The Power Sector Project provided some maintenance training, but much more could be done.

Up to 25 per cent of the electricity sent out by powerhouses is not recorded as sold to customers. These "system losses" include energy losses in wires and transformers, as well as revenue losses due to unmetred consumers, unread metres, and metres which have been tampered with or are not functioning correctly. Each of these leads to increased fuel burning and greenhouse gas emissions. Energy losses in distribution systems also tend to grow rapidly as electricity demand expands beyond the level for which the systems were designed.

The Lomé III Pacific Regional Energy Programme (PREP) sought to assist with the system loss problem through the provision and initial implementation of software to create Geographical Information System (GIS) representations of each system, and to undertake powerflow analysis. However, this was directed at the ACP countries (Africa, Caribbean and Pacific countries of the Lomé convention) only, and it is not yet clear that those countries are able to sustain the considerable level of elaboration of information and analysis that this software requires. There is a need for assistance in methods for detecting the use of unsold electricity and identifying inadequate sections of line that are available to all Pacific island countries and able to be implemented and sustained by both small and large utilities.

Photovoltaic (PV) for remote areas has been successfully implemented from a technical viewpoint.

The equipment problems that have been experienced in some cases have been resolved and adequate training can be made available to enable local technicians to cope with ongoing maintenance. It is now fully apparent that regular maintenance is needed. Enthusiasts promoting PV did much damage years ago in claiming that PV was maintenance free. PV systems will normally replace kerosene and white spirit lamps consuming only minimal quantities of fuel. Hence the potential for rural PV systems to reduce CO_2 emissions is quite small. Photovoltaic for remote areas is attractive mainly as life improvement, rather than for greenhouse gas mitigation.

This does not reduce its significance to rural people, and the demand for PV lighting continues to be strong. However, experiences to date in meeting this demand have not been sustainable. A number of problems remain, in particular:

- finding donors willing to meet high capital costs;
- finding a financial mechanism strong enough to cope with massive peaks in maintenance costs when major parts need replacing. If the initial stock of PV systems is donated, outgoings are low for several years. The batteries are the first major replacement item, after some six to eight years, followed by the panels after some 15 to 20 years. A very large fund needs to be accumulated if these costs are to be met; and
- disposing of dead batteries without poisoning the environment with many tonnes of lead.

The PREA summary report considered that PV "may provide a technically and financially viable option for electrification in rural areas and remote islands". The report concluded that PV was an exception to the failure of new technological options to develop into viable alternatives to conventional energy sources. This assessment is not fully supported by all the country assessments. For example, the Solomon Islands report recommended that "the Energy Division should discourage aid programs for PV systems unless there is a coherent and practical strategy for their long-term maintenance." The solution to the institutional requirements was considered to be the provision of PV electricity as a utility service on the model of the Tuvalu Solar Energy Cooperative Society (TSECS). Unfortunately, this belief in the success of TSECS has proved ill-founded. As a FSED review has since shown, TSECS has not been able to fulfil its role in sustaining its PV systems. A more successful model to date is that in Kiribati, where the SEC confirms the appropriateness of the utility model, but through a government-owned company rather than a cooperative.

Some technical difficulties have been apparent on the trials on **small-scale biomass to electricity**. A range of technologies, notably biogas and gasifiers, has been promoted in the past as means to supply fuel to engines for small-scale electricity generation. Unfortunately, all gasifiers have proved excessively difficult to maintain in Pacific island conditions, while biogas plants have proved viable only where the primary objective is pig or chicken waste treatment, not energy supply.

Further technology development is required. Implementation may be constrained in some situations by the requirement for a significant sustainable source of biomass.

Trials on the use of **photovoltaic for grid supply** have shown technical difficulties in addition to the high cost barrier. Experience with community PV systems suggests that there are severe institutional issues and that the scale of such systems is restricted by high distribution losses.

To date a number of these have been installed commercially in the USA and Australia. These have mostly been as part of "green energy" schemes in which consumers agree to pay a higher tariff in exchange for an assurance that at least part (often only a small part) of their supply is matched by supply from renewable sources.

The economics of such systems in the Pacific have not yet been determined. By comparison with isolated systems, substantial cost items—the battery and its controller—may be no longer required, and the full output of the PV panels can be used. However, an additional item is needed—the inverter—and the PV energy now competes directly against the price of diesel fuel. There may be little or no savings in diesel generator capital since this is required to be available when the sun does not shine.

Two interesting trials are now in progress in Fiji. One is a 10 kW grid connected PV installation, the other a hybrid wind/solar/diesel supply system to an isolated government centre. At this stage both must be regarded as technical experiments. Neither have any prospect of being viably replicated without heavy donor funding.

To date the results of the grid-connected PV trial have been disappointing. Output is well below expectation, and an investigation is needed to determine the source of this problem before final conclusions can be drawn about this technology. However, even if the source can be determined and corrected, the economics of replicating this project appear limiting. The equipment and installation cost was some US$62,500. This implies a cost of electricity in excess of US31c/kWh. Actual costs will be able to be calculated only once the trial is complete. This implies that this technology has a place only in locations where diesel fuel is very expensive, but there is a daytime load of 10 kW or more.

The hybrid system is more innovative than the grid-connected one, and no results from the trial are available as yet. Hence its technical viability, and appropriate possible roles, cannot yet be determined.

The use of **coconut oil as a fuel** has potential mainly in remote areas. There have been some attempts to use coconut oil as a substitute for diesel fuel. This has proved feasible, but has not been developed. The principal limitations are that coconut oil:

- does not have the lubricating properties of diesel fuel, requiring some modifications to the engine;
- sets solid at around 28 to 30^{o}C, so that it will not flow through fuel lines; and
- is a saleable product whose value is often greater than the diesel fuel it could replace.

The first of these can be overcome at no great cost; the second is less of a problem near the equator; while the third is not true in remote locations where transport costs increase the cost of diesel fuel and reduce the returns from selling coconut oil. The barrier in such locations is the lack of an efficient oil production technology suited to producing small quantities in remote locations. Such a technology is as yet only in the experimental stage.

Wind power is fully proven and has already been installed in substantial amounts in Europe, the USA, and Latin America. There are theoretical indications that conditions in some PICs are favourable but the wind regime in the Pacific has not been extensively studied as an energy source. Most wind information relates more to weather forecasting.

The information that is available suggests that generation costs in the PICs may prove to be higher than elsewhere as average wind speeds are modest and variable in most locations, and plant must be engineered to deal with cyclones. Given the high cost of diesel generation, there may well be opportunities for economical wind power even at higher costs and lower equipment outputs than feasible in windier countries. In general, locations further from the equator have higher wind speeds and are more attractive. A study by Danish consultants (Forum for Energy and Development 1998) has provided some provided some information on the potential for and economics of wind development.

A prime limiting factor on the application of wind power is the rapid fluctuations in output to be expected from wind turbines. This constrains the installed wind power capacity to a modest proportion of the load available at all times. Present indications are that this proportion may be as low as 20 per cent, unless either battery storage is incorporated, or several small wind machines are used. Unfortunately both of these measures considerably increase costs.

Wind power has been used for water pumping in some countries. This application has the advantage that fluctuations in output are much less important, since water can be stored. Unfortunately, none of these systems have had long lives. A prime reason is that the equipment was designed for inland Australian conditions, and proved unable to withstand the combination of corrosive conditions and cyclones found in the PICs.

Successful wind augmentations of small-scale diesel systems have been reported, e.g. in the French Antilles. However, this was in a location with much higher wind speeds than available anywhere in the Pacific islands. The potential of wind power in the Pacific remains unknown. Resource information is now required to properly assess the opportunities and technology trials are needed to develop practical working experience.

Geothermal energy has been successfully developed in several countries around the world, and has established itself as a cost-competitive source of heat and electricity. Most geothermal resources produce hot water with high levels of corrosive salts and gases. This, and the difficulties inherent in managing a resource that may be buried two kilometres underground, make

geothermal a demanding technology requiring a wide range of expertise and experience.

The gases produced in the process of exploiting geothermal energy include carbon dioxide. Hence geothermal energy is also a source of greenhouse gases. The amounts produced, per unit of electricity generated, vary widely from field to field. Gassy fields may produce more greenhouse gases than fossil-fuelled generation, but others produce only small amounts of gas.

Geothermal energy is available only in the larger volcanic islands, and then only in rather specialised situations. Surface evidence of a geothermal reservoir has been found in several locations in PICCAP countries, particularly in Fiji and Vanuatu. There is no possibility of geothermal energy in the coral islands, and only a remote possibility in a smaller volcanic island.

A geothermal resource can be proved to exist only by drilling bores into the potential reservoir. This costs several million dollars for a single deep bore. Largely as a result, no bores have been drilled in the PICCAP countries. The existence of a geothermal reservoir in a PICCAP country is therefore still speculative.

These very high costs, and the high demands on technical capabilities, set a minimum scale for geothermal development that is large in comparison with the energy needs of PICs.

Urban waste to energy is proven in larger countries but applicable only in larger urban areas. Further drawbacks for use in the PICs are the air and water pollution risks and the substantial costs.

Nuclear energy is available only on large scale, and at very high cost. It involves very sophisticated technologies and has unsolved waste disposal problems. All these factors preclude it from consideration.

Wave energy is an attractive concept since waves are consistently delivering energy to the shores of every Pacific country. There was a burst of activity in developing technologies for extracting energy from waves in the early 1980s, especially in the UK and Norway. However, a review of the results of work in the UK concluded that all the proposed technologies were uneconomic and further work was cancelled. A wave-power plant was built in Norway. This operated successfully for some months but was then destroyed by a storm.

Since then, wave power has been studied only on a small scale, and no plants have been built. These studies have attempted to find solutions to the problem of high costs, and may have had some success. A report in *New Scientist*, 16 May 1998, claims electricity for under US9.9c/kWh from three systems. The cheapest is the "nodding duck" system with claimed costs of US4.3c/kWh. Energetech Australia Pty Ltd has developed a novel scheme reported in *Australian Energy_News*, March 1998, and *New Scientist*, 1 November 1997. An eventual cost is claimed for this of US 4.7c/kWh.

Note in considering these results that none of these proposals have ever been built. There have not even been any detailed designs. They are paper ideas only. It will be many years at least before wave energy technology reaches a stage of development at which it will be appropriate to build a plant in a Pacific island country. In view of the interest in wave energy, a useful task for a regional organisation could be to keep countries informed on the current state of wave energy technology.

Ocean thermal energy conversion (OTEC) is the concept of obtaining electricity by exploiting the difference in temperature between the warm surface water and cold deep water in tropical oceans. In the late 1970s Japan built a pilot OTEC plant on Nauru with an output of some 100 kW. Unfortunately almost the whole of this output was required to run the plant, and it needed the support of a diesel generator. A storm destroyed the plant.

Since that project, only paper studies have been carried out on OTEC, and no further plants constructed. These studies have suggested that there is a minimum scale of plant for OTEC to be effective. This scale may be in the order of hundreds of megawatts, putting it far beyond the requirements of any Pacific island country. As with wave power, a useful task for a regional organisation could be to keep countries informed on the current state of OTEC technology.

Increasing the **efficiency of fuel supply** is primarily a matter of reducing fuel losses between the original point of supply and the point of delivery to the user. These losses are through spillage and evaporation. The primary results are air, water and ground pollution, rather than greenhouse gas emissions. However, much of this

material is eventually oxidised in the atmosphere, producing carbon dioxide.

The fossil fuels used in PICCAP countries are overwhelmingly petroleum products. The differences in greenhouse gas emissions from using **alternative petroleum products** are marginal, but generally the lighter the product, the lower the greenhouse gas emissions. Hence liquid petroleum gas (LPG) produces the least greenhouse gases, and black oil the most. In practice, differences in efficiency of use are more important than the chemical content of the fuel. Greenhouse gas emissions will be reduced if heating tasks such as cooking are done with LPG, rather than electricity. This is more favourable on both counts.

Only very small amounts of coal are presently used in PICCAP countries, and then only for specialised purposes such as cement manufacture. Coal produces considerably greater emissions of greenhouse gases than petroleum, and is less convenient, but cheaper. When oil prices rise from the low level they are at now (as they certainly will), the price advantage of coal will increase.

With the increasing scale of generation in the larger centres, coal-fired electricity generation is becoming a possibility. If such schemes proceed, the high carbon content of the fuel, plus the modest efficiency of coal-fired generation, will cause greenhouse gas emissions to increase substantially. Looked at purely from the point of view of greenhouse gas mitigation, this would be a backward step.

The same situation applies in the larger countries of the world, and they are, at least as yet, showing little inclination to slow down the use of coal for electricity generation. This is particularly so for China, which now accounts for 75 per cent of the world growth in coal consumption. Hence there would seem to be little justification for a PICCAP country to choose a more expensive option in preference to using a fuel such as coal. Nevertheless some reaction would need to be anticipated in terms of questioning the country's commitment to greenhouse gas mitigation.

3.2.2 Assessment of alternative non-fossil sources of electricity in participating countries

The potential for renewable energy supplies varies between the PICCAP countries, although all have some potential, as indicated in Table 13. The assessment clearly identifies the high significance of solar as a potential source, and the high importance of some of the others in particular countries. The notation used in the table is:

√ √ √ excellent resource

√ √ good resource

√ some resource

?? definite potential but extent unknown

~ unlikely to be an exploitable resource.

Note that the opportunities and costs for wind and wave energy are very site specific.

Considerable advances have been made in many of the renewable technologies over the past decade and both their economics and their reliability have improved. Table 14 below provides a broad indication of what has happened to the costs of selected renewable technologies in recent years and what are evident trends for the future.

These cost estimates are indicative only and should not be taken to be what might be achieved in the PICs. However, they do provide a broad estimate of the approximate relative costs.

3.3 Greenhouse gas sinks

3.3.1 Forestry

Forestry has the potential to provide greenhouse gas mitigation in two ways:

- as a source of non-fossil fuel, notably for cooking, and as an industrial fuel; and
- by acting as a "sink" for carbon dioxide. This occurs only when the standing biomass in the forest is increasing. Carbon dioxide is then being absorbed out of the atmosphere and the carbon becomes incorporated as part of the wood. A stable forest does not have this effect, as in such a forest equal amounts of carbon dioxide are being emitted and absorbed.

Firewood is the prime traditional energy source, and is still the dominant cooking and water-heating fuel in rural areas. At least from a mitigation point of view, changes away from this should be discouraged. This implies that

rural people should be encouraged to maintain adequate supplies of firewood by:

- not subsidising fossil fuel substitutes for firewood;
- discouraging the use of electricity and fossil fuels for cooking and water heating; and
- providing access to planting stock for fuel-wood trees and shrubs.

Historically, the destruction of forests throughout the world has been a major contributor to the build-up of greenhouse gases. The re-establishment of forests could be equally important as a mitigation measure.

