Chapter 1 Introduction

1.1 Scenario

It is currently estimated that, worldwide, two billion people live below the poverty line. Seventy percent of humanity living in the developing countries aspires to a better life and an improved standard of living (Goldemberg and Johansson 1995). In order to achieve these aspirations, socio-economic development is essential and cannot be overly constrained in developing countries (United Nations 1993).

For the developing countries, a better life means "satisfying the basic human needs, including access to jobs, food, health services, education, housing, running water, etc." (Goldemberg and Johansson 1995, p9). In providing for these needs, energy is an important element. As the World Commission on Environment and Development (WCED 1987) stressed, energy is necessary for daily survival. The demand and supply of energy have a tremendous impact on human development. Therefore, energy should be taken into account in any development strategy. A safe and sustainable energy pathway is crucial to sustainable development, however, much of the world's energy is currently produced and consumed in ways that are unsustainable (United Nations 1993).

Today's primary sources of energy are mainly non-renewable, such as oil, coal, natural gas and nuclear (WCED 1987). Goldemberg and Johansson (1995, p11) commented that "Most conventional energy strategies fail to meet basic human needs for the majorities in developing countries." Twenty-five years ago, *The Ecologist* (1972) noted that the consumption of energy and raw materials was extremely uneven between the developed and the developing countries. This situation has not changed. Almost about a quarter of the world's population consumes three-quarters of the world's primary energy. For example, the per capita use of energy in a developed country is more than 80 times greater than in sub-Saharan Africa (WCED 1987). In the developing world, three-quarters of humankind live under conditions where the average consumption of energy per capita is at the level achieved in most European nations and in North

America a century ago. Such low energy usage is accompanied by inadequate diets, poor health care, a low degree of industrialisation, and too often, a general socio-economic malaise (Smil & Knowland 1980).

Around the beginning of 1970s, Meadows et al. (1972) in *The Limits to Growth* warned that developed countries were rapidly undermining themselves through pollution and excessive use of natural resources. In 1972, the Stockholm UN Conference on the Human Environment strongly expressed similar concerns about environmental and resource depletion (Foley 1992). With the following oil crises in the 1970s, environmental concern with energy resources surged. Since the 1980s, climate change and local and trans-boundary air pollution have been areas of concern the world over. The combustion of fuels is a major contributor to these atmospheric problems, energy resources and their consumption patterns have been strongly challenged (Barrow 1995; Common 1995; Lowe 1994; Reid 1995; WCED 1987).

Economic growth and growth in energy demand can be seen as challenges to improvement of social equity and environmental quality both for developed and developing nations (Burnett 1992). The WCED (1987, p195) highlighted that "...every effort should be made to develop the potential for renewable energy, which should form the foundation of the global energy structure during the 21st century".

At the United Nations Conference on Environment and Development (UNCED) held in Rio de Janeiro in June 1992, energy issues were debated intensively as an area of concern. *Agenda 21* is a principal outcome of the UNCED and is an action plan for the 1990s and the 21st century. It elaborates strategies and integrated program measures to halt and reverse environmental degradation and to promote sustainable development in all countries. In Chapter 9 of *Agenda 21*, it was agreed that energy sources for sustainable development will need to be applied in ways that respect the atmosphere, human health and the environment as a whole. *Agenda 21* identified the direction for sustainable energy development: firstly, more efficient use of energy and, secondly, greater reliance on environmentally sound energy systems, particularly new and renewable energy sources (United Nations 1993).

1.2 The Pacific Islands and energy issues

The Pacific Island region consists of 22 independent nations and dependent territories. Their geographical fragmentation and remoteness, the small size of the island state landmasses, and their vulnerability to natural disasters are all still fundamental constraints on their socio-economic development. These countries suffer from a shortage of skilled human resources, together with limited financial resources. Population growth in the region is, in some cases, extremely high. In the Solomon Islands, for example, the population growth has reached 3.4 percent, which is the highest in the world (Fairbairn & Worrell 1996). In contrast, economic growth is very low even by comparison with other developing countries. Also, exploitation of natural resources is clearly unsustainable (Stewart 1994). Such constraints also impact on these nations' energy supply, usage and conservation.

Most of the Pacific Island states lack indigenous commercial energy except for Papua New Guinea. Accordingly, the Pacific Island region is heavily dependent on imports of petroleum products to meet the increasing demand for energy. For Pacific Island economies, energy imports are the single largest import item. Many small island countries and territories, such as Guam, the Marshall Islands, Niue, Tokelau, Tuvalu, and Wallis and Futuna pay much more for their fossil fuel imports than they earn in total from their exports (Thistlethwait & Votaw 1992).

Energy issues in the Pacific Island region provide not only constraints on economic development, but are also the cause of local environmental degradation. For example, in order to help to pay for imported petroleum, these island nations have had to increase exports of timber, cash crops and marine products. The South Pacific Regional Environment Program (SPREP) (1992a) pointed out that this has resulted in deforestation, land degradation, plant and animal extinction, groundwater pollution, and overfishing. Shortages of energy supply have limited socio-economic development and employment in rural and remote areas of the region, and have contributed to people migrating from rural and remote areas to urban centres and overseas. Urbanisation due to internal migration has made environmental issues, such as domestic waste disposal, more acute than ever. In densely populated areas, wood supplies for cooking are becoming scarce and mangrove forests have been damaged partly due to excessive harvesting for firewood (SPREP 1992a).

The vulnerable island economies were badly affected by the oil crises of the 1970s. Oil import bills rose sharply to 20 percent of total export earnings after the 1974 price rise and 40 percent after the

1979 price rise (Dunkerley 1985). Higher prices of petroleum products and other imports accelerated inflation resulting in limited foreign exchange was available for other development imports. Since then, the Pacific Islands countries have been motivated to pay attention to energy matters.

In the early 1980s, the region had high expectations for developing indigenous renewable energy resources and as a result, during the 1980-1990 period, the Pacific Islands spent nearly US$430 million dollars on developing renewable energy, mostly via international aid (Rizer & Hansen 1992). At this time then, the majority of regional energy assistance was devoted to the development of renewable energy (Liebenthal et al. 1994).

After UNCED, many governments in the region positively adopted sustainable development as their fundamental national policy for socio-economic development. For instance, in reference to the Cook Islands' National Environmental Management Strategies, Vaine Tairea (the Minister for Environment, the Cook Islands) declared (SPREP 1993a, p.v):

> ...development is moving rapidly as we approach the 21st century and we must now develop clear environmental legislation, policies and strategies to guide our developmental activities to ensure that our future development is truly sustainable.

As a broad policy framework, SPREP (1992b) has recommended that ecologically sustainable development has the potential for a fundamental policy direction to resolve socio-economic, energy and environmental problems for the Pacific Island region. It has also been suggested that future efforts should go towards establishing an energy system for the Pacific Island region that uses renewable energy resources to meet local energy needs in a way that is socially and culturally acceptable, environmentally sound, economically feasible, and technologically suitable. SPREP (1992a, p49) has declared that its energy policy aims are to:

> ... develop and disseminate economically sustainable, clean, renewable, moderate-scale energy production technology in cooperation with Pacific Island Developing Countries (PIDCs), initially to complement but eventually to replace existing unsustainable energy systems in the Pacific.

However, the transition of energy systems from the unsustainable to the sustainable potentially involves a large degree of economic, technological, policy and institutional adjustment, and is long term, difficult, and involves risk. A statement was clearly issued by SPREP (1992a, p9):

> Our drive towards economic self-reliance is central to the social and economic development of the region. Our cooperative history of development and our consensus approach to problem resolution mean that the goal of sustainable development to which we are committed has every chance of being attained. SPREP, the South Pacific Commission (SPC) and the South Pacific Forum (SPF) are all intergovernmental bodies in the region that, through this consensus approach, have been important to our preparations for United Nations Conference on Environment and Development (UNCED). But we also appreciate that this is not a goal we can hope to achieve on our own. We recognise that the achievement of our goal will require close cooperation with other regions of the world and the continued assistance of the international community. We are ready to play our part.