There has been a great deal of discussion and argument about the potential for countries to include net absorption of carbon dioxide by forests as a credit in greenhouse gas inventories. Although scientifically speaking this would be justifiable, it has many practical problems. No agreement has been reached and none seems likely for several years, at least. The matter is important since the Kyoto treaty allows for the Annex I countries with greenhouse gas emissions reduction obligations to meet these, at least in part, by purchasing

Table 13: Renewable Energy Resource Potentials of PICs (Forum Secretariat Energy Division, 1994)

Country	Solar	Wind	Bio-mass	Hydro	Geo-thermal	OTEC	Wave
Cook Islands	✔ ✔ ✔	✔ ✔	✔ ✔			✔ ✔	✔
Federated States of Micronesia	✔ ✔	✔	✔ ✔	✔ ✔	✔ ✔	??	??
Fiji	✔ ✔	✔ ✔	✔ ✔ ✔	✔ ✔ ✔	✔ ✔ ✔	✔ ✔	✔ ✔
Kiribati	✔ ✔ ✔	~	✔			✔ ✔	??
Marshall Islands	✔ ✔ ✔	✔	✔			✔ ✔	??
Nauru	✔ ✔ ✔	~	✔			✔ ✔	??
Niue	✔ ✔ ✔	✔ ✔	✔			??	??
Palau	✔ ✔ ✔	✔	✔ ✔			??	??
Papua New Guinea	✔ ✔	✔ ✔	✔ ✔ ✔	✔ ✔ ✔	✔ ✔ ✔	??	??
Samoa	✔ ✔	✔ ✔	✔ ✔	✔ ✔	✔ ✔	??	??
Solomon Islands	✔ ✔	✔ ✔	✔ ✔ ✔	✔ ✔ ✔	✔ ✔ ✔	??	??
Tonga	✔ ✔ ✔	✔ ✔	✔			??	✔ ✔
Tuvalu	✔ ✔	~	✔			??	??
Vanuatu	✔ ✔	✔ ✔	✔ ✔ ✔	✔ ✔ ✔	✔ ✔ ✔	??	??

Table 14: Estimated Costs of Selected Renewable Technologies in USc/kWh

Technology	1980	1990	2000
Wind	30–40	5–15	4–15
Wave	40–80	20–40	10–20
Hydro	5–20	5–20	5–20
Biomass	5–15	5–15	5–15
Diesel	10–100	10–100	12–100

Source: Based on statistics supplied in "Renewable Energy" by J. Jackson, *Energy Policy*, September 1992

emission credits from others who have met their goals. This has the potential to provide countries with substantial funds in exchange for undertaking qualifying afforestation projects, and possibly forest protection schemes.

At least as yet, the PICs cannot participate in such trading, as they have no quantitative mitigation obligations. However, there has been some exploration of the concept of offset agreements with pilot projects being promoted under the facility of Actions Implemented Jointly (AIJ). This whole area is intensely political. It has been referred to the Conference of the Parties (COP) of the United Nations Framework Convention on Climate Change (UNFCCC) for consideration. Final decisions will be made through the Conferences of the Parties.

A particular problem is that forests that are being harvested, cleared for agriculture or damaged by fire are net emitters of greenhouse gases, but countries with such forests naturally do not wish this emission to be included in their inventories. There is support in some quarters for including only plantation forests. However, others object to this on the grounds that this would create a benefit for those countries that have destroyed their natural forests, over those that have taken the trouble to preserve them. Continued argument seems the only likely prospect. Also unresolved is the possibility of including the preservation of existing forests by providing a binding and permanent assurance of full protection.

In the PICCAP countries significant forestry potential is restricted to the volcanic islands. Atoll countries do not have sufficient space and soil to offer carbon sinks through increases in their forest areas. The most that can be achieved in their circumstances is to maintain their existing vegetation and supplies of fuel wood for cooking.

The large islands, notably Viti Levu and Guadalcanal, have large areas of grassland capable of being reafforested. Many other islands have significant potential, at least in theory. There are serious barriers to large-scale reafforestation projects. The most familiar, and possibly the most intractable, is land tenure. Few countries have found answers to the problem of either assembling large areas, or obtaining the effective involvement of large numbers of small holders, for reafforestation projects.

Also unresolved is the problem of designing such a project in a form that can be marketed as an offset to other countries' greenhouse gas emissions. This cannot be addressed until international agreement is reached on the treatment of forestry as a greenhouse gas sink. A serious difficulty is the need to develop and demonstrate cultural, institutional and legal mechanisms by which a project can provide credible guarantees of providing greenhouse gas sink performance after payment has been received. A further matter is the wish, clearly expressed by countries at the Regional Mitigation Analysis Meeting, that other countries should not be enabled to use forestry projects in PICs to avoid their mitigation obligations.

There are a large number of donor-supported programmes on forestry in the Pacific, including notably the UNDP and AusAID-funded Pacific Islands Forests and Trees Support Programme (PIF&TSP). These are so numerous that lack of coordination is a real problem. Hence it will be important to ensure that any new initiative does not generate more problems.

This does not mean that additional resources would not be worthwhile. The PIF&TSP ends in December 1999, and activities will scale down unless further funding is found for work of this nature. Not all the work undertaken under the PIF&TSP would qualify as relevant to greenhouse gas mitigation. However, a number of its components could be expected to qualify. These could include:

- development and proving of sustainable forest management and harvesting practices; and
- exploration of potential institutional arrangements for credible carbon offset projects.

Note that there are conflicts between the use of land to provide carbon sinks, and other social and economic development objectives, and the preservation of the rights of landowners to manage their land as they see fit.

3.3.2 Coral

An increased concentration of carbon dioxide (CO_2) in the atmosphere results in an increased rate of CO_2 becoming dissolved in rainwater and into the surface water of the oceans. When dissolved in water CO_2 forms carbonic acid. Limestone rock comprises largely calcium carbonate, which reacts with the carbonic acid

to form calcium bicarbonate, which dissolves in water. This produces the well-known effect of dissolving limestone to form caves in limestone rocks. The overall effect of this process is that limestone acts as a sink for CO_2, but is dissolved in the process.

This process can also occur in the oceans. Of concern to PICs is that by far the largest supply of limestone in contact with surface marine waters in the tropical regions is coral. The implication is that coral has the potential to act as a very large greenhouse gas sink, but that the coral reefs will be corroded and damaged in the process. Fortunately, buffering actions play an important role in reducing the effect of carbon dioxide in changing the chemistry of the oceans.

Changes in the volume of coral reefs appear to have been major influences on atmospheric CO_2 in the past. Opdyke and Walker (1992) have concluded that differences in the rate of coral reef growth may account for the whole of the Quaternary (i.e. over the last million or so years) variations in atmospheric CO_2. Their results show a close match with the increase from 200 ppm to 280 ppm CO_2 from the end of the last glaciation to the end of the 19th century.

Reef growth, and hence deposition of carbonates onto reefs, results in CO_2 being released to ocean water. A number of estimates have been made of the rate of CO_2 release from growing reefs. Ware et al (1991) concluded that this amounted to 0.4 to 1.4 per cent of anthropogenic production from fossil fuels. However, this considers only the effect of biological activity. In a rare direct measurement of the overall CO_2 flux of a reef in Moorea, Gattuso et al. (1993) found that this reef was a net source of CO_2 to the atmosphere. However, the magnitude of the CO_2 flux was much lower than theoretical prediction based on rates of biological calcification. Some other process was apparently offsetting the release of CO_2 by carbonate production.

More recent work by Gattuso (1998) has demonstrated that rising CO_2 concentrations will reduce coral growth. The magnitude of the effect is unclear, but it implies that coral reefs have a reduced capacity to build themselves. This could be particularly important if ocean levels increase due to thermal expansion and/or ice melting.

The severity and rate of any chemical corrosion of coral has not been investigated in detail. Most research has been on the biological process of reef formation. The volumes of CO_2 being emitted and sequestered by reef growth and corrosion probably far exceed those being emitted by PICs from the burning of fossil fuels. The balance can also be expected to change as the atmospheric concentration of CO_2 continues to increase.

The process of reef growth and corrosion is unlikely to occur as a simple process on the outside of the reef. Biological growth will be concentrated there, but chemical reactions need not. Reefs are highly porous and reactions will occur most rapidly wherever coral surface is in contact with rapidly moving and turbulent water. This will include the interstices of the coral, which could be progressively opened up, weakening the coral structure. The weakened sections of coral could then be broken up by heavy wave action such as during cyclones. Much of the resulting rubble is likely to be thrown up onto the shores of atolls. Hence the atoll may temporarily benefit, but at the expense of its fringing reef on which it depends for continued protection.

4. PICCAP country experience

4.1 Regional investigations

Various studies that relate to greenhouse gas mitigation have been undertaken in the PICCAP countries. Initial studies of the potential for **demand-side management** were carried out through the Pacific Power Association for ten countries under the UNDP programme (SRC International Pty Ltd 1995). These concluded that significant benefits could be obtained from a range of programmes aimed at improving information and maintenance, mainly in relation to lighting, refrigeration and air-conditioning.

The studies were completed in early 1995 (SPC–SOPAC 1998). However, very little action has been taken. Since substantial benefits were identified, this suggests that the project was in some way misconstrued. A likely reason is that the benefits from the suggested programmes are expected to accrue entirely to end consumers. However, the targets for the studies were the electricity utilities, which were expected to be net losers from the programmes. If further progress is to be made, the focus of activity will need to be placed elsewhere.

A study specifically on the potential for **appliance labelling and MEPS** has been done (Wilkenfeld and Associates and Energy Efficient Strategies 1996), under the Forum Secretariat. This concluded that both schemes appeared feasible. The only practicable option was considered to be to use the Australian labelling programme.

The PREA summary report, considered that **PV** "may provide a technically and financially viable option for electrification in rural areas and remote islands", and also that "While the performance of these systems has varied, recent experience indicated that PV systems for remote island communities, although initially expensive, can be competitive at current costs with small diesel-based electric power systems". The report concluded that PV was an exception to the failure of new technological options to develop into viable alternatives to conventional energy sources.

The Forum Secretariat has also carried out a supply-side management study under the Lomé programme in three countries—Kiribati, Solomon Islands, and Tonga. However, all countries were invited to learn from the project and even the Cook Islands was able to attend the meetings regularly and gained from the project although it is not an ACP country. One section of the project involved an evaluation of system losses with a detailed report on each system, the provision of guidelines, how to address each loss and the supply of software to enable load flows to be calculated as a basis for future loss identification. In another, manufacturers' representatives provided tutors at workshops regarding generating equipment and its maintenance.

One proposal that came out of the study was the potential use of waste lubricating oil, both to reduce fuel consumption and to avoid the pollution caused either by dumping or burning it as a waste product. The oil can be blended into diesel fuel and hence used as fuel by power stations with heavy engines. The project discovered that there were very considerable differences in efficiency between stations and that these efficiencies could be identified and improved only if additional information was being collected. Fuel use should be monitored at least daily and compared against generation. It is essential that the system operators take full responsibility themselves for maintenance and replacement of their equipment, and not wait for aid projects and aid assistance for this. They also need to undertake long-term planning for their human resource training and development.

4.2 Cook Islands

There have been a number of initiatives on the **demand side** in the Cook Islands. The Forum Secretariat funded a compact fluorescent lamp (**CFL) replacement lighting programme** on the outer islands. Initially this programme appeared successful. However, the lamps proved to have a short life and within one year almost all had failed. The primary reason for this would appear to be that the technology of the lamps was unable to cope with the variable quality of electricity available in the outer islands.

There is no existing **appliance-labelling scheme** in the Cook Islands but one is considered to be desirable.

The government has used **financial measures** to influence the importation of second-hand vehicles that

are arriving in large numbers. A **duty schedule**, imposed on commercial importers, has been established which increases with the age of the car. Returning residents get a duty-free concession on their own vehicles. There is also some variation in customs duties on new vehicles with cars under 1000 cc being levied at 20 per cent, whereas larger vehicles are at 30 per cent. Similarly, vans are levied at 10 per cent below 1500 cc, but 30 per cent if above this capacity. There is also a sliding schedule of duties on motorcycles ranging from 10 per cent on cycles below 50 cc to 150 per cent for those over 800 cc. Most electrical appliances are subject to a 10 per cent customs duty.

The options are modest at present for **diesel generation efficiency and power distribution improvements** on Rarotonga, as the powerhouse on Rarotonga was re-equipped with French machines around 1992. These machines have good efficiency but have not been so reliable and there have been serious problems with unscheduled maintenance and repairs. The main powerhouse has quite good ancillary equipment and has a fuel centrifuge, although there is no operating oil centrifuge. The majority of the reticulation on Rarotonga was also replaced with aerial bundled conductors at the same time as the new equipment was installed in the powerhouse. This has resulted in system losses being reduced to only 6 per cent. However, there are some problems developing with this reticulation due to rapid corrosion in pole boxes. Outside Rarotonga, electricity generation in the Southern Group has been improved in recent years through development assistance from New Zealand and Australia. However, reticulation systems are in poor condition on Aitutaki. Operational and financial responsibility for the power supply on each island is in the process of being transferred to the Island Councils. The details of the transfer process, and the extent of the Island Councils' autonomy, have yet to be finalised.

On the **supply side**, there is a **PV scheme** on the Northern Group island of Pukapuka (population 780). This scheme was funded through a French loan, payments on which are being met by the Cook Islands Government. The sets were substantially gifted to the individual house owners who are responsible for subsequent maintenance and replacements. This scheme was installed in late 1991 and ordinarily the batteries would be requiring replacement about this time. However, the batteries in Pukapuka are exceptionally large and have been under-utilised by the equipment provided. The scheme would appear to have anticipated the installation of additional appliances such as refrigerators, but the cost of these has dissuaded the owners from purchasing them. As a result, the equipment has been very lightly used. This is likely to mean that battery life will be longer than would ordinarily be achieved. There has been a hybrid PV/diesel scheme on Penrhyn since 1994. However, no results of monitoring this scheme are available.

Danish consultants investigated the **wind potential** on Rarotonga and promoted a development scheme for a substantial wind turbine. However, this project required substantial funding for local costs by the Cook Islands Government. This funding has not been approved and the project has not proceeded. The project appeared to have quite favourable economics. However, these depend crucially on assumptions about the performance of both the wind turbine and of the diesel system into which the wind energy would be injected, and there is considerable uncertainty about these matters. Consequently the project must be regarded as a high risk one from the Cook Islands' point of view.

There have been **wave height measurements** undertaken off shore from Rarotonga for a period of some five years using a wave rider buoy.

A number of areas have been reafforested. Most of the early reafforestation was to combat soil erosion, particularly on Rarotonga. Afforestation also proceeded on Atiu and Mangaia following the end of the pineapple industry. Some of these trees are now sufficiently mature that harvesting is being considered.

On Rarotonga the ownership of these trees has been handed over to the landowners. There are no plantations on government land; indeed the only mechanisms available to the government to encourage forestation are education and the supply of seedlings. There is a German-funded four-year programme establishing nurseries for this purpose, under the Pacific German Regional Forestry Project. The sum of US$400,000 has been allocated to the Cook Islands. The Cook Islands is also looking to the Food and Agriculture Organization (FAO) for assistance with forestry for shoreline protection.

The **greenhouse gas inventory for 1994** is still proceeding, with some exclusions in the Cook Islands. Calculations are not being attempted for some minor gases such as nitric oxide.

4.3 Fiji

The mitigation of greenhouse gases in Fiji is to be framed within legislation to control environmental emissions including ozone-depleting substances and potentially greenhouse gases. The Department of Environment is currently progressing a revised Bill through the legislative system following Asian Development Bank-funded assistance to develop an initial draft. The Environment Bill has been written by consultants with a strong eye to New Zealand's Resource Management Act (RMA), including its theme of sustainable development. The Bill provides for unleaded fuel to be mandatory by December 2000. In practice however, the use of leaded fuel has virtually ceased already as the oil companies are no longer bringing leaded fuel to the Pacific islands.

Fiji has also moved to secure a funding base for projects. The Global Environment Facility (GEF) has established a facility for medium-sized projects. These are projects under US$750,000. These require only a one-page proposal and an assurance has been given of a 15-day turn around in New York for approval or rejection. To date there has been a high emphasis on PV in the projects promoted under this facility.

On the **demand side**, the Department of Energy recognises the potential for demand-side management (DSM), particularly in relation to household uses. It has made progress toward a pilot and voluntary **labelling scheme** for refrigerators and freezers, funded by SOPAC. Importers have agreed to put rating labels on appliances coming into three chains of shops. However, this is on hold at present. One issue delaying the start is the projected revision of the Australian labelling system, which is expected to be implemented around the middle of 1999.

The possibility of applying **minimum energy performance standards** (MEPS) has been considered but little action has been taken on this to date. A significant problem in both labelling and MEPS is obtaining the data from all the manufacturers regarding all their different models so that this information can be used in booklets and publicity. There are no existing labels on refrigerators and freezers coming from any country other than Australia and New Zealand.

The Department of Energy commissioned a number of **energy-auditing** studies, mostly in government buildings, especially hospitals. These examined steam supply and use, lighting and heating and also the scheduling of air-conditioners. The audits revealed seriously deficient services as well as wasteful or inefficient energy use. In some cases, correcting the deficiencies in the levels of services resulted in increased energy consumption that offset the reductions gained by removing the waste. In these cases the end result was a major improvement in service quality being achieved without a substantial change in energy use. There were also some audits about five years ago on private industries. Subsequent implementation of the recommendations has been patchy—only a few have been implemented.

Fiscal measures play an important role in transportation. **Differential tax rates** are used to encourage the efficient use of fuel. Rates for passenger vehicles start at US$44 per annum for vehicles below 1000 cc and ramp up to US$330 per annum for vehicles in excess of 6000 cc**. Import duties** have also been adjusted to favour fuel-efficient vehicles. Duties rise from 40 to 50 per cent on cars of up to 1600 cc to 250 per cent duty on cars in excess of 3000 cc. The present **tax on petrol** is now close to 100 per cent.

The Department of Energy has also undertaken education projects in relation to transport. A survey of the bus industry about ten years ago established the need for improvements in maintenance. However, no known maintenance programmes were instituted as a result.

The Department of Transport has smoke measurement equipment capable of measuring the opacity of exhaust gases, but does not make extensive use of it. At present Fiji's legislation does not allow vehicles to be failed or otherwise removed from the road for excess smoke production and the Department is able to provide advice only. A Land Transport Authority is to be set up under a Bill that has already passed through parliament and awaits only the presidential assent. Under this Bill the required frequency of inspection for passenger vehicles will be reduced from annually to six monthly.

Road policies do not as yet incorporate energy saving as an objective. However, there have been some proposals to reduce road traffic, in particular, a proposal for a train line from Suva to Nausori.

The main diesel stations on Viti Levu are now being used more as a result of the saturation of the capacity of the Monasavu hydro scheme. Powergen now has a programme to **increase diesel generation efficiency** by reinstating the diesel generation units at each end of

the main transmission line to their full nameplate capacity, and then attempting to improving their efficiency. This programme is to be completed this year. A number of small and low-efficiency plants at Deuba, Nadi and Singatoka (which are really relics of the days before the construction of the main cross-island transmission line) are to be closed. It is recognised that there is a need for efficiency improvements in all the smaller stations. Powergen provided estimates of fuel consumption for their sets that range from 0.23 tonnes/ MWh for a main station set in good condition, up to 0.28 tonnes in the worst case. However, on smaller sets and isolated systems 0.35 tonnes would be a typical average consumption for an isolated station with a low plant factor.

In terms of **power distribution system efficiency** there is a lot that could be done to reduce losses. However, a prerequisite for this is a load flow study to identify overloaded areas, particularly on the 11 kV and 400-volt systems. So far only some preparatory work has been done, and some software supplied through the Forum Energy Division under the European Union–funded Lomé III project. The Fiji Electricity Authority (FEA), since splitting into three companies, developed an overall power development programme covering generation, distribution and retail and also load forecasting. This had a formal external review some ten years ago by Sinclair Knight but there has been no external review of power planning since then.

On the **supply side**, the Department of Energy is placing the emphasis on the development of renewable energy, particularly to replace fossil fuels, and also on conservation. In particular, they are encouraging the development of fast-growing fuel woods. With UNDP the department is looking at forestry developments with the possibility of GEF funding. They are also looking to GEF for funding to extend and replicate the Nabawalu hybrid power scheme.

The **biomass** fuel steam system built by Adrian Tarte years ago at his plantation in south-western Taveuni is still operating after at least 20 years, and has been replicated in a village in Taveuni. However, the village scheme has had practical and operating problems.

With the deregulation of electricity supply in Fiji there are now a number of independent power producer (IPP) proposals on Viti Levu using wood residues. These would come from forest pine and the existing chip mill plus other sawmill wastes to produce some 15 to 30 MW. There are also other possibilities for generation on Vanua Levu from a number of sawmills in the Savusavu area. These produce enough waste to generate in the order of 10 MW, well in excess of total demand. However, this would only be for the life of the exploitation of the natural forest in that region. A consortium including Transfuels has been formed to promote an IPP project. This includes the development of a 15MW capacity plant burning biomass fuel including eucalyptus grown on a three-year cycle. The economics of this project are somewhat questionable and fuel is estimated to cost some US$500 per tonne. The commercial potential of these schemes will be revealed late in 1999 as the Fiji government is looking to purchase power from an IPP.

The Department of Energy has also looked at production of briquette fuels from waste from the Tropic Woods factory but at the moment the IPP project is potentially a better prospect for using this material.

Fiji produces around four million tonnes per annum of **bagasse** of which only one million is burnt for energy. The remainder is dumped and is a large potential source of energy. The main obstruction to its increased use is that the production is concentrated in the crushing season of only five months. Electricity generation could be expanded if means could be found to spread generation around the year by storing bagasse. This will also require some additional fuel to be used during the season while the sugar mills are not operating.

Hydro plays an important role in power supply in Fiji, particularly on Viti Levu. Currently producing 71.5 MW, output from the Monasavu Hydro Scheme will be increased to 77 MW by 1999 and can be further extended to the full design capacity of 80 MW. This is no longer sufficient to meet the island's full requirements.

There are possibilities to develop additional hydro capacity on Viti Levu to help meet the growth in electricity consumption of around three per cent per year. Water from the Vaturu water supply scheme behind Nadi has the potential to develop 12 MW and 56 GWh per year in about three years' time. Another possibility is on the Ba River, which could be diverted at Korolevu into the Singatoka River to generate some 60 MW. A scheme is also possible on the Navua River. The latter scheme has often been linked to a potential mining development.

The hydro potential on Vanua Levu is much more restricted. There is already an 800 kW run-of-river scheme and a potential for a joint water and power scheme for Labasa. But there are few other potential developments of any magnitude. When sufficient load has been developed, Powergen may supply Vanua Levu by underwater cable across from Viti Levu.

Fiji has a rural electrification subsidy policy under which the government provides 90 per cent of the capital cost of establishing an electrification scheme in a village. This arrangement provides a large incentive to install capital intensive systems such as **photovoltaics** rather than diesel schemes. However, the rate at which schemes can be constructed is still constrained by the funds allocated by the Fiji government in each year's budget. In a number of villages, PV systems have been installed, but these are restricted to providing lighting only in village halls, not to households.

A few villages have more comprehensive PV schemes but the penetration across Fiji as a whole at present is still very low. The existing small schemes have been undertaken primarily as technology trials. Commercial sustainability has not been expected and staff of the Department of Energy have provided maintenance without cost recovery. The results have been positive, but such an arrangement could not, of course, be applied to a larger scale implementation of PV. A privately funded and operated scheme in the late 1980s was based on the use of plastic keys which the user purchased and broke in a specially designed lock to obtain lighting for a specific period. This scheme failed from a combination of consumer dissatisfaction and institutional reasons.

More recent schemes usually involve some external finance. France is currently funding a 170-house scheme in the Lau Group. Under this project, after three years the householders must pay for all replacements. This has the unfortunate consequence of encouraging the community to move over at that stage to a hybrid system including diesel generation. This process has already been observed near Nausori. The problem is dissatisfaction with the limitations of the PV supply. Since these schemes provide lighting only, some households install their own diesel systems in order to run refrigerators in addition to the PV lighting schemes, or connect to a government or community diesel-powered supply. It is anticipated that in cases where diesel-based power is available, when the PV systems require a replacement for a high-priced component the PV system may be abandoned.

Photovoltaic energy has also been considered as a potential source of power to the grid and the FEA has monitored a pilot project at Lautoka over the last year. However, the costs at the moment preclude its widespread use. In addition, the grid supply project is supplying considerably less power than expected. During a site visit the nominal 10 kW scheme was producing only 7 kW at a time when peak output could be expected. The reasons for this shortfall are not clear, but from the available instrumentation there appears to be a shortfall in the output from the panels. Further investigation is needed to establish the cause.

An experimental **hybrid power supply** has been installed at the Government Centre in Nabawalu. This has been designed and installed by the Pacific Islands Centre for High Technology Research and Energy (PICHTRE). This scheme started in April/May 1998 and so far has been functioning well. PICHTRE staff in Honolulu directly monitor its performance. Initial results suggest that approximately 50 per cent of the energy is being generated from diesel in the hybrid scheme. The scheme is a hybrid of 40 kW of PV solar, two 100 kW diesel generators and eight wind generators of 6.7 kW each. Funding involved expenditure by Japan of some US$634,000 and by Fiji of FJ$180,000 for local costs.

There has been some experimentation in Fiji with **biofuels**. The Australian National University (ANU) has a project developing a device to provide direct extraction of coconut oil under pressure alone from grated coconut on a fairly small scale. This would seem to have relevance to remote locations, both in Fiji and other countries, as an energy source. There has also been some work at ANU on obtaining ethanol from molasses, and on electric vehicles.

There are five **wind**-monitoring stations in Fiji. All of these are primarily gathering meteorological data. So far development has been restricted to the use of wind in the Nabawalu hybrid scheme. Wind speeds averaging speeds in excess of 6 metres per second have been measured in some places in Fiji. This suggests that there may be an economic potential for wind power in such locations. However, some of the sites are visually prominent, and energy development could clash with tourism values.

There have been many reports of **geothermal** energy but these are surface indications only. No deep drilling

has been carried out to prove the existence of a resource and there are no development projects to date.

Fiji has some 36,000 ha of **forest** that is either forest reserve, nature reserve, or some other form of park or reserve. In addition, Fiji has some seven or eight times this area reserved as watershed protection forest.

Fiji is interested in the concept of reserves of existing forest being set aside from logging as greenhouse gas sinks. However, this requires a firm set of guidelines. The present reserves have been created for other purposes. In these cases the Department of Forestry pays lease fees as compensation to the owners for their loss of stumpage revenue from the standing trees. To be able to establish any further reserves, the department would need funding from outside. The stumpage revenues are substantial, so the required funding would be considerable. The fire hazard is some risk to the security of such reserves but experience to date is that this does not become a serious problem until population pressure causes people to expand agricultural activities into the forestry areas. This is particularly a problem once forestry activities have opened up roads into the forest.

Of the existing reserves, there is one each in Vanua Levu and in Taveuni. The rest are in Viti Levu. There is no donor funding behind any of the existing reserves. One feasible alternative source of revenue for reserves is eco-tourism, which can do something to offset the costs. There has been an attempt to do this at Colo a Suva. This is a small forestry reserve close to Suva. A user-pays policy has been established there with money collected from people entering the reserve. However, this has run into significant problems with people finding ways to bypass the collection point and also thieving the collected money. The cost of enforcing the collection is a significant burden on the funds collected. There is one area of 1,881 ha near Udi Point that is of particular interest to the department. Udi point is the most easterly extremity of Vanua Levu. The area has never been logged and has a rich diversity of species. But considerable difficulties are being met in an attempt to establish a reserve in this area. The underlying problem is the need to achieve agreements with, and amongst, a large number of landowners.

The department has established about 60,000 ha of hardwood forest, mostly mahogany. This has been planted in areas following the harvesting of the natural forest. Planting, which began in 1959, has been converted into a commercial operation and is being corporatised. The corporation will be set up as the Fiji Hardwood Corporation. Harvesting of the oldest trees should begin in the next few years. There is considerable potential to expand mahogany plantations into previously logged areas and those currently being logged. The optimum time to plant mahogany is immediately following harvesting of natural forest. However, logging activities has decreased on Viti Levu as the resource is substantially exhausted. Logging is primarily now on Vanua Levu.

The Department of Forestry has been attempting, for many years, to minimise the damage to forests through harvesting and to maximise the potential for subsequent cropping, and has established a 35 cm diameter lower limit on loggable trees. However, this has not achieved an optimal outcome and *Deutsche Gesellschaft fur Zusammarbeit* (GTZ) is currently running a programme at Nakava trying to establish and design a sustainable optimal harvest regime and maximise regeneration post-harvest. However, in practice restricting the output from harvesting is very difficult and large numbers of logs are cut which do not meet the restriction.

The national programme of improving rural road access is having a major impact in opening up additional forests to logging so that very few areas are now beyond the economic limit for logging. The result is a sad picture. The crucial component of any improvement is landowner awareness. The International Tropical Timber Organisation (ITTO) has produced an awareness package and the department has run a number of trial workshops for landowners. These have proved highly effective in increasing landowners' understanding of the issues concerned. However, the department is unable to fund a substantial number of workshops.

Fiji now has a substantial pine forest established on the western side of Viti Levu and there are large additional areas that could, at least in principle, be planted with pines or similar species. However, fire and land accessibility are major problems in maintaining and developing such plantations. Many areas of existing pine forest have been destroyed by fire. The Fiji Pine Corporation, which owns the existing forest, lost US$3M last year. Hence, no large-scale expansion of these forests is happening at present.

Fiji has not yet completed its **greenhouse gas inventory for 1994** and is having difficulty in completing this task. The US assistance that was provided for the 1991

inventory was not available for the 1994 inventory. Fiji has to undertake this task without external assistance.

4.4 Kiribati

Kiribati has implemented some demand-side measures in recent years although the major thrust of projects affecting greenhouse gas emissions has been in alternative energy sources, principally photovoltaics.

On the demand side, Kiribati is also looking at **labelling schemes** for appliances following the SOPAC-funded scheme being trialled in Fiji. However, little progress has been made to date.

Kiribati has **annual taxes on vehicles** that depend on their size. There are import duties but government vehicles are exempt. Other vehicle owners pay a duty that changes with the vehicle's capacity. Fifteen-seater buses pay a 40 per cent duty. Saloons pay 60 per cent duty if they are under 1600 cc and 80 per cent if over. Tax on fuel is US$0.48 per litre for petrol and US$0.47 per litre for diesel.

More cars are coming into the country and the volume of traffic is rapidly increasing. A high proportion of these are second-hand vehicles from Japan. The transport system in Kiribati is operated by private owners, most of whom are owner–operators using 15-seater van-type buses. These have displaced the older 30-seat buses. They are faster and provide a better service. There is no centralised maintenance system. Owners are responsible for maintenance of their own vehicles.

The government has a fleet of about 50 vehicles that are owned and maintained through the Plant and Vehicle Unit (PVU). Some of the PVU mechanics are qualified, but others have only on-the-job experience. The lack of testing equipment for components such as injection pumps or for emissions compromises the quality of maintenance. Few of the persons maintaining the privately owned vehicles are qualified motor mechanics.

The Public Utilities Board (PUB) on Tarawa supplies electricity and water. Inadequate revenues from the water supply and disposal side placed severe strains on the PUB's finances, resulting in a cessation of routine maintenance on the electricity equipment between 1994 and 1997. By 1997 the reliability of the electricity supply had deteriorated severely. The financing problem has been especially severe since 1996, when water charges were suspended. This measure followed damage to the water reticulation, which caused a serious reduction in service quality. Repairs are expected to be complete by the beginning of 1999, and charging for water is then to resume.