1.3 Hypotheses, purpose and objectives

International aid from developed countries and international organisations plays an important role in the economic self-reliance, maintenance of social equity and environmental protection of the Pacific Island region. Availability of international aid is a key factor in the development of sustainable energy systems in the region. For example, Australia is one of the Pacific Island nations' closest geographic neighbours and has traditionally been a major donor country to the region. As a developed country and a member of SPREP, Australian policies and activities in the international aid area will significantly affect the future of the region. Australia could potentially make an important contribution in terms of the development of sustainable energy systems in the region.

At the opening of the 25th South Pacific Forum in Brisbane on August 1, 1994, Mr. Paul Keating, the former Australian Prime Minister, said to 14 Pacific Island leaders that the region's problems could no longer be left for the next generation to solve (Stewart 1994). This is a commendable attitude. However, the most important and useful factor in the resolution of the region's problems will be how developed countries help the Pacific Island nations to resolve their problems.

The hypotheses of this thesis are:

- Renewable energy is the most appropriate energy source for the needs of Pacific Island countries.

- International aid directed to the Pacific Island region can play an important role in promoting the use of sustainable energy systems.

The main proposes of this thesis are to:

- Discuss the main socio-economic, political, cultural and environmental issues with respect to developing sustainable energy systems in the Pacific Island nations.

- Examine the theory and practice of international aid or cooperation for the development of sustainable energy systems in the Pacific Island region.

- Provide some recommendations for developed countries and international organisations with regard to supporting diverse renewable energy systems in the region.

The objectives of this thesis are to:

- Establish a framework for energy policymaking. As a tool of analysis, it could help island governments in the region to formulate appropriate energy policies; and present a clear picture to donors for selecting energy programs or projects that should be given assistance.

- Review international aid and cooperation to date in terms of the appropriateness of human resources and institutional development, trade, financial support and technology assistance to help the Pacific Islands realise the transition from existing unsustainable energy systems to sustainable ones.

- Analyse donors' domestic issues, such as their industry, energy, environmental policy; their socio-economic development; their international relationships, trade and diplomatic strategies.

- Identify the best means of encouraging investment in, and improving development of, sustainable energy systems in the light of institutional frameworks, policy and implementation regarding international aid and cooperation.

1.4 Research approaches

There is great geographic, cultural, historic, political, socio-economic and natural resource diversity within the Pacific Island region. In the region, also, energy problems are embedded in a wider range

of issues. Different nations have different access to socio-economic development and energy resources. The form and type of renewable energy systems currently in use vary from country to country. In order to look at the present energy systems and the future potential for developing renewable energy in the region, case studies of Fiji, Kiribati, Nauru, the Cook Islands, and Western Samoa have been employed.

The case studies focus on socio-economic background, culture, environment, governmental energy policy, human resources, institutional development, international aid, and other related energy issues in the region. The decision to choose these five countries was mainly based on the following three factors:

- *Different geographic and cultural groupings.* Fiji is a Melanesian country; Kiribati and Nauru belong to Micronesia; and the Cook Islands and Western Samoa are Polynesian countries. Fiji is comprised of large, rugged, mainly volcanic islands which are extensions of undersea mountain ranges. The Cook Islands and Western Samoa are raised coral islands surrounded by fringing reefs. Kiribati lies in the mid-Pacific, astride both the equator and the International Date Line. It consists of low-lying atolls, and its elevation does not exceed five metres, being in most places between one and two metres. Nauru is a tiny coral island nation situated in the Central Pacific 3,000 km to the northeast of Australia.

- *Economic development scale.* Nauru is one of the largest exporters of phosphates in the world. Phosphate mining and export is Nauru's main economic base. In 1992, its gross domestic product (GDP) was up to US$123 million (Poirine 1995). Fiji is a diversified middle-income country. In 1992, its total GDP exceeded US$1.5 billion (Poirine 1995). In the same year, however, Western Samoa's total GDP was above US$152 million (Poirine 1995). The total GDPs of the Cook Islands and Kiribati were respectively around US$72 million and US$58 million (Poirine 1995).

- *Indigenous renewable energy resources.* Fiji and Western Samoa have abundant hydro, solar and biomass resources. Especially in Fiji, hydropower has been successfully developed. The Cook Islands also have solar and biomass resources; wind and hydro potential will need to be determined in the future. Kiribati has solar resources, but no

hydropower potential. Nauru is well endowed with solar energy resources. Ocean thermal energy conversion may be a major renewable energy source for Nauru in the future.

In order to review the situation regarding international aid for renewable energy in the region, a survey was conducted of 13 bilateral donor countries, and 13 regional and international organisations. As a major donor country in the Pacific Island region, Australia's international aid policies and its domestic issues regarding aid for renewable energy in the region were examined.

In this study, the main methods for research employed included both direct approaches and documentary research. The direct approaches involved face to face, in depth, semi-structured interviews and discussions with government officers, energy suppliers and consumers in the Pacific Islands. Donors, regional and international organisations, as well as Australia's renewable energy industries and research institutes were also approached. Fax letters, e-mails, and telephone calls were also used for obtaining information from individuals and organisations.

Documentary research included searching publications, government documents and unpublished papers.

1.5 Structure of the thesis

In order to provide information about the current international aid that contributes to the development of renewable energy systems in the Pacific Island region, this research has specifically focused on international aid policies and the related domestic issues of donors. To date, studies on international aid for the development of renewable energy in the Pacific Islands have been minimal. Very little literature exists in this field and, in particular, evaluation of Australian international aid policies and activities with respect to renewable energy in the region is untraversed territory. This research thus fills a major gap in the study of international aid policy associated with the development of renewable energy systems in the Pacific Islands.

There are ten chapters in the thesis. Chapter 1 is a general introduction to the thesis and the research approach employed. Chapter 2 mainly gives historical perspective on energy development and the use of renewable energy in the Pacific Islands. Chapter 3, as background to the rest of the thesis, describes the socio-economic, energy, environmental and cultural status of the Pacific Islands.

Chapter 4 gives an overview of the existing energy systems used in the region. In Chapter 5, the energy issues of Fiji, Kiribati, Nauru, the Cook Islands, and Western Samoa are closely looked at in detail as case studies, to provide information about the energy problems and current limitations on further introduction of renewable energy in the region.

In Chapter 6, a suggested framework for energy policymaking in the Pacific Islands is outlined, in order to examine further energy policy prospects in the region. To explain how the framework is applicable to formulating energy policies, energy policymaking in Kiribati is analysed as an example.

Chapter 7 concentrates on issues for international aid with respect to the development of renewable energy in the region. As a part of this study, a survey was carried out to reveal the trends of international aid for sustainable energy since the late of 1970s; the main findings of this survey are discussed.

In Chapter 8, Australian foreign aid and domestic issues associated with developing renewable energy in the region are discussed as key issues for further exploring international assistance or cooperation. In Chapter 9, the main issues forthcoming from the research are discussed. Based on this discussion, the main conclusions and recommendations are presented. Finally, Chapter 10 draws together the major outcomes of this study.

Chapter 2 Renewable energy and the Pacific Islands: an historical overview*

2.1 Introduction

In the Pacific Islands, most of the renewable energy systems installed to date, have not been particularly successful. In this chapter, the reasons for the failure of these systems that are raised in the literature are overviewed.

2.2 Energy resources and the role of renewables in the Pacific Islands

Energy is one of the fundamental needs of human society and provides a motivating force for all human economic activities. Low energy consumption is used as an indicator for poverty, and is related to concerns such as poor education, bad health care, and hardships imposed on women and children (Goldemberg & Johansson 1995). As with science, technology and social development, energy production and use exercises a great influence on national economies, accelerating or retarding their growth or revising their structure (Liu 1987).

Cheap energy stimulates economies. Expensive energy chokes them. The world oil crises of 1973 and 1979 triggered steep rises in prices of petroleum products, choking world economic growth and leading to economic stagnation (The Cook Islands Government 1988). The World economy grew in real terms in 1973 at the record rate of 6.4 percent in terms of real gross national product (GNP), but in 1974 the rate of growth fell dramatically to one percent (United Nations 1976).