An Australian aid programme is now under way, doing overhauls on all the major generators in both of PUB's powerhouses. The programme is providing engineers to undertake the work, and a complete set of spare parts. Although only partially complete, this has already resulted in a **major improvement of the power supply.** However, the PUB's financial constraints have not been overcome and the supply of spare parts for generating machinery is still a problem. The overhaul programme is upgrading the main generating units but ancillary plant still requires upgrades and improvements. The station's lube oil centrifuge has broken and it has no fuel centrifuge. Units on which major overhauls have been completed were achieving a fuel efficiency of 0.29 L/kWh in July 1998. Engineers from Integral Energy of Sydney, who are also doing analyses of the distribution system, are carrying out the overhaul programme. This is expected to result in recommendations for extensive rehabilitation to improve reliability and reduce losses. The engineers have been working since near the middle of 1998 and expect to finish early in 1999. Funding for this programme has been provided jointly by Australia and New Zealand.

The existing powerhouse on Betio is considered unsatisfactory and is producing a severe oil pollution problem that is contaminating the ground water. The PUB is applying to Japan for a grant to construct a complete new powerhouse close to the coast. This would have two or three units of around 2.5 MW each. This will not only cope with growth in consumption, but also enable all generation to be consolidated into one powerhouse, except under fault conditions.

Maintaining both quantity and quality of the South Tarawa water supply is becoming increasingly problematic. The underlying problem is increasing population, and the resulting impracticality of preventing people from taking up residence on areas used for water collection. The consequence is gross pollution of the water lens. The consensus is that the most practicable long-term solution is to convert to desalination to obtain water. This is an electricity intensive process, requiring some 3 to 4 kWh per cubic metre of water produced. This will be a significant addition to total electricity requirements.

The major operator in **photovoltaic** solar energy in Kiribati is the Solar Energy Company (SEC), which now has 312 customers (the national population is estimated at 79,000). The SEC is continuing to purchase additional panels with donor funding. However, this is on a small scale only, notably for high schools funded by Canada and some other sets funded by the CFTC. A possible larger programme is under discussion with the French. In aggregate, Kiribati now has 79.6 kW of solar PV systems, including those used for water pumping and communications. The majority of these sets were supplied under the Lomé programmes and by the Japan International Cooperation Agency (JICA)

The SEC is still looking for donor assistance to enable it to expand its coverage, as it perceives a need to obtain economies of scale in order to be financially capable of sustaining itself and funding replacement costs. The SEC charges A$10 per month as rental for its equipment for a household system and also charges A$50 installation fee for any new plant. At present they are renting 305 systems. From its experience the SEC estimates that it requires one field technician for each 125 house systems. Each field technician is currently paid A$2,000 per annum.

The SEC has not yet faced any major replacements of its PV system components. Battery replacement is a major forthcoming problem for SEC as many of their systems have batteries that are now approaching the end of their lives. These replacements cost about A$230 each and the majority of the 305 systems will require replacement over the next one to two years. The SEC does have some reserve funds available to fund replacements when necessary, but not sufficient to meet the cost of replacing all the batteries. At its present scale of operation the SEC depends on revenue from sales of equipment. It cannot cover its costs from rentals of PV systems alone. The SEC is continuing its manufacturing operations and still making control units but has ceased making night lights.

Forward financial projections by the SEC indicate that with its present costs and prices it is viable only while new sets are being provided by donors and then only up until the point when panel replacements are required. With existing funding arrangements it can build up a surplus in the short term but replacement costs will subsequently force this down to zero or negative. It estimates that it would be able to cover all costs, on a long-term basis, if it were to increase its charges to A$15 per month.

The SEC is continuing with its manufacturing operations but is experiencing delays in obtaining parts for the regulators. It has orders to fill in Thailand and Bhutan. The majority of SEC PV hire systems have been installed in the 16 atolls of the Gilbert Group. The population in the other groups is much smaller. Its clients obtain the majority of their cash income from the sale of copra and of marine products, particularly seaweed.

The European Union (EU) has recently had a team examining the sets provided under the Lomé agreement. Their report is not yet available but indications are that they are pleased with the performance of the EU-provided kits.

A significant additional use for PV is small-scale water pumping for villages outside the reticulated district on South Tarawa. The Public Works Department operates these systems, with the SEC acting as a contractor for their installation and maintenance. To date only ten fairly large (ten-panel) village systems have been installed. This will be expanded by the installation of 112 smaller (two-panel) systems over the next two years. The primary objective of this programme is to improve health, both by obtaining water from wells further from houses and by providing a more water with less effort. This programme is being funded by the UNDP.

The Department of Agriculture has EU funding to establish and operate a tree nursery. However, this is a rather small-scale activity growing trees in hundreds rather than thousands, rather than a significant **forestry** project. There is an emphasis on traditional native trees that are the source of medicines. These are being planted out on government land with managed harvesting being permitted by local people.

Mangrove harvesting is also a matter of concern and a national committee on the management of mangroves is undertaking the assessment with US Department of Agriculture (USDA) assistance. It is considered that Kiribati has a serious need for a good fast-growing fuel-wood tree. Casuarina could possibly fill this role.

The majority of Kiribati is not well suited to **wind power**, as winds are too light and variable. However, a wind diesel hybrid has been suggested on Kirimati, where adequate wind speeds have been measured. The population on Kirimati is now around 3,000, and is growing rapidly (about 500 per annum) due to migration

from Tarawa. In addition, groundwater supplies are very limited so that desalination will soon be needed. The implication is a rapidly increasing requirement for electricity generation.

4.5 Federated States of Micronesia

Little has been done in the way of **demand-side** measures in the Federated States of Micronesia (FSM) even though, like a number of other PICCAP states, FSM has experienced a rapid increase in the number of vehicles in recent years with an influx of second-hand vehicles (in this case from the USA rather than Japan as is typical elsewhere, because vehicles drive on the right). The number of vehicles in Pohnpei has now reached close to 7,500 of which almost 1,000 are taxis. The very high proportion of taxis appears to be related to a relatively poorly developed bus system.

FSM has taken no **fiscal measures** to influence fuel efficiency of passenger vehicles. Registration fees for cars do not depend on the size or engine capacity of the vehicle. There is a sliding scale of annual registration fees for trucks. However, these are quite modest by the standards of other PICCAP countries, starting at US$8.50 for all vehicles below 1350 kg and ranging up to a maximum of US$26.50 for a large heavy truck.

Vehicles are subject to an annual check primarily for safety. The FSM does have **emission standards**. These are based on the US Environmental Protection Agency (EPA) standards of some 15 years ago and have not been updated since. There is little application of these to existing vehicles, whose maintenance standards are considered to be fairly poor.

FSM has only modest **hydro** potential, most of which is on Pohnpei. There are three main streams there, but even if fully developed these could only supply well below a half of the current demand on Pohnpei. Only one of these streams has yet been developed, in combination with the water supply to the town of Kolonia.

All other generation for public supply is from diesel stations. The power supply to Pohnpei became highly unreliable a number of years ago, resulting in the abandonment of the existing diesel station and its replacement by generators on a floating power barge in Kolonia harbour. However, a recently completed US aid project has seen the construction and equipping of an entirely new power station in the hills behind Kolonia and the near complete replacement of the reticulation system throughout Kolonia. Pohnpei now has a modern and efficient power supply system that should serve well for several years before requiring heavy maintenance expenditures. Although the Public Utilities Corporation (PUC) has a nearly new powerhouse in very good condition there are still some opportunities for **improvements in fuel efficiency**. In particular, the PUC does not blend its waste oil into its fuel and the disposal of the waste oil constitutes an environmental problem.

The other states of the FSM depend entirely on diesel generation for their supplies and there is little potential for this to change. The potential for **biomass** and **other sources of energy** for electricity generation has been noted but there has been little activity in this field.

PV lighting systems have been installed in houses in several of the smaller islands of Pohnpei. Much of this has been financed by Italy. The state of Pohnpei has a committee to oversee photovoltaic projects and which trains technicians in their installation and maintenance. Households pay US$50 to have a system installed plus US$5 per month. For this the householder gets four lights and a night light supplied by two 55 watt panels. The administering committee presently has US$4,000 in the bank after some three years of operation. The accounts show that the initially high collection rate has fallen to around 55 per cent. This will not be sufficient to fund replacement costs. The technicians have been instructed to remove systems where payments have not been received and to use the parts from the removed systems as spares for the remaining systems. However, it is clear that this policy is not stringently enforced, as evidenced by the low and shrinking collection rate. Overall, the prospects for the survival of these systems are poor in the absence of a substantial external subsidy to fund battery replacements in a few years time. Neither FSM nor Pohnpei governments will be well placed to supply such subsidies in view of the declining funding from the US (funding under the Compact of Free Association ends in 2001).

FSM has a significant problem of progressive deforestation. This is not substantially due to logging but to clearance for agricultural purposes. The primary crop concerned is kava, which is being grown in the highlands underneath semi-cleared forest. This is very destructive of the forest but kava growing is very attractive due to the high returns it brings. The Forestry Department is growing some 12,000 tree seedlings per annum in total, which are distributed to farmers for erosion control and as fruit trees. However, this is not

successfully reversing the deforestation. The end result of the process is that the forest is being converted into grasslands. Excluded from this are some 500 ha which are reserved as water catchment for the town of Kolonia.

All sawmills on Pohnpei have closed, although there is sufficient forest to support a small sawmill over an extended period. Kava growing is at present more attractive. Any attempt to organise reforestation would need to deal with the tenure system under which 3 ha is given to each person for their use. There is not very much public land that could be made available for reforestation purposes. Reforestation would need to be undertaken on a small wood-lot basis. The Forestry Department provides a few hundred trees a year for planting in wood lots. These are mostly mahogany, casuarina and eucalyptus species.

4.6 Samoa

Greenhouse gas mitigation, and indeed the overall climate change problem, was considered by informants to have a low profile in Samoa. However, there have been a number of developments on both the demand and supply sides that have impacts on greenhouse gas emissions, and assistance is now being received to promote demand-side management.

On the **demand side,** some **energy efficiency awareness programmes** have been promoted, particularly in schools. The school programmes have been comprehensive and considered to be effective. More public education regarding the use of cars has been undertaken. However, this has not been evaluated and the benefits are not clear. The government has prepared a policy statement regarding the maintenance and driving of cars. The proposal has been worked up for education in relation to maintenance and driving of trucks and buses. However, this has not yet been implemented. There is potential for an increase in the level and range of education projects, but the design and presentation of these projects is a significant problem. A regional basis for development of education projects was seen as acceptable and helpful.

Other energy conservation projects that have been implemented in recent years include **lamp exchanges** in government buildings: the majority of lamps have already been changed to efficient lamps.

Government regulations on energy efficiency are recognised as being insufficient and a committee has been established to work towards resolving the problem of effective energy regulation.

Samoa has not made any moves to use **fiscal measures** to influence vehicle fuel efficiency. The **import tariff** on vehicles is a 20 per cent tariff plus 20 per cent GST. There is no variation in the tariff with the size or engine capacity of vehicles. Neither is there any regulation regarding the sorts of vehicles that people may own.

On the other hand, the desirability of encouraging the use of alternative renewable energy sources is recognised and **reduced import tariffs** have been established for LPG appliances and solar heaters.

The number of vehicles in Samoa has doubled since 1989 and there are now between 10,000 and 11,000 vehicles. There are regulations regarding emissions from vehicles. However, enforcement of these has not been effective. Testing is carried out regularly on buses and taxis and this includes smoke emissions. The problem is that many of the mechanics in Samoa are not qualified and some are deliberately adjusting diesel engines to produce smoke in order to maximise power output. In order to deal with this the Transport Control Board would like to obtain smoke testers.

Other measures undertaken in relation to ground transport have been **improvements to the roads**; the **regulation of fuel quality**, although there is no regulation on fuel emissions; and the **design of information materials**. ⁻There is the potential for publicity to be used to look for improved efficiencies in trucks and other heavy vehicles.

There has been some discussion on the feasibility of improving fuel efficiencies by placing **restrictions on vehicles**, particularly those for public transport, and forcing taxis to use later models. In earlier years Samoa had restrictions on the weight of vehicles. However, since the 1991–1992 cyclones these have been abolished. There are restrictions on the length and width of vehicles only. In order to place some limits on the problem of second-hand imported vehicles, these are now permitted to be a maximum of ten years old and must be left-hand drive. Right-hand drive vehicles are permitted in special cases only. At present no preference is given to public transport vehicles over other types of vehicles. Encouraging the use of buses is considered to be difficult.

There are opportunities to **increase diesel generation efficiency** as well as improve performance. At present the main generating units in the diesel station are subject to de-rating due to temperature problems. This is due to a shortage of capacity, which is forcing overhauls to be delayed with some consequential loss in performance and increase in fuel consumption. However, this problem will be markedly reduced with the commissioning of a 4 MW diesel unit in June 1999. This should also enable two hired generators to be released. There is a considerable amount of work required to improve the efficiency and effectiveness of the diesel station. The restraint on this is funding as the staff have the capability to do nearly all of the work required. Additional auxiliary plant could be required to maximise efficiency as at present there is no centrifuge for fuel and filters are missing.

Opportunities for **improvements in power distribution efficiency** are potentially modest. Overall system losses in the electricity systems on Upolu are some 13 per cent while on Savai'i they are 24.5 per cent. However, it is considered that 70 per cent of these losses are "non-technical" losses, meaning mainly unread meters and theft. Only 30 per cent is considered to be actual losses in the lines. The Electric Power Corporation (EPC) is running a power system losses campaign. They have already caught three larger users who were tampering with their meters. There is a project designed to reduce line losses through the Lomé III Programme, which EPC has looked at, but not to date taken advantage of.

In terms of **energy appliances**, the EPC looked at the experience of the Tonga Electric Power Board in promoting **compact fluorescent lamps** (CFLs) to consumers. In this project the price of the CFL was built into the electricity bill. However, the project was not considered to have been successful, as the take-up rate was low. This was thought likely to be because the offered terms were not sufficiently attractive to consumers.

The EPC has not yet run any efficiency programmes on **air-conditioning or refrigeration**. The DSM project developed under the Forum Secretariat as part of the UNDP Power Sector Project has not been implemented. Regional support of the implementation of DSM projects would be welcome. Asian Development Bank (ADB) funding has been obtained for an energy adviser to work on demand-side management for two to three months. The adviser is to start work in late 1998. There is at present no legal framework for demand-side management measures and establishing a desirable framework will be a job for the energy adviser. Other tasks will be the development of awareness-raising programmes and appliance efficiency projects such as labelling. However, it is recognised that some projects, notably energy labelling, will not be able to be implemented in the limited period for which the adviser will be working.

On the **supply side**, exploration of opportunities for **renewable energy** have been limited although a Peace Corps volunteer did look at **solar** in the late 1970s and early 1980s. At present Samoa does not have any comprehensive policy in place although progress towards one was developed with SOPAC assistance.

Biomass has been used in the past for electricity generation at the steam power plant at the Asau Sawmill in Savai'i. While the plant is still operational, the mill has now been privatised and does not appear to be exporting significant electricity to the grid. A number of years ago a proposal for a wood-fired power station on Upolu was abandoned and this concept is no longer regarded as viable.

Some time ago there was a proposal to **burn solid waste for energy**. However, the volumes of solid waste were found to be insufficient. It was proposed that coal be brought in from Indonesia to supplement the waste. However, the Samoan government did not accept this.

The potential for **photovoltaic** systems is restricted since good electrification distribution systems are now extensive in both of the two major islands. The areas without access to good power are now restricted to the two small islands plus some inland areas in each of the major islands. Even these areas have been further reduced by progressive extensions of distribution systems and may be further limited by a project to link the larger of the two smaller islands to Upolu by an undersea cable. There was a PV project some years ago targeting the two smaller islands. However, this project was cancelled, possibly when the Electric Power Corporation (EPC) decided it was interested in the undersea cable project.

The electricity supply on Upolu is part **hydro**, part diesel with the proportion from hydro projects varying widely depending on the recent rainfall, as little storage is available. In dry periods this can drop as low as 30 per cent while reaching 90 per cent average during wet seasons. In recent years the weather patterns have

appeared to be changing, with rainfall becoming less predictable. The major future hydro development project on Upolu is an expansion of the Afililo Scheme by a further 2 MW. Beyond this, relatively small projects only remain to be undertaken.

On Savai'i, all generation is presently diesel apart from minor self-generation at the Asau Sawmill. However, there is a proposal for a 4 MW hydro station on the Sili River, which would be sufficient to supply 100 per cent of usage. This is at the feasibility study stage. Japan is funding the feasibility study through the ADB, and there are hopes that Japan will also assist with construction finance.

Samoa's major potential for further hydro development is the Sili Scheme on Savai'i. In principle this could be developed to more than twice the planned capacity, and the power brought to Upolu by an undersea cable. However, the landowners are unlikely to agree to this.

It is intended to supply Manono, the closer of the two small islands to Upolu, by undersea cable. However, there is no prospect of a cable to Apolima as the electricity requirement is too small relative to the distance. There is, though, a potential for a **solar PV diesel hybrid system** of around 20 kW capacity.

An American group undertook an investigation into the potential for **wind** and **wave power** four years ago. However, no report is available on the outcome of the investigation.

There has been a long history of assistance from New Zealand in **forestry** development. This has now ended, although some discussions have been held with New Zealand regarding the potential for assistance with the development of more efficient forestry. With the end of New Zealand's assistance, systematic afforestation has stopped.

The major **forest** plantations on Savai'i were very severely damaged by a fire that burned for five weeks. This mostly burned out the plantations in the western area. The eastern area was mostly spared. All of this has been replanted since 1992.

There are some existing plantations in Upolu, mainly of mahogany, but no further expansion of these is anticipated with only maintenance work being carried out. Eucalyptus was trialled on Upolu but not found to be successful. The resulting trees were suitable for fale poles only.

Mahogany is much more successful with a life cycle of 20 to 25 years. A proportion of the plantations established prior to the 1991–1992 cyclones was destroyed by those cyclones. Some 2,300 ha have been replanted since that time. However, this is still less than existed before the cyclones.

The Forestry Department has a community forestry programme to assist farmers to establish plantations on their land and also a private forestry programme that will assist farmers to convert land that can no longer be used for taro into forestry. It will also continue to maintain a nursery. There is a continuing programme of watershed management attempting to maintain water quality.

Land ownership issues are a problem in establishing forest plantations, although there is some freehold land. The government is phasing out its involvement in planting on leasehold land and restricting itself entirely to government land.

Samoa is still preparing its **inventory of greenhouse gas emissions** for 1994 and hopes to have it finished by the end of 1998.

4.7 Solomon Islands

The Solomon Islands has an effective PICCAP national team. However, the team has been concerned primarily with adaptation issues and has not discussed mitigation. The Solomon Islands is looking for economic benefits from any projects that may be established. However, the Solomon Islands does not wish to have industries (and greenhouse gas production) shifted there so that other countries may meet their greenhouse gas mitigation obligations.

A master plan study has started under Japanese aid by Japanese consultants. Over two years this will study the whole of the Solomon Islands' energy supply with a focus on renewable energy. A rural electrification authority funds village electrification. This operates under provincial governments. There are also projects that need to be developed in other islands outside Guadalcanal; for example, the Malu Project needs to be expanded from its present 35 kW to its capability of 100 kW.

On the demand side, growing interest was expressed in obtaining **more efficient energy using appliances** and in **alternative energy supply technologies**. Particular interest lies in the villages' requirements for fuel to provide light in both houses and churches. The village people need to know what technology is available to them. A further concern is for crop and fish drying. At present people use their most valuable hard-wood species as a fuel for drying. This suggests a need for other technologies such as solar drying.

The Solomon Islands Electricity Authority (SIEA) **recognises consumer appliances** and energy use as a major area in which it cannot hope to satisfy everybody. However, change is already apparent in some areas. There has already been, for instance, a trend away from **incandescent lamps**, and fluorescent lamps are now usual in both new houses and new commercial work.

Officials still see many problems related to appliances and consider that the Solomon Islands is receiving appliances that are dumped there and are not appropriate for local conditions. A **labelling project** would be welcome since it would help to avoid this. A particular problem at present is that Asian-sourced products are not meeting the safety standards. Unfortunately, legal changes in the Solomon Islands have resulted in the responsibility for safety standards having become rather unclear although these may now reside with the Public Works Department.

The potential for **educational programmes** is recognised but SIEA is not able to do as much as it would like. One programme was undertaken as part of an Australian-funded Air-conditioner Efficiency Project. This focused primarily on refrigeration and air-conditioning, particularly on ensuring that condensers were well ventilated and clean, and that filters of air-conditioners were cleaned. The project also demonstrated that minimising the operation of air-conditioners while rooms are unoccupied could make major savings.

The Department of Transport tests vehicles for safety purposes but not for **fuel efficiency**. The Solomon Islands does not have smoke test equipment but it would be required under legislation being considered.

In terms of **fiscal measures**, fuel taxes are low relative to other countries but are now being reassessed. There is an annual **vehicle tax that is graduated** by both load capacity for goods vehicles, and engine capacity. There are also substantial **duties on imported vehicles**, particularly second-hand ones. Due to the number of second-hand car imports and the problems these are creating, import duties on these could be increased. Trucks are also being brought in second-hand.

There have **been substantial road improvements** in the last few years, notably in the road between Honiara and the airport. Further improvements are to start soon.

The Solomon Islands has fewer motorbikes than in the past, due primarily to the danger of riding bikes on rough roads with increasing volumes of traffic. The bus population has also changed: smaller buses have almost entirely replaced large buses.

On the supply side, there is a major opportunity for the use of **industrial biomass** for energy at Solomon Islands Palm Oil Ltd (SIPL). This plant produces steam and electricity from plant wastes. There is considerable potential for this to be expanded and to export electricity. However, there may then be a need to use oil fuel during the off-season to sustain electricity generation.

An extensive resource assessment of **hydro** potential is being completed and a large database of potential hydro schemes has been assembled. Many of these have substantial economic potential.

Approval has been given for a 25 MW hydro scheme at Lungga. This SI$300M BOOT project is being coordinated by the Snowy Mountains Energy Corporation (SMEC) which will sell the output to **the** SIEA. On commissioning, due in 2003, the main Guadalcanal system will obtain the majority of its energy from hydro. At present **the** SIEA's two powerhouses in Guadalcanal are using some 44,000 litres of diesel fuel a day. Diesel generation can be expected to start again within three to four years to meet growing demand. Maximum demand is now in excess of 10 MW and growing at about 8 per cent per annum. In addition, the Gold Ridge mining project will take about 10 MW. At a later stage the Koromindi Scheme will also be developed. Subsequently, development will be moved to the southern side of the island where there is a greater water supply and hydro potential. Development there has been prevented to date by the lack of infrastructure. A number of other worthwhile hydro projects outside Guadalcanal have already been identified, including a 150 kW project at Kirakira. However, at present these projects are unfunded.

The SIEA has provided technical assistance to two villages for the utilisation of **solar PV systems** and is considering becoming a PV systems supplier. This is the subject of a current development project. The SIEA-assisted schemes are considered to be operating successfully. However, other PV schemes have failed, although the causes are not documented.

In terms of the **efficiency of its diesel-based electricity generation**, SIEA has adequate technical expertise at its main diesel plant with the assistance of an overseas engineer. However, repairs and maintenance are lacking, primarily due to lack of funding for the purchase of spares. There is a need to develop maintenance programmes so that maintenance is carried out on schedule rather than when problems arise. There is also a need for improved maintenance of auxiliaries and to upgrade auxiliary equipment. One objective at present is to move to condition monitoring, which would then enable the SIEA to improve the efficiency and reliability of its plants. At present they are achieving around 26 L/ kWh on average with diesel machines from 50 kW upwards.

In terms of the **efficiency of power distribution**, the overall energy loss rate on the SIEA distribution system is 12 to 14 per cent. There is no data available on the losses on individual lines, and hence remedial work cannot be effective. The SIEA is now working through a GIS project using the technology provided from the Lomé III Programme, and building up a database. When the database is more complete the SIEA intends to use it to identify the sources of its line losses. This is a major project for the SIEA and is proceeding without further donor funding. The SIEA is the licence holder for the load flow software supplied under the Pacific Regional Energy Programme (PREP). Once this project is complete and line loss problems are identified, the SIEA intends to fund some line upgrade work but recognises that the costs will be high and progress will necessarily be slow.

The Department of Energy has prepared a concept plan for a request to the Global Environment Facility (GEF) to fund rural **photovoltaics** at health clinics. There are some possible extensions to this plan to include community PV schemes to supply houses. The request will be for funding of the supply of hardware only. A further concept plan is to be prepared for submission to GEF for the funding of hydro development.

A report has been prepared on the **geothermal** potential of two sites in Guadalcanal but prospects for development are not good. Both schemes are in locations where there is little demand for electricity.

Forest logging is a substantial industry in the Solomon Islands. The rate of logging has slowed somewhat with the Asian economic crisis. Even so, the resource is being rapidly depleted. Logging at present rates can continue for only about another ten years. There is a standard requirement for loggers to pay a 7.5 per cent levy to pay for reafforestation. However, this money goes to the landowners who cannot be forced to spend it on replanting, and frequently do not.

The Solomon Islands Government has a **reafforestation programme** proceeding in three or more provinces, taking place mainly on government lands that were logged some ten to 20 years ago. However, the funds have been exhausted and work has ceased. A Korean logging company was doing some reafforestation on its own behalf. This has stopped with the decay of the Korean economy. Very little has been done on customary land except for a New Zealand–funded programme on Malaita. In all, around 21,000 ha have been planted on government land. All the plantings are exotic species, mostly eucalyptus, mahogany and teak. Some of the eucalyptus is now being logged. The Forestry Department has too few staff to cover or enforce the reafforestation requirements and they are concentrating their efforts on the monitoring of logging and milling activities.

There are some small areas that have been set aside as reserves, but protection mechanisms are not effective and in some cases these reserves have been logged. Prospects for preserving the present reserves or effectively establishing further reserves are not good, as protection is extremely difficult to enforce. The reserves are likely to come under increasing pressure as the forest resource dwindles.

The Solomon Islands did not do a **greenhouse gas inventory** for 1991. It is now well advanced with its 1994 inventory but this is not yet complete.

5. Proposed Programme

The design of a programme to implement an appropriate mix of measures needs to address a range of issues:

- the severity of mitigation efforts which are justifiable, considering the role and benefits of setting targets from various viewpoints, including acting as a demonstration to other countries. Potential conflicts of mitigation measures with growth in population and living standards must also be assessed. The nature and distribution of impacts, costs and risks both in terms of policy and individual projects must also be taken into account;
- the role of donor and other funding in terms of capital costs, operating and maintenance costs, and revenues;
- the roles of and relationships between regional and national programmes, particularly in terms of national revenues, economies of scale, scarce expertise, attractiveness to donors, legal requirements, and separation from other objectives;
- the sustainability of the programme in terms of resource availability, waste disposal, financial viability, willingness to pay, fund management, and technical demands; and
- coverage by other programmes and agencies identifying possible duplication, gaps, and complementarity.

A consideration in assessing options for inclusion in a mitigation programme is the extent to which it could place financial or other resource burdens on the host countries. In formulating recommendations, the principle has been that greenhouse gas mitigation alone should not be an adequate justification for a project. Other richer and more intensive producers of greenhouse gases are not prepared to do this. It is hard to see that there is, at least as yet, any justification for PICs, who are among the world's most modest greenhouse gas emitters, to accept economic burdens to mitigate greenhouse gas emissions. A project should be recommended only if it could be justified on other "no regrets" grounds, such as cost savings or other benefits.

5.1 Criteria for inclusion in regional programme

Eight criteria have been defined as the basis for developing the regional programme:

(1) appropriate to implement at regional level;

(2) effective at mitigating greenhouse gases;

(3) attractive to donor funding;

(4) implementation appears practicable;

(5) provide information on resources;

(6) provide information on technologies;

(7) requires only proven technology; and

(8) acceptable costs.

In applying these criteria to the available supply of options, it is helpful to have an indication of how the amount by which greenhouse gas emissions are reduced compares to cost. This is the concept of cost effectiveness. Accurate cost effectiveness measures cannot be calculated for options that have yet to be designed, let alone tested. More accurate estimates can be made for options involving hardware supply, but even there the "soft" costs of project management and implementation need to be included to provide meaningful measures. These can be substantial and are subject to wide variability. Country experience shows that low expenditures on soft components are related to high rates of project failure, so it is important to include substantial allowances for these costs.

A comprehensive cost-effectiveness assessment of a wide range of options is beyond the scope of this report, and very few analyses have been published. Notwithstanding these caveats, some generalised indication of relative costs and mitigation effectiveness can be estimated. The results are charted in Figure 3.

It is clear from Figure 3 that industrial use of biomass is far more cost-effective than other options. This is closely related to the attractive overall economics of using bagasse or fuel wood where available, in industries requiring large inputs of heat and electricity. These applications do not require assistance from a regional mitigation programme: they are already standard practice. Hence it is helpful to consider the chart with that option removed. This is shown in Figure 4.

The remaining options show a significant variation, but all options show sufficient effectiveness to justify consideration.