Owing to the absence of fossil fuel reserves in the Pacific Island region except Papua New Guinea (PNG), most of the island nations are almost totally dependent on a supply of seaborne petroleum products. Imports of fuel are a major constraint to sustainable socio-economic development and environmental protection in the region. The Pacific Island economies and societies were adversely affected by rising costs of imported fuel during the years following the oil crises of 1973 and 1979.

In some Pacific Islands, such as Niue, the Marshall Islands, Tokelau and Tuvalu, the import bills for fuel alone exceed their total export earnings (East-West Centre 1982; SPREP 1992a). Fiji is one of the larger and more developed Pacific Island nations (Australian International Development

* Sections of Chapter 2 have been published in the papers: Yu et al. (1997a); Yu & Taplin (1997a & 1998).

Assistance Bureau 1992a). Its growth rate in terms of GNP was 12.7 percent in 1973. However, in 1974 the rate of growth fell to 2.6 percent and then continually to 0.2 percent in 1975 (United Nations 1977).

Since the first oil crisis in 1973-74, the higher cost of imported fuel and the threat of shortages prompted the assessment of energy needs and increased the incentive to develop indigenous energy resources in the Pacific Islands. For instance, over 80 percent of the Pacific Island countries placed emphasis on the need for renewable energy resources in their National Reports to the UNCED (SPREP 1992a). In American Samoa, the Commonwealth of the Northern Mariana Islands, the Federated States of Micronesia, Guam, and the Republic of the Marshall Islands and Palau, more than a total of 100 renewable energy projects have been conducted since the mid-1970s (Takahashi & Woodruff 1990).

The Pacific Island governments had high expectations for the development of indigenous renewable energy resources (World Bank 1992). In order to develop indigenous renewable energy resources, wide ranges of efforts were experimented with demonstration projects, feasibility studies, engineering surveys, and commercial development. A variety of technologies were involved such as: large and small scale hydro power; small scale wind power systems; wind-driven water pumps; solar photovoltaic (PV); solar water heaters; heat pumps; biomass based steam power; biogas from animal dung and municipal waste; biomass gasifiers; and alcohol fuel, coconut oil, wood and charcoal stoves. A number of studies have also been carried out on: the potential of experimental tree farms for the production of firewood, renewable transportation fuels; more efficient end-use equipment; geothermal energy; ocean thermal energy conversion (OTEC); and tidal and sea wave power (Institute of Natural Resources 1994; Takahashi & Woodruff 1990; World Bank 1992).

During the last 20 years, the installation of hydropower and solar energy systems has been successful in some island countries. Unfortunately, however, most renewable energy systems have not made a marked contribution to the energy supply in the region as a whole. There are many causes as to why renewable energy systems have not had a marked impact. The provision of international aid for developing renewable energy in the region has been one factor. Other main problems that have been raised (Liebenthal et al. 1994; Rizer & Hansen 1992; Takahashi & Woodruff 1990; World Bank 1992) are:

- *Inappropriate projects.* Frequently, project ideas have originated from those interested in carrying out the project rather than from an objective assessment, and often the proposals have been marred by over-optimistic assumptions about costs, reliability, and the skills required to manage the proposed projects.

- *Donor preferences.* Frequently, donors prefer short term funding commitments (1 to 3 years) for capital costs of projects, rather than longer term support (5 or more years) for institutional development.

- *Lack of training, support, and commitment.* Most of the renewable energy projects have not adequately trained the local people in system operation and maintenance and have not included adequate support for local organisations to plan, operate, maintain, manage, finance, expand, and evaluate the projects.

- *Problems associated with remoteness.* The physical remoteness of the islands has made it difficult to supervise projects, provide maintenance and spare parts, and attract high quality consultants and contractors. Further, the remoteness has meant that there is limited understanding of the social, economic, and geographic characteristics of the area.

Besides these factors mentioned above, an important issue needs to be emphasised: some donors do not give positive support and long term aid for renewable energy systems in the region, due to their own domestic issues and self interest.

In order to establish renewable energy systems in the Pacific Islands, the issues mentioned above need to be resolved. Attempts to answer these problems have been addressed via the following main approaches: the technological approach; energy conservation and end-use efficiency; the institutional approach; the social, political, cultural and community approach; and the international aid approach.

2.3 The technological approach

Technology is a vital agent for the development of the Pacific Islands (Marjoram n.d.). The cost of production is a fundamental factor to any energy system. At present, development of many renewable energy resources has not achieved commercial success. This is due to their costs being higher than conventional energy resources, hence they cannot compete with conventional energy.

Reducing the cost of energy systems is the main challenge in establishing renewable energy systems. Taking solar technology as an example, the cost of production of PV panels has dropped from $1,000 per peak watt in 1958 to around $5 per watt in 1989. By 2000, the costs are expected to drop to $2 per peak watt (Prasad 1991).

As a product or a process, technology is usually invented and introduced because it is a new or improved way of tackling an existing or perceived problem. Technology can be invented and developed locally, but often technology transfer occurs from outside. When the cause of failure for renewable energy is analysed, a common complaint is that local people cannot properly operate and maintain equipment (World Bank 1992). However, Marjoram (n.d.) argued that the main problems with the introduction of technology to the Pacific Islands is generally due to the fact that technology derives from large developed countries with a completely different socio-economic and environmental context to the small island countries. The technology is thereby liable to be a poor fit in the Pacific Islands. Marjoram (p.6) further explained that:

> Technology transferred into Pacific Islands is often too big and too complex - often very few local people understand how it works or how to maintain and repair it. Also, much of the technology used in the islands is not originally intended for such rugged conditions - for example, the outboard motor, intended mainly for the Western leisure market. The technology may perform inefficiently, and because of poor maintenance breakdown quickly, the cause of breakdown being difficult to diagnose and spare parts difficult to obtain.

As Schaeffer, Program Manager of the World Bank's Asia Alternative Energy Unit, pointed out, the right technology at the right price is still the key to applying alternative energies (Regional Energy Resources Information Centre (RERIC) 1993a). The introduction of new technology may also cause negative social and environmental changes, just as the supply and conversion technologies used by the developed countries are not sustainable in the long term. This is because they are too costly, inefficient and damaging to the global and local ecosystems.

As to the choice of energy system in the Pacific Island region, especially in rural and remote areas, diverse, small scale, sustainable energy systems have been found to be more suitable than others. Schumacher (1973, p168) suggested that "...intermediate technology would also fit much more smoothly into the relatively unsophisticated environment in which it is to be utilised." This is because in this technology the equipment would be fairly simple, easy to understand and suitable for

maintenance and 'on the spot' repairs. Also, human resources for technical support are more easily trained, and supervision and organisation are simpler than for conventional energy.

WCED (1987, p194) further mentioned that "Most renewable energy systems operate best at small to medium scales, ideally suited for rural and suburban applications." Generally, they are labour intensive and this is better for increasing employment. Also, they are less susceptible than fossil fuels to wild price fluctuations and foreign exchange costs. In addition, most countries have some renewable resources, and their use can help nations towards self-reliance.

Lowe (1990) suggested that use of energy efficient end-use technology and a mix of small-scale local supply technologies could match the diverse demand. Also, Prasad (1991) highlighted that in the next 10 to 20 years, renewable energy systems should play a very strong role in increasing energy self-sufficiency. However, this will depend on the future costs of equipment, advances in technology, economic growth and the demand for energy.

The Pacific Island countries, however, need access to other resources, such as capital to finance energy investments. The development of energy systems also requires resources such as skilled personnel. In the region, the shortage of skilled personnel is serious problem for the future. The education and training of personnel is as important as technology. Without the development of education and training, it is not surprising that even though there is suitable technology it still cannot be operated and maintained in the right way by local people.

It should also be emphasised that the enlargement of markets is another approach for reducing costs of renewable energy systems. Market distortions, lack of information and lack of interest of utilities have slowed down the expansion of renewable energy markets. Current energy pricing policy in most of the world emphasises subsidised tariffs for rural electricity. This represents a market distortion which renewable energy suppliers would find hard to beat. For example, real pricing of current rural schemes could result in an estimated high kWh cost of around 20 cents, which would open new opportunities for solar PV use (RERIC 1993a).