Figure 3: Indicative Effectiveness of Mitigation Options

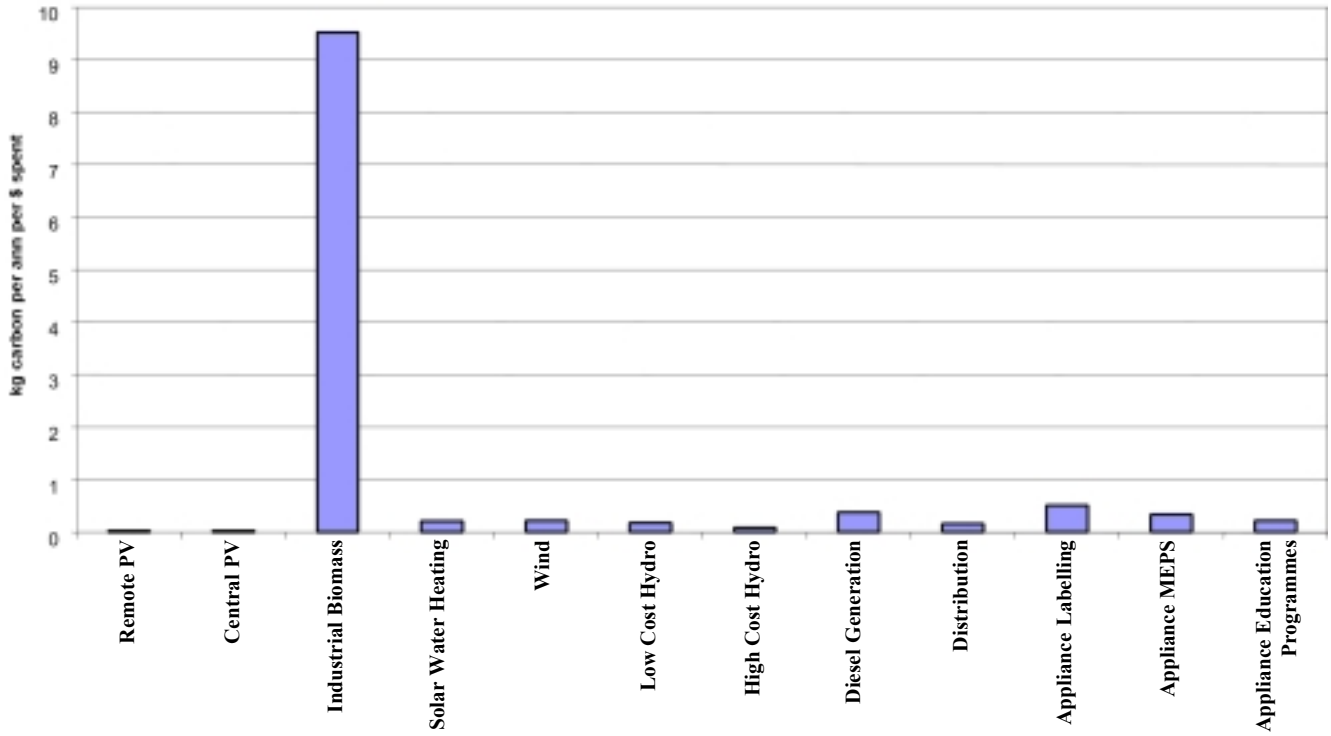
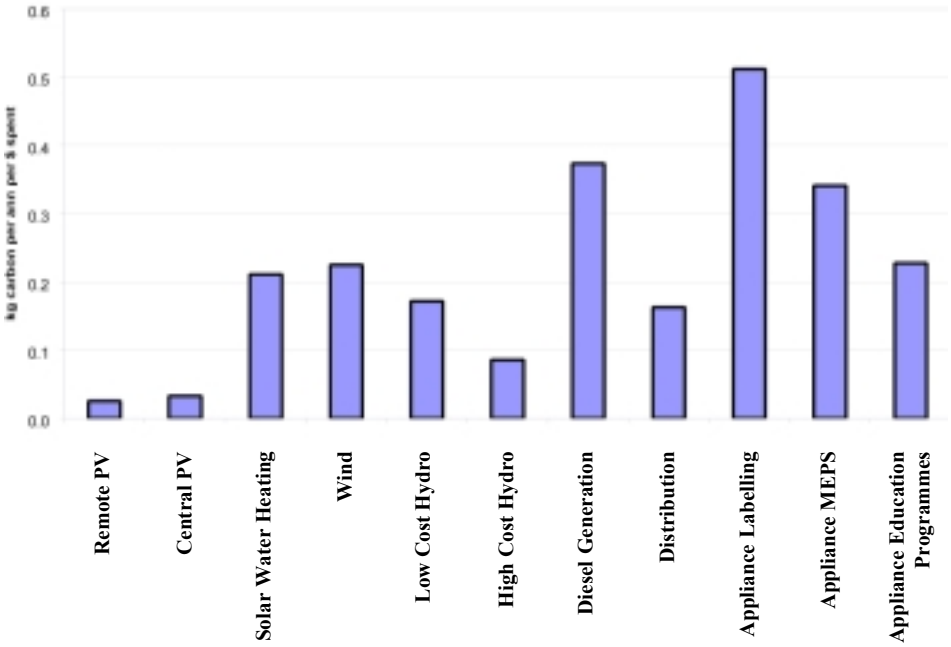


Figure 4: Indicative Effectiveness of Mitigation Options Excluding Industrial Biomass



6. Preferred Options

The participants at the PICCAP Regional Mitigation Workshop held in Port Vila from 30 November to 4 December 1998 selected a range of measures and initiatives for inclusion in a regional GHG mitigation programme. All PICCAP member countries were represented at the meeting. In addition, representatives from Niue and PNG attended and participated. After considering the wide range of possibilities described in section 3, the selected measures were identified by the participants with a view to meeting the criteria in section 3, while being consistent with the other political and cultural objectives of the member countries. For convenience, the grouping of measures into demand side, supply side and sink enhancement was used at the workshop and is continued here.

Ideally, the selection would have been made after setting a numerical target for reductions in GHG emissions. This would then guide the selection of measures adequate to achieve such a target. It was clear that in both cases, from interviews while investigating the mitigation options, and at the workshop, that countries have not sufficiently considered the implications of mitigation to be in a position to decide that targets are desirable, or to identify at what level such targets might be set. Neither were the delegates in a position to do this. Hence the selection was made without the assistance of such a guide.

6.1 Preferred options: demand side

The selected demand-side options are:

- efficiency labelling schemes;
- appliances designed for tropical islands;
- training and education programmes; and
- ground transport:
  - mixture of measures needed.
  - varies by country.

6.2 Preferred options: supply side

The selected supply-side options are:

- efficiency increase in existing systems;
- biomass for heat and electricity;
- coconut oil fuel;
- wind power; and
- photovoltaic.

6.3 Preferred options: forestry

The selected forestry options are:

- sustainable supplies of fuel; and
- information on income opportunities—not to be used to allow other countries to avoid their mitigation responsibilities.

7. Implementation Mechanism

The preferred programme contains a variety of elements, with a wide range of characteristics. No single implementation mechanism is suited to all of these. Past experiences in implementing many projects and measures provide a guide to the requirements for successful mechanisms.

From those experiences, and particularly the causes of failed projects, the seven criteria for a successful implementing agency are that it should:

- be, or represent, the beneficiaries;
- have a clear mandate for its programme;
- possess adequate technical and managerial skills;
- have, or have access to, adequate funding to complete the programme;
- be acceptable to all other parties involved;
- be free from confounding incentives; and
- be subject to effective external financial control.

Few existing organisations could, in their present form, meet these requirements. If the programme is not to become stymied for lack of suitable institutions, it will need to include components to address these requirements. In most cases the potential implementing organisation's technical and managerial skills are already stretched to, or beyond, their limits. They have no real capability to take on additional responsibilities. The design of each programme component will need to address the limitations of the existing institutions. This will need to ensure that any additional capabilities required are either supplied or created as part of the project. Only rarely will these capabilities be already available within the organisation, and able to be used without damage to other aspects of the organisation's responsibilities.

In numerous instances, institutions face confounding incentives. This is particularly likely if it is exposed to influence for short-term political purposes, or if it has too broad a mandate. In such cases institutional reform may be essential before an effective mitigation programme can be mounted. Greenhouse gas mitigation is unlikely to be an adequate reason to undertake such reform, but such an institution is likely to be better able to undertake its existing functions more effectively after effective reform.

Given the range of elements selected for a regional mitigation programme, some suggestions can be made regarding the elements that would be appropriately handled by a variety of potential implementing agencies.

Electricity utilities, including IPPs

- Renewable energy supplies, including wind and large-scale biomass to electricity, to be fed into central grid systems; and
- efficiency improvements to power stations and distribution systems.

Government energy departments

- Setting policy frameworks;
- appliance efficiency labelling programmes—local implementation;
- appliances designed for tropical islands—local coordination;
- training and education programmes—local implementation;
- advice to planning, works and treasury departments on ground transport fiscal measures, road and traffic management improvements, and regulatory controls; and
- encouragement for increased uptake of renewable and efficient technologies once commercialised.

Government forestry departments

- Programmes to enhance fuel-wood supplies—local implementation; and
- advice to planning and treasury departments on opportunities to obtain funding for carbon offset forestry projects.

Regional organisations

- Appliance efficiency labelling programmes—design, organisation and management;

- appliances designed for tropical islands—initiation, negotiation, and management;
- training and education programmes—design of programmes and preparation of materials;
- design, acquire funding and implement projects for coconut oil fuel, wind and PV;
- dissemination of information on carbon offset opportunities in forestry;
- execution of donor-funded programmes; and
- coordination of programmes.

Private and cooperative sector

- Supply and promotion of energy efficient appliances;
- own and operate large and small IPPs;
- construction and operation of schemes to use biomass for heat and electricity;
- ownership and operation of plant to extract coconut oil for use as fuel; and
- design and implement projects under contract.

A sustainable mechanism for the ownership and maintenance of PV equipment cannot be clearly slotted into any of the above categories. As described in section 3.2.1, and in the experiences of the individual countries in section 4, many different mechanisms have been employed, but none have yet proved fully sustainable. Some innovation seems to be required. The character of an organisation that would be able to meet all the requirements for long-term sustainability is not yet clear, but some likely elements of such an organisation would seem to be that it:

- be a special purpose utility business, so that it operates on a commercial basis and is not distracted by other lines of business, or confounding objectives;
- be a multi-country operation to obtain economies of scale in building strong technical and managerial capabilities;
- operate under contract to a regional organisation, so that donor funding can be accessed for initial capital, and financial oversight and control provided;
- have funds to meet replacement costs built up in a secure trust fund; and
- possibly be partly or wholly privately owned to instil financial discipline.

7.1 Integration with the SOPAC/SPC Joint Regional Energy Programme Design

The 15 projects that comprise the SOPAC/SPC Joint Regional Energy Programme Design (JREPD), and notably its large PV component, overlap to a degree with the components of the regional mitigation programme. The JREPD projects are at a slightly more advanced stage of development, being individually profiled but not yet designed. The Joint Communiqué announcing the JREPD programme stated: "we envisage that this programme would be based at the Pacific Community's headquarters in Noumea". However, direct integration of the two programmes is complicated since SOPAC, and even more so SPC, has many more member countries and territories than does PICCAP.

This problem may be ameliorated by the recommendation, if accepted, that the jointly (Australian and French) funded programme comprise renewable energy implementation projects restricted to rural electrification with PV systems, wind and mini/micro hydro development, solar thermal and biomass.

The JREPD also recognises the institutional difficulties associated with the management of household PV systems. In the profile for 10,000 household PV systems it suggests criteria for their management. These differ from those recommended here, but are not inconsistent with them. One additional criterion is a requirement for a demonstration that households will be capable of paying their fees. However, in the experiences of the PICCAP countries reviewed in the course of this project, a lack of ability to pay does not seem to have been a significant component of any of the projects' problems.

One other significant aspect of the 10,000-household project (estimated cost US$10,900,000) is a suggestion that private funding could cover "perhaps around 50 per cent" of the initial costs. The private capital would presumably need to be serviced through the fees to users. When no existing project has been able to demonstrate financial sustainability (except where ongoing external contributions are available) even with 100 per cent donor funding of initial costs, this is a tall order. The implication is that user fees will need to be set at a level much higher than that charged by any scheme to date. Willingness to pay could then become an issue. The wind and biomass projects in the JREPD do not present any conflicts with the corresponding components of the regional mitigation programme.

8. Next Steps

There are two specific matters that need to be addressed in preparation for implementing a regional greenhouse gas mitigation programme: one is to find an effective answer to the management problem that has hobbled past attempts to develop renewable energy resources and technologies; the other is to design the programme.

8.1 Feasible management structure

Large renewable energy projects have been successfully designed, constructed, maintained and operated in several PICCAP countries. Problems have been met in these projects, but these problems have been dealt with and overcome. Small-scale renewable energy projects have been much more problematic. Many of the projects were based on inadequately developed or unsustainable technologies. However, PV technology has been developed to the point where solutions are available for technical problems. Nevertheless, unresolved institutional issues remain, although many models have been tried. As a result, most countries have been unable to:

- expand the use of PV lighting systems beyond the small numbers supplied by donors; or
- develop a financial mechanism capable of long-term funding of component replacements.

Consequently, before a larger scale of implementation of PV systems commences, there is an urgent need to devise a sustainable management structure. This structure should also be capable of dealing effectively with the problem of safe disposal of failed batteries. Although aimed at PV systems, such a structure is likely to be relevant to other small-scale renewable energy technologies.

8.2 Mitigation programme design

The present project is aimed at identifying the mitigation options appropriate for inclusion in a regional mitigation programme. Before raising funding for implementation of such a programme, a package of mitigation options that comprise the elements of the programme will need to be specified and costed in detail. This programme design would be presented in a form suited to submission to financial institutions.

The design would be primarily intended to be presented to the GEF. However, the possibility of obtaining financing from other sources should be retained. Numerous national and multilateral donor agencies have shown a close interest in the climate change issue.

9. Implementation Issues

Development of an implementation plan for the elements of the programme that relate to new and renewable energy needs to take into account the experience of previous programmes in PICs. The most important experience in this respect has resulted from the Lomé II PREP. Johnson's (1994) evaluation of this programme concluded that:

> *The programme had two main objectives, reducing dependence on petroleum through technologies to harness renewable energy resources, and assessing the technical and economic feasibility of these technologies, but failed on both counts.*

Johnson considered that the primary reason for this failure was institutional, not technical and that failure was virtually guaranteed from the beginning. In his opinion, the insistence on the use of "new" technologies in remote rural locations created insoluble institutional difficulties.

The only technology that was considered proven under the PREP as suited to the region was photovoltaic (PV). Adequate institutional support, including funding for that support, not just expressions of intent to provide it, is essential for any project. If the project is novel the need is intensified.

A further requirement is that if information is to be gained and made use of as a result of a project or programme, then funding must be allocated to the collection and dissemination of this information.

The Lomé III PREP agreement was signed in early 1994, and was expected to last three to five years. It was completed, apart from a minor extension to one project, in May 1998. No further PREP programme has been included in Lomé IV.

It is clear that the problems of the Lomé II PREP are not unusual. Johnson provides a summary of problems with other renewable energy projects, showing similar results.

A study of a mini-hydro scheme in Vanuatu (Zieroth 1997) shows a similar picture, even for a comparatively mature technology. It was characterised by being:

- a project whose selection was guided by objectives other than potential to succeed, e.g. funding available;
- technology driven;
- actioned without its economics being properly considered; and
- promoted although local people did not regard electricity as a high priority.

Greenhouse gas mitigation needs to be undertaken in ways that provide an approach to sustainable development. Johnson (1995) has also examined this concept and its application to PICs. He notes that sustainable development is evolving and contentious, but it nevertheless provides a useful broad guiding principle.

The PREA's main findings were that:

- there have been disappointing results from new technological options;
- there has been continued reliance on petroleum imports and biomass;
- there has been inadequate performance by power utilities; and
- there has been ineffective government management of the sector.

These findings need to be taken on board in any programme of measures to deal with greenhouse gas issues. The underlying failure has been undue reliance on the thin institutional capabilities of the PICs. Projects to enhance institutional capabilities have become popular, but run into comparable problems of:

- raiding competent staff from other areas, possibly of higher priority; and
- leaving the institution with an ongoing level of cost, after the donor funding ends, which PICs cannot, or cannot justify, supporting.

The PREA suggests that further projects in the energy sector should concentrate on:

- solar PV systems for remote islands,
- hydro;
- biomass use by agro-industries;

- petroleum pricing and safety issues;
- power sector performance and efficiency improvement (the highest priority); and
- reduced involvement by governments in sector management and operation.

The conclusion that the only renewable supply technologies that should be pursued at present are PV, hydro, and industrial biomass has been reinforced by later studies (AusAID Centre for Pacific Development and Training 1997). Even for these three the record is mixed.