The difference in cost structure of renewable energy to conventional energy is a major financial constraint for growth of the market. Solar PV power, for example, involves major expenditure in initial capital investment rather than in running costs. If cost analysis is based on life cycle costing, solar PV is competitive with conventional energy without consideration of social and environmental

costs for rural and remote areas. But translating this into practical use of solar PV requires alterations in thinking in relation to traditional accounting and financing procedures (Liebenthal et al. 1994).

Involvement of the private sector could result in more sustainable outcomes in energy supply. This is because the public sector in the Pacific Islands tends to concern itself with large-scale generation projects, utilising donor support. Moreover, effective decentralised use of solar PV power depends on a 'responsive service capability', which is less likely from larger, more bureaucratic organisations (eg Kiribati Solar Energy Company).

2.4 Energy conservation and end-use efficiency

Some studies (Eden et al. 1981; FairClough 1993; Lowe 1994a; Organisation for Economic Co-operation and Development 1992; Reddy & Goldemberg 1990) have stressed the promotion of efficient energy use. They argue energy conservation can make a valuable contribution to the standard of living and economic growth. At the national level, they reason energy conservation can help the balance of payments through reduction in fuel imports, or through permitting extra exports. These researchers also point out, from a global viewpoint, that energy conservation is essential because it will promote continual economic growth and raise living standards throughout the world. At the same time, they argue that pursuit of energy conservation will provide enough time for the transition of energy systems from conventional to renewable.

It is also noted by Lowe (1994a) that energy conservation is more economical than introducing new supply technology. This is because conservation investments are typically small scale, more flexible and provide much more rapid returns on invested capital. In developing countries, there is a lot of potential for energy efficiency. As a whole, 30 percent of the total energy use in developing countries consists of non-commercial fuels (such as biomass fuels), and this approaches more than 50 percent in many of the poorest countries (Goldemberg & Johansson 1995). Such energy is used in extremely inefficient ways. Also, the end-use efficiency of commercial energy could be significantly increased.

Some analyses show that efficient use of energy would make it possible to achieve considerable improvements in living standards without significantly increasing per capita energy use above the present level. Goldemberg and Johansson (1995, p13) explain that developing countries could reach

"the West European material standard of living during the 1970s with energy requirements as low as 1 kW per capita, which is only about 20 percent higher than the 1985 level in developing countries." One Japanese study claims that developing countries can reduce energy needs by as much as 17 percent by adopting small energy-saving steps (RERIC 1993b). However, energy conservation and end-use efficiency in developing countries should not be achieved through a decrease in services. The same services should be delivered with less energy consumed or more services with the same energy.

Socio-economic growth in poorer countries is perceived as a necessary precondition for sustainable development (FairClough 1993). This socio-economic growth needs energy. In order to relieve poverty and promote economic self-reliance, according to Reddy and Goldemberg (1990) developing countries should achieve annual GDP growth rates of between five and 10 percent.

Due to the demand for energy in the Pacific Island region, which is continuously increasing, the promotion of renewable energy systems cannot be postponed. Moreover, energy conservation will require: improvements in technology and equipment, a change in people's energy-consuming habits, constant cooperation from industry, commerce and management, including tariff reform, and support from developed countries and international organisations.

2.5 The institutional approach

Management and planning of the energy sector is of critical importance for the development of renewable energy. Management and planning of energy systems should involve a process of devising projects that use indigenous resources to meet local energy needs in a way that is socially and culturally acceptable, environmentally sound, and economically feasible. The purpose of such planning and management is to avoid the pitfalls of energy projects which are not accepted by the consumers who are meant to benefit from them, an example of this is inappropriate technologies, which are not economically feasible, and ignore the human resource and environmental limitation.

In the Pacific Island region, most government run energy agencies are weak and ineffective in terms of planning and management (World Bank 1992). The Pacific Island nations are attempting to manage and plan for the energy sector with too few financial and personnel resources. Rizer and Hansen (1992) argued that the success of renewable energy systems is dependent on the

improvement of planning and management capacity in the energy sector. Based on the Pacific Regional Energy Assessment, the World Bank (1992, p.vii) strongly recommended that:

> ...the governments streamline their involvement in the energy sector by using their powers only to define the policy framework and ensure that agreed objectives are met in an efficient, sustainable and socially equitable manner. Government should not be involved in the direct administration, implementation or maintenance of energy projects but rather rely on private or government-owned enterprises. If appropriate companies do not exist, the government should consider creating them, but should not become involved in their operation. In addition to streamlining their energy management functions, governments should also support the development of the energy sector by enhancing the supply of technical manpower, addressing environmental concerns, coordinating assistance from the donors and strengthening regional cooperation.

Since the 1970s, a number of institutional approaches have been attempted in the region, but so far most of them have failed to deliver reliable electric power to the consumers. However, Tuvalu Solar Electric Cooperative Society (TSECS) has been successful in providing rural consumers with solar power through cooperative owned, installed, and periodically maintained systems with fee collections. According to the experiences of Tuvalu and other Pacific Island nations, Liebenthal et al. (1994) suggested that in the future, institutional considerations would be critical in determining the success of renewable energy systems. They concluded that in the future, the main challenge in the region for the application of renewable energy resources would be the development of an appropriate institutional approach.

Indeed, an institutional approach is fundamentally important to the development of renewable energy systems. However, it should not be forgotten that most of the island nations have limited resources in both finance and skilled personnel. Their financial capability does not allow them to employ more foreign experts. In the short term, it seems that it will be virtually impossible to significantly improve the management and planning of the energy sector. Also, the institutional approach cannot replace other approaches, such as improvement of technology, economic incentives and international aid. For instance, the expansion of solar lighting systems in Tuvalu is limited by the supply of new solar PV units. At present the Tuvalu Solar Electric Cooperative Society does not have the capital to provide new installations and it needs help from the European Community (Liebenthal et al. 1994).

2.6 Social, political, cultural and community approach

Norimarna (1992) employed a culturally based determining approach in his PhD study. The study was based on a philosophy of development, which could be widely accepted by the islanders in the Pacific Island countries. Norimarna looked at their indigenous values (such as love, collective spirit, and harmonious relationship between *God-human-nature*) and compared these with Western values (such as efficiency, achievement, and rationality). Norimarna suggested that both sets of values are important in the development process for renewable energy, under the given socio-economic circumstances of island countries.

In his study, Norimarna developed a strategy of implementation for renewable energy systems. This strategy includes three basic elements: a community focus, ecological soundness, and a holistic approach. These elements are linked to political, socio-economic, cultural/traditional, technological, and environmental issues as a whole. Norimarna expected the development of the energy sector to lower the already high level of dependency on foreign assistance. Norimarna argued that if energy supply and consumption raise the dependency level in the region, then, "the real meaning of political independence will be diluted" (p44). He further argued that substitution of imported fossil fuels with local renewable resources would certainly improve the balance of payments of the island countries a great deal.

However, Norimarna also suggested that it would be difficult to establish, at least at present and in the near future, well managed renewable energy systems for the island communities of developing countries. This is because in the islands of developing countries, the socio-economic, technological, environmental, cultural/traditional and political conditions are not yet favourable enough to be able to develop renewable energy (Norimarna 1992).

Local community involvement could be a successful approach to developing renewable energy in the region. A Sydney based non-government organisation, Appropriate Technology Community and Environment (APACE), has demonstrated this approach with its experiences in the Pacific Island region. One of APACE's main aims is to encourage scientists and technologists to use their skills to devise new means of responding to the challenges posed by the deteriorating environment (Waddell 1993). Since the 1980s, APACE has carried out many small rural hydro electrification projects in the region, especially in the Solomon Islands. During the implementation of these projects, APACE encouraged local village communities to participate in discussions and the design of projects. The

local communities also participated in the construction of civil works, installation of machinery, and testing of electrical cables. After the construction of these projects, local communities have continued to successfully operate these power systems including load management and maintenance. The Voko hydropower scheme in the western Solomons, during its thirteen years of operation, has had minimal outside assistance (Bryce et al. 1995).