As noted in 7.1, the SOPAC/SPC Joint Regional Energy Programme Design (Redding et al. 1998) has suggested a range of project types. However, the renewable energy supply projects proposed for joint Australian/French funding extend beyond the PREA list only in including solar thermal applications.

Two recent Australian-funded projects illustrate both the potential and the problems with greenhouse gas mitigation initiatives. One was a renewable energy supply project, the Grid Connected PV Project in Fiji, the other an efficiency project, the Air-conditioner Efficiency Project in the Solomon Islands.

The first demonstrates:

- a longer period to implement than planned, due to communication difficulties; and
- performance shortcomings relative to expectations based on theoretical calculations, for reasons that remain to be explained.

The second shows that:

- the expected opportunities to achieve energy savings really do exist;
- these savings can be achieved by a practicable project;
- savings in practice fall well short of theoretical expectation;
- implementation takes longer than planned due to shortages of technically capable staff;
- the capabilities of local organisations are weak;
- sophisticated equipment is prone to unreliable operation;
- incentives are distorted due to taxation effects;
- communication and information collection materials designed by technical people proved unworkable;
- savings tend to not be sustained after a short-term project withdraws.

The UNDP funded a project called "Support to the Pacific Islands Power Sector" (RAS/92/363) from 1993 to 1996. This undertook a range of initiatives, primarily in capacity building, in the electricity utilities. In particular, it provided training and technical assistance in several areas of efficient utility operation, and developed proposals for demand-side management. A proposal to extend this project has not proceeded.

The largest single donor assistance energy programme at the regional level over the last 15 years has been the European Union–funded Pacific Regional Energy Programme (PREP). The effectiveness of the regional initiatives of this programme was somewhat reduced by its restriction to the eight ACP countries. Its initial phase, under Lomé II, also suffered from its concentration on untested technologies. The second phase under Lomé III included a specific emphasis on "improved technical operation and maintenance standards in the energy sector" and "implementation of higher regional standards for energy efficiency and conservation" (Zieroth 1997 undated). Hence, although this programme was not explicitly concerned with greenhouse gases, it had significant implications for this subject.

A very high proportion of the PREP was directed toward electricity supply and use. However, PREP also sponsored technical courses in preventative maintenance of vehicle and diesel engines, and an emission mitigation study for buses in Fiji. Although the results of this study were publicised, it is unclear if lasting benefits have been achieved in this area.

It is clear that solutions are available to the technical problems of PV systems. The problems that remain are institutional and financial. A wide variety of modes of organisation have been trialled in the Pacific islands, "but most of them have failed to deliver reliable electric power to the consumers" (Liebenthal et al. n.d).

Some pertinent conclusions can now be drawn from the widely varying experiences, both successes and failures, of countries to date in establishing institutions to implement PV schemes:

- The utility model is confirmed as the most likely to provide a successful administering organisation.
- A high level of oversight of the administering organisation is essential to enable a successful building up and management of funds in the initial years.
- The administering organisation must be sufficiently remote from its customers, and have effective internal control systems, so that those customers who fail to pay their fees are refused supply.
- PV systems must not be introduced in a concentrated project over a short time period, as the resulting periodic financial and workload shocks on the administering organisation will be unsupportable. PV systems should be introduced progressively over an extended period of years with a view to enabling installation, maintenance and replacements to be undertaken and funded as a rolling programme.
- There is a minimum scale of operations required to enable an administering organisation to operate efficiently and successfully. What this minimum scale is remains unclear, but it is certainly substantially greater than the few hundred systems per country, which are all that are in place now.
- A rather higher level of monthly payments appears needed to enable a long-term financially self-sustaining organisation than is charged by most existing schemes. Whether such charges are within the users' willingness to pay remains unproven, but indications are that this is likely to be so.

10. Conclusions

The PICCAP countries have a range of opportunities to mitigate their greenhouse gas emissions. These fall into three basic categories:

(1) using renewable energy sources in place of fossil fuels;

(2) using energy more efficiently; and

(3) absorbing greenhouse gases back out of the atmosphere.

There is, in principle, a wide range of renewable sources of energy, and means to save energy, that PICs might use. Attempts to use a number of these have demonstrated that the technologies to obtain useful energy from these sources, or reduce energy use, need to be fully proven before they are implemented in the Pacific. These attempts have also demonstrated that it is not sufficient for a technology to be able to operate successfully when carefully looked after by a research institution. It should be considered proven to be sustainable only when it is able to operate within the technical, financial and institutional frameworks and capabilities available in Pacific island countries.

This suggests a division of the theoretical opportunities into three levels.

(1) Unproven

Technologies that are clearly not yet at the proven stage are those to obtain energy from waves, and OTEC, and to obtain electricity on a small scale from biomass. Photovoltaic (PV) energy for central supply systems is still in this level, in that it has not been shown to be economical without heavy subsidy.

Technologies at this level need to be fully tested and operating successfully elsewhere before attempts are made to implement them in the PICs.

(2) Proven only outside PICs

Wind power and geothermal energy development are at this level. Banning the import of inefficient appliances should also be included in this category, although the evidence is less clear-cut.

Technologies at this level have been fully tested and operated successfully elsewhere, but have not yet been demonstrated to meet all the requirements in PICs. There is a considerable range within this level, from geothermal, which is completely untested in PICs, to PV energy for remote areas, which has been extensively trialled, and shown to meet all but one requirement for sustainability.

(3) Fully proven

Technologies proven to work effectively in PICs include biomass energy in agricultural processing industries, and providing consumers with information so that they can select those with low energy and overall running costs. Others are hydro and solar water heaters, increased energy supply efficiencies, and improved control systems for appliances.

Measures in ground transport include taxation levels and structures for both vehicles and fuels. Others are the improvement of road standards and designs to smooth traffic flows.

The development of plantation forests could also be placed in this level, although energy supply or greenhouse gas mitigation has not been a significant motivation for forestry up to date.

These three divisions suggest that mitigation programmes should also be at three levels, with the content of projects at each level designed to recognise the limitations of exploiting technologies at that level.

(1) Unproven

Implementation of one of these technologies would be justifiable only if a donor was prepared to regard a trial as a pure experiment and not only fund all capital costs, but also provide the funds and expertise to operate, maintain and monitor the project throughout its life.

The only programme component that could have been recommended is:

- provide an information service to national governments on the development of renewable energy technologies.

The workshop did not select any options that fall into this level for the mitigation programme.

(2) Proven only outside PICs

These technologies are ready for a trial in one or more PICs. The primary output of trials will be information on the applicability of the technology within the circumstances of a PIC, rather than their energy output or energy saving in itself. Hence monitoring and reporting needs to be explicitly included as part of the project. It is particularly important that negative outcomes be examined carefully so that means can be found to overcome the problems. Nevertheless, there should be a good level of expectation of a positive result.

Programme components at this level need to be funded in ways that recognise the possibility of a negative outcome, and do not place PIC finances at risk. Hence, in general, all major capital costs, including major expense items within the host country, should be donor funded. Host countries could reasonably be expected to cope with ongoing operating and maintenance costs, as long as the project was producing benefits with a value that more than covered the costs.

Selected components of a programme at this level are:

- a wind power demonstration project;
- an urgent project to determine how an institution can be structured such that it will be able to sustain an installed base of PV systems with adequate technical and management expertise, and able to collect sufficient revenue and use this to reliably build up funds sufficient to fund periodic battery and panel replacements;
- once the issue of sustainable PV system management has been addressed, a PV implementation project designed to demonstrate the ability of the purpose-designed organisation to achieve its goals. As noted in the section on PV above, this will require a programme of substantial size in each host country, and for the supply of hardware to be progressive and sustained over several years; and
- coconut oil fuel extracted and used on small scales in remote areas.

(3) Fully proven

Many of the proven technologies are either so well proven that they should be left to normal commercial processes, or involve measures such as taxation that are necessarily matters for national governments. Nevertheless, several areas remain where a regional programme could potentially be useful. The options selected are:

- efficiency labelling for appliances, including the necessary liaison with manufacturers, other governments and public education;
- exploration with manufacturers and suppliers of the potential for the supply and promotion of high efficiency refrigerators and freezers optimised for PIC costs and climate;
- support for training and education by providing designs and materials for programmes;
- material and technical assistance to electricity utilities to design and install equipment to increase efficiency of diesel generation, and to identify, design and implement least cost measures to reduce losses in distribution systems;
- investigation utilising biomass for both heat and electricity on smaller scales than presently proven to be fully commercially viable, including specific feasibility studies and pilot implementation and monitoring;
- advice to governments on a mix of measures to improve the energy efficiency of ground transport;
- wood-fuel resource assessment and demand forecasts for each country, and investigation of measures to achieve environmental sustainability of supplies; and
- advice for governments on developments in the treatment of forests in greenhouse gas inventories, on the development of international carbon offset trading agreements that permit the inclusion of forests as carbon sinks, and other means to obtain funding for afforestation or forest preservation such as through the Clean Development Mechanism.

During detailed programme design it may be found that one or more of these is impractical due to constraints imposed by donors, or because institutional limitations cannot be overcome within the time frame of the programme. Even so, it would not be desirable to attempt to implement a programme that contained all elements operating simultaneously. Hence the design should desirably provide for a progression of programme elements, starting with a mix of elements which do not seriously challenge the abilities of existing institutions, such as appliance labelling, and those which lay the ground for success in the more difficult elements, such as utility efficiency improvement.

Climate change caused by greenhouse gases is an issue that is clearly going to take decades rather than years to deal with. Consequently the mitigation programme to be implemented over the next few years should include consideration of the longer term options. The potential of these will only become apparent as the nations of the world grapple with the issue and succeed or fail in their efforts to translate fine intentions into practical performance.

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Annex I: Terms of Reference

Regional Mitigation Analysis

The results of the greenhouse gas inventories undertaken in PICCAP countries (Cook Islands, Federated States of Micronesia, Fiji, Kiribati, Marshall Islands, Nauru, Samoa, Solomon Islands, Tuvalu and Vanuatu) shall form part of the basis for this contract. Applicable existing studies, feasibilities, programmes, and activities, shall also be used as the basis of this contract and contribute to the development of the analysis.

During the Regional Planning Meeting for PICCAP National Coordinators, and at the PICCAP Greenhouse Gas Inventory and Methodology Training Course, held in Apia and Suva in January and April 1998 respectively, countries identified and prioritised the main sectors that they felt should be addressed in the context of mitigation measures to combat climate change. The energy sector was overwhelmingly the first priority; agriculture and transport were secondary priorities.

This mitigation analysis will be done with a view to identifying and promoting long-term measures that will be cost effective and environmentally sustainable. In this context:

(1) The consultant and a Pacific island counterpart shall:

- undertake a review of existing feasibility studies and data related to the mitigation of climate change in the Pacific region. The review should cover the energy sector including renewable energy;
- identify existing and potential options for mitigating climate change through appropriate, affordable and environmentally sound energy use, including options for renewable energy technologies;
- devise a mechanism that could undertake the development and implementation of regional energy-appropriate mitigation options, taking into account the SOPAC/SPC Joint Regional Energy Programme Design (1999–2004); and
- present an overview of existing and potential sinks in PICs as they relate to terrestrial ecosystems, and link those to coastal and marine ecosystems and their management.

(2) In undertaking the review of any studies and data related to climate change mitigation in the Pacific region the consultants should use the the following approaches:

- research and compilation of existing information and studies related to energy and energy technologies being used or proposed for the Pacific region;
- consultations with relevant organisations, agencies, and ministries involved in developing and using energy planning, sources and supplies; and
- take account of linkages with the SOPAC/SPC Joint Regional Energy Programme Design (1999–2004).

(3) The identification of regional mitigation options should be undertaken using the following approaches:

- a cost–benefit analysis of energy technologies currently in use in the Pacific region, including renewables;
- a cost–benefit analysis of energy technologies proposed for the Pacific region, including renewables; and
- consideration of the applicability of identified energy options to the Pacific region.

(4) The consultants should outline and elaborate on how the identified regional mitigation options and the proposed mechanism for the programme could be organised and possibly implemented under a regional energy programme. This should include outlining the viability of having Pacific governments as partners/ owners, and what could be offered to attract private sector investment so as to ensure longer term viability and sustainability. The discussion should:

- outline whether such a mechanism is feasible and why;
- outline how the mechanism could be attractive to private sector investment and why;
- outline strategic approaches to establishing such a mechanism; and
- outline any programme implementation constraints.

(5) The consultants should investigate and outline existing and potential sinks with regard to enhancement and reductions of greenhouse gases in Pacific island countries.

(6) The consultants should assist with and conduct a regional mitigation meeting for PICCAP countries who would consider the outcomes of the regional mitigation analysis with the aim to endorse the analysis and plan the next steps for national implementation of options leading to appropriate implementation.

(7) The consultancy:

- must be completed by 6 November 1998;
- total consultancy time allowed is 60 days;
- the regional consultant will be required to work with and discuss the findings of the consultancy with a Pacific island counterpart. This collaboration is designed to enhance the capacity of the counterpart within the region, and introduce Pacific policy experience and Pacific perspective to the consultancy;
- travel in the Pacific region would include visits to:
  - relevant organisations, e.g. SPREP, SPC, SOPAC
  - up to five selected PICs
  - other applicable organisations
- the consultant will need to undertake extensive interviews and consultations with relevant regional organisations and agencies, national governments and individuals with relevant and appropriate expertise to develop the analysis;
- the consultant shall report to SPREP in two parts:
  - a main report that will contain the substantive and technical information of the analysis;
  - an executive summary for policy-makers (no more than 10 pages).