2.7 The international aid approach

Energy is a fundamental ingredient in the economic development of the provision of affordable and reliable energy supplies. The demand for energy has rapidly grown, and further increases in energy requirements will be unavoidable in the years to come. The development of renewable energy systems will require a major mobilisation of resources. The World Bank estimated that investment needs of the energy sector in developing countries would be over $50 billion a year (1980 dollars) during the 1990s (Dunkerley & Ramsay 1982). Due to scarcity of financial resources, developing countries have struggled against formidable hardships to meet growing energy needs with a corresponding deterioration in living standards (Munasinghe 1992).

The economic independence of Pacific Island nations is not possible without self-reliance in energy supply. The Pacific Island people face an extremely vulnerable situation in the areas of the physical environment, economy, finance, industry and technology. International aid could be a key approach to the development of renewable energy in the region. It may also be noted that international aid has contributed in other ways such as, technology transition, financing of renewable energy, energy conservation, human resource and institutional development, as well as the adjustment of economic structure.

It has been predicted (Rose 1993) that over the next 30 years, an unprecedented global boom in the use of renewable energy sources will take place. By 2020, wind energy is expected to reach some 85 million tons of oil equivalent (Mtoe), nearly a hundredfold increase from today (Rose 1993). The amount of solar energy is expected to increase tenfold, reaching 109 Mtoe (Rose 1993). Modern biomass energy, such as bio-fuels, municipal waste incineration, and agricultural residues, will double, reaching 243 Mtoe (Rose 1993). This boom in new renewable energy is not expected to be confined to any particular region of the globe.

The Pacific Rim including China will account for a further fifth of the world's renewable energy consumption and will develop the entire range of renewable energy technologies (Rose 1993). Western Europe will also exploit the entire range of renewable energy resources and will account for 15 percent of the world's consumption of renewable energy (Rose 1993). North America will generate a quarter of the world's renewable energy consisting of biomass, wind, solar and geothermal energy (Rose 1993). Latin America will contribute a fifth of the world's total, mainly from biomass and solar energy (Rose 1993). Patterson (1993, p46) stressed that:

> Given adequate support, renewable energy technology can meet much of the growing demand at prices lower than those usually forecast for conventional energy. By the middle of the 21st century, renewable energy sources could account for three-fifths of the world's electricity market and two fifths of the market for fuels used directly. ... By 2050 global carbon dioxide emissions would be reduced to 75% of their 1985 levels. Such benefits could be achieved at no additional cost.

For the Pacific Island region, Rizer and Hansen (1992, p21) also mentioned that:

> Although there is considerable potential for both large and, especially, small hydro projects in the islands region, the overwhelming majority of these will not be developed without support from the Asian Development Bank and World Bank or assistance from Japanese, German, Chinese, South Korean, US or other aid donors.

In 1970, the United Nations set a target of 0.7 percent of GNP for official development assistance (ODA) (Hayden 1987; Remenyi 1991). In 1992 at the United Nations Conference on Environment and Development in Rio de Janeiro, the UN target of 0.7 percent of GNP for ODA was reaffirmed by industrial countries (Fuavao 1993). However, the official development assistance from members of the Organisation for Economic Cooperation and Development (OECD) has fallen sharply in recent years and the ODA/GNP ratio was 0.27 percent in 1995 (see Table 2.1). This is the lowest on record since the UN in 1970 (Commonwealth of Australia 1996a) adopted the 0.7 percent goal.

Since the 1970s, many developed countries and international organisations, such as France, the United States, Japan, New Zealand, the Asian Development Bank (ADB), European Union and the United Nations Development Program (UNDP) have made successful contributions to the development of renewable energy systems in the Pacific Islands. Australia made its effort towards the application of biomass energy in the region in the 1980s. However, in more recent years,

different donor countries have contributed differently to process of the development of renewable energy systems in the region.

In the 1980s, the Territory of French Polynesia, the French Atomic Energy Commission, and the French Agency for Energy Management supported the South Pacific Institute of Renewable Energy (SPIRE) in designing, testing and promoting renewable energy systems (Takahashi & Woodruff 1990). Nowadays the French Polynesia's solar technology systems have become well known in the region. These solar systems have not only been used in French Polynesia but also in New Caledonia, the Cook Islands, Vanuatu and several other places in the Pacific Island region, as well as in Africa, India and France (Australian Broadcasting Corporation 1993).

Interestingly, American foreign aid for renewable energy projects did increase for the fiscal year 1993. Fifteen million dollars was set aside for renewable energy projects overseas and the budget available to the Office of Energy of the US Agency for International Development (USAID) was increased from $20 million to $25 million (RERIC 1992). In the last decade, Australia has supported some renewable energy projects in the region. However, since the 1990s, Australia has almost stopped assisting any renewable energy projects in the Pacific Islands via its bilateral aid program.

The development of renewable energy is not the main task and interest of the Australian Agency for International Development (AusAID). So far, Australia has not had an international aid policy for renewable energy in the region (Vardor, Director of Pacific Islands Section II, AusAID & Fisher, former Assistant Secretary of Energy Environment Branch, Department of Primary Industries and Energy 1994, pers. comm. 13 September).

Normally, any donor country's foreign aid policies, diplomatic policies, and international relationships with recipients are largely determined by the donor country's domestic issues. Although international affairs and relationships often influence a donor's foreign aid policies, the donor's self interests and domestic issues play a more important role. Ultimately, foreign aid policy is a policy decided in relation to donor nation's domestic level policy. It is reasonable to assume that this is the reason why Australia has not provided positive support for developing renewable energy systems in the region since 1990. This is because Australia has its own national interest and domestic

issues, such as politics, the economy, industry, energy, trade, public attitudes to foreign aid and international relationships that influence how Australian aid is distributed.

Table 2.1 Official development assistance in 1995*

Donor country	Net ODA (US$billion)	ODA/GNP (%)
Denmark	1.6	0.97
Norway	1.25	0.87
Sweden	1.9	0.85
Netherlands	3.3	0.80
France	8.4	0.55
Canada	2.1	0.39
Belgium	1.03	0.38
Australia	1.14	0.34
Switzerland	1.08	0.34
Finland	0.39	0.32
Austria	0.75	0.32
Germany	7.5	0.31
United Kingdom	3.2	0.29
Japan	14.4	0.28
Ireland	0.14	0.27
Portugal	0.27	0.27
New Zealand	0.12	0.23
Spain	1.3	0.23
Italy	1.5	0.14
Luxembourg	n.a.	n.a.
United States	7.3	0.10
	Total: 58.73	Average: 0.27

Source: Commonwealth of Australia (1996a).

*Deposit method of calculation.

2.8 Conclusion

This Chapter has examined past approaches used and influences on establishing renewable energy systems in the Pacific Islands. It highlights that international aid would be a fundamental support for further development of renewable energy in the region.

Chapter 3 Socio-economic, cultural, historical and environmental background*

3.1 Introduction

Energy issues are always interwoven with political, economic, cultural, environmental, technological and educational issues. A better understanding of the history, culture and political status of these island nations and an understanding of their socio-economic and physical environments is necessary to recognise their energy issues and develop renewable energy. In this Chapter, the geographic characteristics, history and culture, political status, socio-economic development, and environmental management issues of the region are introduced.

3.2 Geographic characteristics

The Pacific Island region is one of the world's three major concentrations of microstates, the others being the Caribbean and Persian Gulf States (Senate Standing Committee on Foreign Affairs and Defence 1978). The combined Exclusive Economic Zones (EEZs) of the Pacific Island nations cover more than 30 million square kilometres of the Pacific ocean (an area one third larger than the former Soviet Union, more than three times larger than China, seven times the area of the Caribbean, ten times the size of India and about one-sixth of the globe's surface). But their landmass is less than two percent of that total (SPREP 1992).

As an island zone, the Pacific Island region is geographically fragmented. Some tens of thousands of islands are dispersed over the region, ranging from tiny coral islets like Minerva Reef, barely visible above the surface in comparison with big volcanic islands like Fiji's Viti Levu and New Caledonia's 'La Grande Terre' (Howard & Durutalo 1987; Oliver 1977). The region stretches north from the Northern Mariana Islands and Palau, and west to New Caledonia, and southeast to French Polynesia and the Pitcairn Islands (see Map 3.1).

There are four geological types of island in the region: (i) continental islands, which are part of undersea mountain ranges; (ii) volcanic islands, which are peaks of dormant or active undersea volcanoes and are often surrounded by fringing reefs; (iii) raised limestone islands composed

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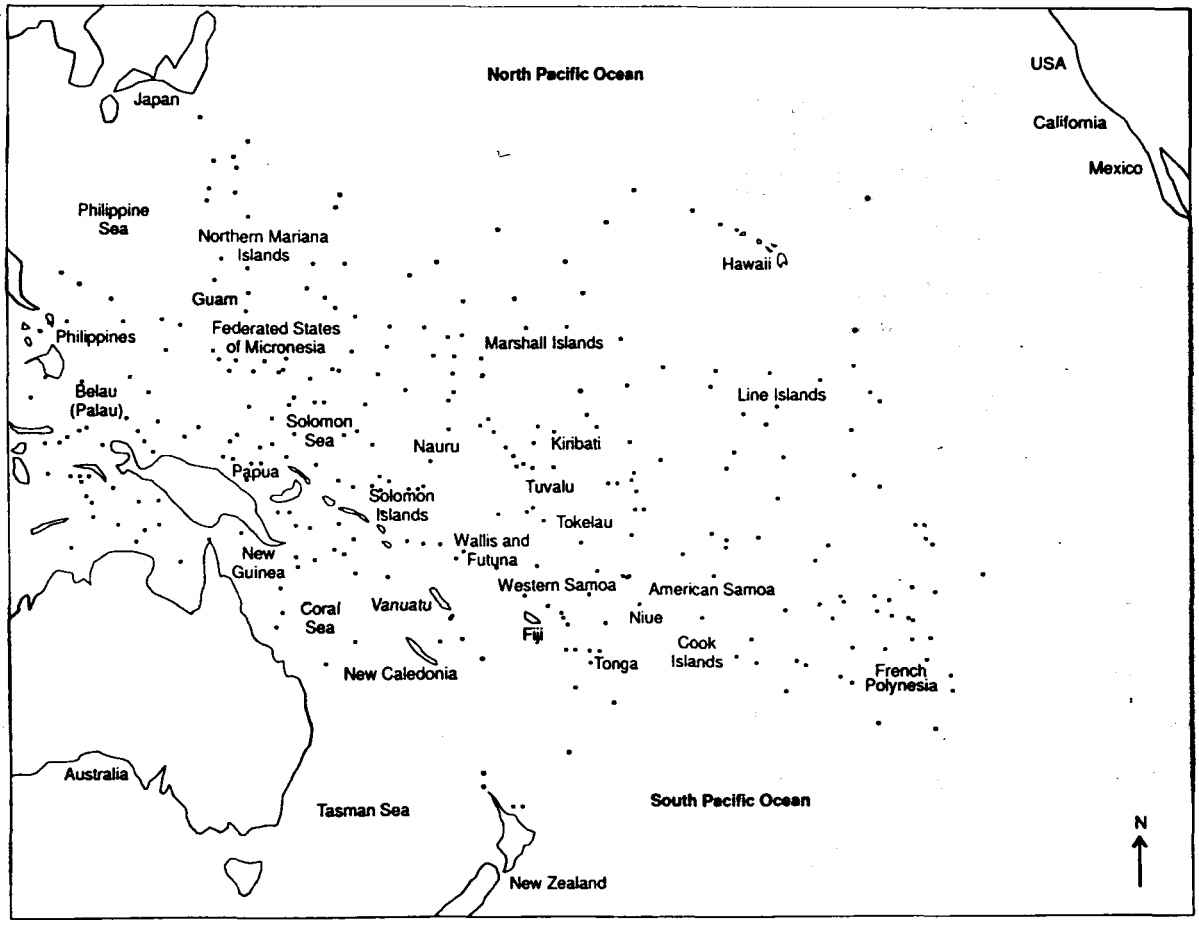
* Sections of Chapter 3 have been published in the papers: Yu et al. (1997a); Yu & Taplin (1997a & 1998).

primarily of coralline limestone which formed in waters surrounding older volcanic islands and then rose above sea level; and (iv) low lying coralline limestone atolls which generally enclose a lagoon (SPREP 1992b, pp147-148).

Map 3.1 Political entities of the Pacific Islands



Source: Bryant (1993).

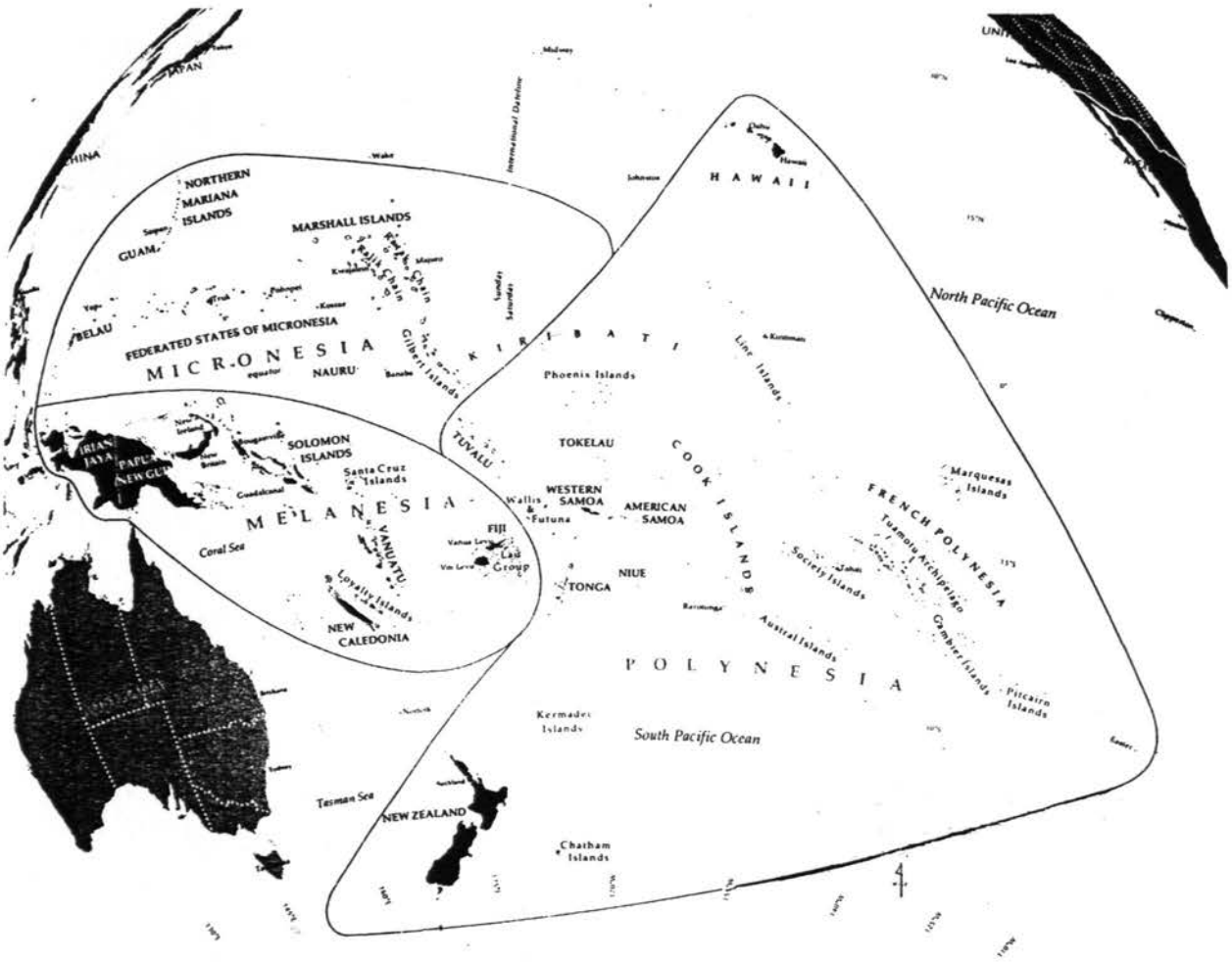
These small island nations and territories are divided into three geographic and cultural groupings: Melanesia, Micronesia and Polynesia. Melanesia lies to the southwest, Micronesia to the northwest, and Polynesia to the east (see Map 3.2).