Annex II: People Consulted

SAMOA

Tuesday 22 September

1. Mr Wayne King, PICCAP Programme Manager, SPREP
2. Mr Suresh Raj, Waste Management Coordinator, SPREP
3. Ms Sili'a Ualesi, Energy Officer, Treasury Department
4. Ms Francis Brebner, Chief Treasury Officer, Treasury Department

Wednesday 23 September

5. Mrs Jan Sinclair, Editorial and Publications Officer, SPREP
6. Mr Tautulu Roebeck, Executive Officer, Treasury
7. Mr Foli Crowley, Acting General Manager, EPC
8. Mr Iulai Lavea, Deputy Director, Treasury

Thursday 24 September

9. Teulealeausumai Atiotio, Distribution, EPC
10. Tile Leia, Generation, EPC
11. Mr Taputoa, Development, EPC
12. Mr Sailimalo Vole Pati Liu, Assistant Director—Environment, Department of Lands, Surveys and Environment (PICCAP National Coordinator)
13. Mr Maselino Sitagata Tominiko, Assistant Secretary, Maritime Division, Ministry of Transport
14. Mr Misi Tupuola, Secretary Transport Control Board, Ministry of Transport
15. Mr Sami Lemalu, Chief Reforestation and Utilization Officer

FIJI

Tuesday 6 October

1. Mr Paul Fairbairn, Energy Coordinator, SOPAC

Wednesday 7 October

2. Mr Leone Limalevu, PICCAP Coordinator, Dept of Environment
3. Mrs Susana Tuisese, Forestry Officer, Department of Forestry
4. Mrs Jenny Bryant-Tokalau, Sustainable Development Advisor, UNDP

Thursday 8 October

5. Mr Devendran Kumaran, Director, Department of Energy
6. Mrs Makereta Sunguturanga, Principal Scientific Officer, Department of Energy
7. Mr Apiliasi Kasa Saubulinayau, Chief Executive Officer, PowerGen
8. Mrs Premila Kumar, Senior Environment Officer, Department of Environment

Friday 9 October

9. Mr Jese Balewai, Head of Personnel, Road Transport Department
10. Dr Surendra Prasad, Head of School, SPAS, USP

Thursday 22 October

11. Hon Tat Tang, Programme Coordinator, Pacific Islands Forests and Trees Support Program

Monday 26 October

12. Mr Rajeshwar Pal, Mechanical Workshop Superintendent, FEA
13. Mr Dan Gunadarsana, Generation Engineer, FEA
14. Mr John Pirie, Former Power Adviser, PREP
15. Mr Nakibae Teuatabo, PICCAP Coordinator, Kiribati

SOLOMON ISLANDS

Monday 12 October

1. Mr Mike Ariki, PICCAP Coordinator
2. Mr Selwyn Riumana, PICCAP GHG Inventory
3. Mr Tia Masolo, PICCAP GHG Inventory
4. Mr Douglas Yee, Vulnerability and Adaptation
5. Anska O'ou, Secretary, National Planning and Development
6. Mrs Ruth Liluqula, Undersecretary, National Planning and Development
7. Eddie Gaza, Consumer Services Engineer, SIEA
8. Mr Martin Razu, Distribution Engineer, SIEA
9. Mr Gregory A Sisiolo, Generation Engineer, SIEQ
10. Mr David Naqu, Principal Forestry Officer, Department of Forestry
11. Mr Kenneth Bulehite, Hydropower Engineer, Department of Energy
12. Mr Johnson Taaru, Department of Road Transport

NEW CALEDONIA

Tuesday 13 October

1. Mr Patrice Courty, Rural Energy Technology Adviser, Rural Energy Development Unit, SPC
2. Mr Richard Mann, Head, Planning Unit, SPC

Wednesday 14 October

3. Dr Bob Dun, Director General, SPC

Thursday 15 October

4. Mr Emmanuel Vincent, Regional Manager, Pacific Energie

KIRIBATI

Tuesday 27 October

1. Rutete Ioteba, Energy Planner

Wednesday 28 October

2. Mrs Tererei Abete, Environment Coordinator
3. Mr Michael Phillips, Environment Impact Assessment Trainer
4. Mr Menate Tenang, Agriculture and Forestry

Thursday 29 October

5. Mr Eita Metai, OIC, Water Unit, PWD
6. Mr Tiira Redfern, Power House Engineer, PUB
7. Mr Peka, Manager of the Plants and Vehicles Unit
8. Mr Pokia Greig, General Manager, PUB
9. Mrs Tairi Tuare, Deputy General Manager, Solar Energy Company
10. Mr Ioteba, Marine Engineer, Kiribati Shipping

Friday 30 October

11. Mrs Tererei Abete, Environment Coordinator

NAURU

Sunday 1 November

1. Mr Joseph Cain, PICCAP Coordinator

FEDERATED STATES OF MICRONESIA

Monday 2 November

1. Mr Maderson Ramon, Officer in Charge of Energy
2. Mr Ken Boit, Sustainable Development Officer
3. Mr Herson Ansen, Division of Resource Management and Forestry
4. Mr Tony Actouka, Energy Officer, Pohnpei State
5. Mr Elton Environment Protection Agency, Pohnpei State
6. Mr Ngukai, Department of Police

COOK ISLANDS

Wednesday 4 November

1. Mr Kelvin Passfield, PICCAP Coordinator
2. Mr Tom Witchman, Private Consultant
3. Mr Mark Brown, Head of Ministry of Agriculture (MoA)
4. Mr Veia Maui, Director of Policy, MoA
5. Mr Anau, Manarangi, Director of Research, MoA
6. Mr Sabati Solomona, Senior Planning Officer, MoA
7. Mr Noora Tokari, Planning Officer, MoA
8. Mr Tereapii Timoti, General Manager Operations, Te Aponga
9. Mr Mareko Reno, Engineer, Te Aponga

Thursday 5 November

10. Mr Kato Tama, Secretary, Ministry of Outer Islands Development (MOID)
11. Mr Tenga, Technical Officer, MOID
12. Mr Nga Mataia, Acting Director, Prime Minister's Office (PMO)
13. Mr Keith, ADB Consultant, PMO
14. Mr Kevin Carr, Finance Secretary, Ministry of Finance (MoF)
15. Mr Kona Browne, Customs
16. Mrs Anna Passfield, Programme Manager, Takitumu Conservation Area
17. Mr Mata Nooroa, Director of Energy, Department of Energy, Ministry of Works Energy and Physical Planning (MOWEPP)
18. Mr Tangi Tereapii, Energy Officer, MOWEPP
19. Mr David Akaruru, MOWEPP

Friday 6 November

20. Mr Manfred Fortsch, Technical Director of Energy, MOID
21. Mr David Lobb, Finance Manager, Ministry of Finance

Annex III: Inventory Data and Calculation Issues

GENERIC

Estimates of emissions and removals from land-use changes and forestry in all cases omit emissions from natural decay. Consequently several countries report substantial net removals (the Solomon Islands is a notable exception due to high rates of harvesting). This gives an erroneous impression of the overall emissions position.

Excretion of nitrogen in pig manure is given as zero by most countries, resulting in zero estimates of nitrogen oxide emissions from this source. This seems to result from some aspect of the template that the countries have not been able to cope with.

Emissions of carbon monoxide, volatile organocarbons, sulphur dioxide, sulphur hexafluoride and fluorocarbons have not been aggregated as too few countries attempted to estimate them to make comparisons or aggregates meaningful.

COOK ISLANDS

Emissions from international transport fuels have been calculated in using calorific values that appear to be thousands of British thermal units (BTUs) per pound, rather than kilojoules per kilogram. This results in emissions from this source being underestimated by 57 per cent. Correct values have been used.

Nitrous oxide emissions from pasture. Total 0.001609245 Gg (i.e. 1.609245 tonnes).

Apparent misunderstandings and information limitations have led to problems in the emissions from solid wastes:

- only Rarotonga included;
- calculation of proportion removed to disposal sites not carried through into emissions calculation; and
- calculation of methane correction factor uses incorrect entries for the proportion of solid waste disposed by type of site.

The effect on total emissions is not clear, but may be small.

Bitumen and lubricants have been treated as 99 per cent oxidised, when they mainly are not.

The areas of some species of plantation forest seem surprisingly high, notably of acacia and Pinus caribaea. One possible source of this problem is that the destruction of much of the Pinus caribaea plantations on Mangaia by wildfire may not have been allowed for. The areas of mixed hardwoods and mixed softwoods would appear to relate to native vegetation, and are not realistically considered as plantations. It would be more realistic to consider these as being in a steady state, rather than as having a biomass increment. The latter areas have been removed in the aggregation tables.

FEDERATED STATES OF MICRONESIA

Some confusion is clear about the conversion of tonnes to terajoules. Two methods have been used and both presented. The correct one is used here.

FIJI

There appears to be a serious error in the quantities of all the fuels exported from Fiji. The quantities are too small in relation to those imported by the countries supplied through Fiji; e.g. gasoline exports are only 220 kL, about 166 tonnes, whereas Samoa alone imports over 17,000 tonnes. Exports of diesel fuel are only 22 kL (20 tonnes). The likely result is that domestic consumption is substantially overstated. This also shows in that known domestic uses are well below apparent domestic consumption; e.g. use of gasoline in road transport is given as 54,092 kL, whereas apparent domestic consumption is 110,641 kL. Comparing total apparent petroleum consumption against international reporting confirms that an error has occurred.

There is confusion between jet kerosene and other kerosene. It is not credible that international aviation bunkers are mostly other, not jet kerosene.

The supply of 101 tonnes of coal to international bunkers is possible, but surprising.

KIRIBATI

The consumption of traditional biomass burned for fuel is estimated at 0.004 kg per person per annum. As a result all emissions from this source are calculated to be miniscule. A more realistic estimate is 0.4 tonnes per person per annum. Hence emissions estimates from this source are increased by 105. The resulting estimates are still modest.

The generation of solid waste is estimated at 0.000049863 kg per person per day (0.5 to 1.5 kg would be more realistic). The estimate of methane generation from MSW seems to have been calculated independently of this generation rate.

The volumes of wastewater and sludge are similarly unrealistically low. The problem derives from the estimates of degradable organic component of wastewater and sludge, which are too small by a factor of 106. It would seem that a number has been divided by 1000 when it should have been multiplied by 1000.

REPUBLIC OF THE MARSHALL ISLANDS

Petroleum quantities are said to be kilotonnes, but must actually be tonnes. Consequently GHGs from fossil fuels have been reduced by 103.

The domestic consumption of jet kerosene is surprisingly high. This may be due to international bunkers not being removed, since none has been allowed for.

The use of coconut husk and shell as fuel has been estimated from copra exports, and seems unrealistically low.

Emissions from solid waste, on the other hand, are estimated from an estimate of solid waste generated of 10 million tonnes, which is unreasonably high. These have been reduced by a factor of 1000.

NAURU

The quantities of fuels imported and consumed are stated to be tonnes x 1000. Based on the size of the figures given, it is assumed that they are tonnes.

Carbon dioxide emissions have been calculated with an assumption that half or more of the carbon in petroleum is stored. For fuels this has been changed to nil stored.

The numbers of pigs stated (10,600) is surprising for Nauru, but is accepted in the absence of an alternate estimate.

The estimates of carbon uptake in the Abandonment of Managed Lands module imply an assumption that the mined out areas are covered with rapidly regrowing vegetation. Since this is not the case, the uptake estimates will be much too high. For the present purposes nil growth is assumed, which will not be far from the actual situation.

SAMOA

Unlike any other country, Samoa has provided inventories for each year from 1994 to 1997. However, the inventories for 1994, 1995 and 1997 are based on identical estimates of fuel imports, with changes in calculated emissions being due only to variations in deductions for international bunkers.

The calorific values used are quoted as terajoules/unit, with the units of fuel being tonnes. However, the factors are actually in units of megajoules/kilogram, equivalent to gigajoules/tonne. To compensate for this, the calculated numbers for carbon content and CO2 emissions have been reduced by a factor of 1000.

The quantity of lubricants reported to be imported in 1994, 1000 tonnes, is surprisingly high relative to the total petroleum fuel used of 44,300 tonnes. The 300 tonnes shown for 1996 would be more typical.

The emissions of nitrous oxide from animal wastes in the soil are estimated at a level that would make this Samoa's dominant GHG emission. Detailed calculations are not provided for 1994, but an incomplete calculation in the 1997 sheets is sufficient to make clear that the correct quantity is much lower. The actual correction required is unclear, but is of the order of a factor of 1000. This factor has been applied here.

The annual rate of aboveground biomass growth on abandoned lands is estimated in the 1997 sheet at 1000 tonnes/ha/year for the first 20 years, and 2000 tonnes/ha/year thereafter. These rates are much too high. Similar problems are likely to have occurred in the 1994 calculations. In addition the detailed sheet does not seem to agree with the summary. In this situation the figures are best disregarded until investigated.

A similar problem occurs in the calculations of the growth by non-forest trees. In this case it seems likely that the growth rates used are too high by a factor of 1000. In addition, the growth is likely to be matched by a similar rate of decay. Net emissions are likely to be small.

SOLOMON ISLANDS

The IPCC detailed worksheets do not appear to have been used except for petroleum. Summary reports only are shown. Consequently, it is not possible to determine whether the emissions, other than carbon dioxide from petroleum, have been correctly calculated.

The volume of jet kerosene is repeated under kerosene, leading to it being double counted. From the tables in Section 7 it would seem that households used a considerable volume of Jet Kerosene as lighting kerosene. This is entirely feasible since the products are very similar.

The entry for international marine bunkers equates to the total supply of all fuels. Aviation bunkers are shown as zero. This would seem to be a misunderstanding over the meaning of the term bunkers.

The methane emissions from manure management are shown as 419 Gg, i.e. 419,000 tonnes. This is an excessively high figure. However, the total of the emissions from the listed types of animals is only 0.416 Gg (416 tonnes), a much more reasonable estimate, and the one used here.

TUVALU

No units are shown for the fuel quantities. The size of the numbers suggests that they are either tonnes or kilolitres. In other cases where this has occurred the unit used can be inferred from the conversion factors to terajoules. However, in Tuvalu's sheets these factors have been rounded to two decimal places and show in the printed sheets only as 0.00. From the quantities of carbon dioxide calculated, the use of kilolitres seems more likely.

Some additional data are given in sectoral reports and in the summary report. Unfortunately the total carbon dioxide in these data is some 2,000 times greater than the total emissions calculated from fuel imports. They greatly exceed what is credible for a country of Tuvalu's size. As no calculations are shown, the reason for this cannot be determined.

VANUATU

Fifty per cent of diesel fuel is assumed to be stored in products. This appears to be a misunderstanding resulting from this assumption being suggested for fuel used as a feedstock. This is not relevant to any PIC since none has a petrochemical industry. Compared to the usual assumption of nil storage, this results in emissions from this source being halved. The emissions have been recalculated with a nil storage assumption.

International marine bunker fuel is assumed to be zero. An explanation is given which indicates that it is small, but there will in practice have been some.

International aviation bunker fuel is stated in the text to have been assumed to be the total of jet kerosene. However, some jet fuel is undoubtedly used by internal aviation. It is noted that the apparent consumption is less than the total supply. It is tempting to allocate the difference to bunkers, but this is unlikely to be the correct explanation.

The estimate of carbon dioxide removed by growth in plantations is very substantial, but its accuracy cannot be checked since the underlying data sheets are not available.

Annex IV: Workshop Timetable

Day 1			
09:00	Introduction	Official opening and introduction of participants and officials Housekeeping matters, timetable general approach	SPREP and Vanuatu Govt SPREP
.	Break	Morning tea	
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10:00	PICCAP	Progress and update of PICCAP	SPREP
.	National approaches	PNG, Niue	SPREP
.	Previous and parallel programmes	Descriptions of programmes such as PREP, SPC renewable energy, SPC forestry, SOPAC, UNDP Power Sector	SPC, SOPAC, UNDP Panel discussion
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11:00	Mitigation study Introduction	Origins of study Mitigation processes	ME, SF
.	Workshop objectives & outputs	Mitigation opportunities not exploited Objectives for PICCAP workshop & expected outputs	ME, SF
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12:00	Break	Lunch	
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13:00	Mitigation Issues	Introduction of issues Interaction with other programmes with GHG implications	ME, SF
.		Parallel working groups on issues	
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14:00		Plenary on issues	
.	Characterisation	Description of the characteristics and measures of options	ME
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15:00	Break	Afternoon tea	
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.	Demand options	Description of demand options	ME, SF
.		Parallel working groups on demand options	
16:00			
.		Plenary review	
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17:00	Close		

Day 2

09:00		Description of supply options	ME, SF
.	Supply options	Parallel working groups on supply options	
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10:00	Break	Morning tea	
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.	Supply options	Plenary review	
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11:00	FORUM	PICCAP and rural electrification	WK, ME, SF to lead
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.	Design criteria	Programme criteria for inclusion Allocation between national and regional	ME
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12:00	Break	Lunch	
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13:00	Option selection	Working groups to discuss and apply criteria to options Plenary session	
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.	Regional programme design		
14:00		Working groups to discuss and make selections	
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.		Plenary session	
.	Summary	Summarise position reached on regional programme	ME
15:00	Break	Afternoon tea	
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.	Funding	Description of funding options and requirements by funding agencies. Proposal for Block B funds for project design under the climate change focal point of the GEF. Panel discussion and plenary session	WK, SPC, UNDP
16:00			
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17:00			
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18:00			
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19:00			
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.	Review	Individual country interpretations of implications of programme proposals for own country	
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20:00			
.		Final plenary on programme content	
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21:00			