The Melanesian group consists of Fiji, New Caledonia, Papua New Guinea (PNG), the Solomon Islands and Vanuatu. These islands comprise large, rugged, mainly volcanic islands. They have relatively fertile land, some mineral wealth and abundant living marine and terrestrial resources. Micronesia is made up of the Federated States of Micronesia (FSM), Guam, Kiribati, Nauru, Palau, the Marshall Islands, and the Northern Mariana Islands. Polynesia consists of American Samoa, French Polynesia, Niue, Pitcairn Islands, the Cook Islands, Tokelau, Tonga, Tuvalu, Wallis and Futuna, and Western Samoa.

Polynesian and Micronesian countries are generally composed of small island groups. In the Cook Islands, the Federated States of Micronesia, Tonga and Western Samoa, a few islands are volcanic in origin and have rich soils. However, most of the islands are small, isolated, low lying atolls with poor soil. In Kiribati, Marshall Islands, Tokelau and Tuvalu, the maximum elevation is five metres and many islands stand only one to two metres above sea level (SPREP 1992b). The Micronesian and Polynesian seas are rich in living resources and have significant prospects in exploitable mineral deposits. But other natural land resources are severely limited. Their economies and physical environments are extremely fragile.

Rain falls abundantly and frequently in the region during the southern summer months (December to March). This is also the hurricane season south of the equator. From April to November, when the southeast trade winds sweep the South Pacific, the weather is cooler and drier. Temperatures range from warm to hot all year round. However, the sea moderates the humidity on the islands by bringing continual cooling breezes. Countries nearer the equator are hotter than those farther south. The windward slopes of high islands catch the trades head-on and are usually wet, whereas the leeward side may be dry. There is almost no twilight in the tropics. When the sun begins to go down, there is only less than half an hour before darkness (Stanley 1989).

Map 3.2 Cultural distribution of the Pacific Island region



Source: Albinski et al. (1989).

Broad circular ocean currents flow from east to west across the tropical Pacific, clockwise in the North Pacific, counter-clockwise in the South Pacific. In the north and south of the 'horse latitudes' just outside the tropics, the currents cool and swing east. Westerlies blow east above the cool currents north and south of the tropics. This brings warm water to Australia and Japan and cooler water to Peru and California (Stanley 1989).

3.3 History, socio-cultural and political status

History. The Pacific Island region was the last area on earth to be settled by humans, the last to be discovered by Europeans, and the last to be colonised and decolonised. The date of arrival of the first Islanders in the region has not yet been agreed upon. It is thought that somewhere between 40,000 and 50,000 years ago, the first humans made their way eastwards to the western rim of the Pacific Ocean (Lockwood 1993; Scarr 1990). They spread south through South East Asia and across the relatively shallow waters to Papua New Guinea and Australia, then to remote archipelagos in the Pacific Island region. During the Pleistocene (Ice Age), when sea level was 100 metres lower than today, people could cross the narrow channels from Indonesia on primitive rafts without losing sight of land (Albinski et al. 1989; Euromonitor 1990; Haas 1989; Howard & Durutalo 1987; Oliver 1977; Segal 1990; Senate Standing Committee on Foreign Affairs and Defence 1978; Stanley 1989).

European penetration of the Pacific Islands began early in the 16th century. To seek sea passages to East India from South America on journeys south and east from Portuguese possessions in India, and Spanish possessions in Eastern Asia, Portuguese and Spanish explorers sailed into the region. At that time, European explorers believed *Terra Australis Incognita* was a great southern continent to balance the northern continents. The search *for Terra Australis Incognita* also brought explorers to the region. The Dutch explorers followed in the late 16th century and continued until the 19th century. British exploration began late in the 17th century and French, American and German explorers came into the region during the 18th and 19th centuries.

Colonisation began in 1565 when Spain annexed the Mariana Islands in Micronesia. The British established colonies in Australia in 1788. The French seized Tahiti-Polynesia in 1842. From 1870 German trading firms came into the Pacific Islands. By the beginning of the 20th century, every major island group was under the rule of either a European or American power. Asian

administration came to the region in 1914 when the Japanese took over German colonies in Micronesia. During the Pacific War, between 1941 and 1945, the Japanese penetrated further into the South Pacific.

After World War Two, the United Nations encouraged the trend toward self-government and independence from colonial rules. In 1962, Western Samoa's independence marked the beginning of decolonisation in the Pacific Island region. Currently, 16 of the 22 small Pacific Island nations and territories have become self-governing. The other six territories in the region are still under colonial rule, and the process of decolonisation is still continuing. These territories are American Samoa, Guam, French Polynesia, New Caledonia, Wallis and Futuna, and Pitcairn.

Socio-cultural status. In the region, humans (Senate Standing Committee on Foreign Affairs and Defence 1978) inhabit some 3,000 islands. Their total population is about 6.5 million as Table 3.1 shows (Poirine 1995). The region's population consists of Melanesians, Polynesians, Asians, Micronesians and Europeans. Ninety percent of the population lives on high islands and the rest on low-lying island and atolls. About one million people reside in urban areas (Stanley 1989).

Rich cultures and traditions, such as the extended family system, customary land and sea tenures, and benefit sharing practices, enable the Pacific Island people to live a relatively safe, secure and community oriented lifestyle. The average life expectancy in the region is over 60 years, which is high by world standards (World Bank 1995a).

In most island countries, there is rapid population growth. In the 1990s, the net growth of population is between two and three percent. In Wallis and Futuna, the population increase has reached five percent (SPREP 1992a) The region's population has more than doubled since 1945, and will probably double again by the early years of the next century. Over half of all Pacific islanders are under the age sixteen (Albinski et al. 1989). Population distribution is extraordinarily variable throughout the region. The estimated population density ranges from eight people per square km in Papua New Guinea to 4,167 people per square km in South Tarawa, Kiribati (SPREP 1992b).

Table 3.1 The Pacific Islands: Area, population and density in 1992

Country and Territory	Total Area (000 km^2)	Land Area (km^2)	Population (000)	Density (Pop/km^2)
American Samoa	2,390	197	49	249
Cook Islands	1,830	240	19.5	81
Federated States of Micronesia	3,050	710	114	161
Fiji	1,290	18,272	750	41
French Polynesia	5,030	3,265	203.7	62
Guam	220	541	137	253
Kiribati	3,550	690	75.2	112
Marshall Islands	206	180	52	289
Nauru	320	21	9.6	457
New Caledonia	1,740	19,103	178	9
Niue	390	259	2.2	8
Northern Marianas	1,870	471	50	106
Palau	616	460	15.6	34
Papua New Guinea	3,120	462,840	4056.9	9
Pitcairn*	800	5	0.1	20
Solomon Islands.	1,340	28,369	335	12
Tokelau	290	10	1.6	160
Tonga	680	747	97	130
Tuvalu	900	26	9.4	362
Vanuatu	680	11,880	156	13
Willis and Futuna	300	255	13.9	55
Western Samoa	120	2,935	162	55
Total	30,372	551,476	6,489.9	11.8

Sources: Poirine (1995); SPREP (1992b); United Nations (1997).

* 1988 data.

Social systems of authority vary among the three main cultural groups in the region. In Melanesia, the dominant members of the society hold positions of authority. In Micronesia, matrilineal descent determines the ruling hierarchy. Polynesian chiefs are determined by patrilineal descent. Religion also plays an important role in the Pacific Islands and religion is central to life and government at the village level. Although there are other beliefs practised in the region, Christianity is the dominant religion as a result of colonisation.

Linguistically, the Pacific Islands is one of the most complex regions of the world. Some 1,200 languages, a quarter of the world's total, are spoken in the region. However, most of these languages have relatively few people speaking them. A conservative estimate suggests that Melanesia alone has about 1,200 languages, another 36 or more are classified as Micronesian and Polynesian. Pidgin English is also spoken in Papua New Guinea, the Solomon Islands and Vanuatu. English and French are common languages of commerce in the region and second or third languages for islanders.

Political status. Although many countries of the region have gained independence, the region is firmly aligned with Western ideology. All of the Pacific Island nations, including Australia and New Zealand, retain at least some political, trade and economic dependence from metropolitan powers. Most states have adopted Western-style political systems. An independent, Westminster-style, democratic political system predominates in the region with the exception of the remaining US-administered territories of Micronesia, and American Samoa, and the French territories of New Caledonia, Wallis and Futuna and French Polynesia. In the last decade, Japan and the US have played a greater economic and political role in the region. Most of the larger Asian states have been increasing their diplomatic and commercial presence in the Pacific Islands.

Since the Second World War, the region has been politically relatively stable, although there have been some political tensions in New Caledonia, Vanuatu, Papua New Guinea and Fiji. Trade unions exist in several countries, but there have been very few strikes in the island states. Since the 1987 coup in Fiji, the trade union movement throughout the region has been weaker than in the past. Only Papua New Guinea, Fiji, Vanuatu and Tonga have their own defence forces.

Post-World War II, a number of regional organisations have been established in the region: namely, the South Pacific Commission (SPC), the South Pacific Forum (SPF) and the South Pacific Regional

Environmental Program (SPREP), the Forum Fisheries Agency, and the University of South Pacific. In accordance with the 'Canberra Agreement', the SPC, based in Noumea, New Caledonia was established in 1947. Now, the SPC includes 22 island state political entities as well as the Pacific colonial powers: Australia, Britain, France, New Zealand and the United States. It was primarily set up as a research and service organisation designed to assist the colonial administrations. It is funded by all participating governments as well as several international organisations.

The SPC has major programs in fisheries evaluation, health and nutrition, agriculture and rural development, demography, statistics and women's affairs. Today, all the Pacific Island nations and territories have equal membership with the metropolitans in the SPC, but the SPC still carries the stigma of being a creature of the colonial past (Albinski et al. 1989). Thus, it is now far less influential than a newer entity, the SPF.

The SPF was created in 1971 as an informal, intergovernmental organisation. It has 15 member nations[1]. The Forum leaders meet once a year and its Secretariat is located in Suva, the capital of Fiji. It serves unofficially as the region's voice in world affairs and deals with political and economic issues including transport and trade. The SPF is outside the realm of the SPC, though there are regular meetings between the two organisations on issues such as fisheries and energy.

Many Pacific Island states have not joined the United Nations, primarily because of the costs involved. To date, only Fiji and Western Samoa are full members of the United Nations. However, the United Nations has more than 30 agencies that operate in the region (United Nations 1985). Many of these UN regional offices, such as those of the Food and Agriculture Organisation (FAO), the World Health Organisation (WHO) and the United Nations Fund for Population Activities (UNFPA) are based in Suva, Fiji. The United Nations Economic and Social Commission for Asia and the Pacific (UNESCAP) and the Asian Development Bank (ADB) are based in Port Vila, Vanuatu. The United Nations Educational Scientific and Cultural Organisation (UNESCO) is in Apia, Western Samoa. The UNDP has set up regional offices in Apia, Suva, and Port Moresby, Papua New Guinea.

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[1] Australia, Federated States of Micronesia, Fiji, Kiribati, Nauru, New Zealand, Niue, Papua New Guinea, Solomon Islands, the Cook Islands, the Republic of the Marshall Islands, Tonga, Tuvalu, Vanuatu, and Western Samoa.

3.4 Economic development

Before Europeans came into the region, Pacific Island economies were based on a subsistence economy. That is, the local people themselves usually produced what was consumed locally. Plentiful fish supplies enabled living standards to be kept above subsistence levels in these economies. A diet with ample calories and protein and an equable climate contributed to relatively long life expectancy (Browne & Scott 1989).

When Europeans first explored the region between the 16th and 18th centuries, Spain, Portugal, the Netherlands and the United Kingdom had been interested in the trade of precious metals and spices. During the first half of the 19th century, US whaling industries boomed in the region; trade in sandalwood also developed with Australia, New Zealand and China. During this period, the Germans and the French set up their trade organisations in the region (Browne & Scott 1989).

During the second half of the 19th century, the region became increasingly integrated into the main international trade routes. As they grew more urbanised, Europe and North America increased their attention on the region primarily looking for raw material sources, such as foodstuffs and coconut products that could furnish soap and edible oils. In many of these islands, copra and banana production was increased and sugar and cocoa were introduced as a result of European invasion. Mining operations also commenced in a few islands. Gold was extracted in Fiji and Papua New Guinea, and phosphate in Nauru and Kiribati. Since local labours were often unwilling to accept the discipline of the foreign enterprises, the labour force for these economic and trade activities was imported from Asian countries. Last century, for example, the British recruited many Indians for the Fiji sugar industry (Browne & Scott 1989).

After World War I, a wide range of goods were shipped from Australia and New Zealand to these Pacific Islands and agricultural and mining products were in turn shipped to Australia and New Zealand. After World War II, subsistence and monetary economies existed side by side throughout the Pacific Island region and Western countries exercised a major influence over economic affairs in the Pacific Islands. Even today the close economic links with previous metropolitan colonial powers remain strong.

Agriculture and fishing are two major economic activities in the region. However, mono-agriculture and overfishing have impeded the economic development of the region in an ecologically sustainable

way. Many island countries have started to diversify their mono-agricultural economies into light manufacturing and product processing industries. Tourism has significantly developed in some countries of the region. For example, the Cook Islands' gross earnings from tourism amounted to NZ$5,300,000 in 1979 (Department of Development Planning 1984). This compares with total export earnings of NZ$3,800,000 (Department of Development Planning 1984). Mining activities are mainly located in Papua New Guinea, New Caledonia, Nauru, Fiji, and Kiribati. Also in some highland countries, such as the Solomon Islands, Vanuatu and Western Samoa, commercial logging and the timber industry have made a considerable contribution to national incomes.

Foreign financial assistance is a major fact of economic life for most of the Pacific Islands. The region receives the highest foreign aid per capita in the world (in 1992 it was US$1,415 per person). The American and French territories, in particular, have received high levels of aid (see Table 3.2). In 1989, for example, the 189,000 inhabitants of French Polynesia received as much French development aid as the combined populations of China, India, Egypt, and Algeria (Poirine 1995).

Between 1983 and 1993, the Pacific Island countries invested an average of 29 percent of their GDP in their economy. Public investment was 17 percent of the GDP, and 12 percent of the GDP was provided by private sectors (World Bank 1995a).

Although the region does not suffer the absolute depths of poverty experienced in other regions of the world and its GDP per capita (Table 3.3) is relatively high compared with many other developing countries, the Pacific Island region is not without serious social and economic problems. As the World Bank (1995a, p.v) mentioned, in the region "...economic growth has been slow. Unless the islands achieve moderate sustainable economic growth, improvements in the quality of life may not be possible". For instance, in the region during the period from 1983 to 1993, the average annual growth rate of real GDP was 2.1 percent (World Bank 1995a). However, in the Caribbean, Africa and the Indian Ocean it was 3.2, 5.4 and 5.4 percent respectively (World Bank 1995a). During the same period, the average annual growth rate per capita of the real GDP in the Caribbean, Africa and the Indian Ocean was 2.3, 3.4 and 3.4 percent respectively (World Bank 1995a). In the Pacific Islands it was only 0.4 percent (see Table 3.4) (World Bank 1995a).

In most of the Pacific Island countries and territories, geographical fragmentation and remoteness from major international markets, and small domestic markets, cause serious problems for the

development of viable economic activities. Also, the paucity of natural resources, industry and technology, high unit cost of infrastructure, and shortage of skilled human resources fundamentally constrains economic development. Heavy dependence on the outside world for aid, concessional trade, investment remittances and borrowing has made the Pacific Island economies extremely vulnerable to external economic shocks and natural disasters (Connell 1993; Euromonitor 1990; World Bank 1992). For example, cyclones in 1987 caused damage to the order of 150 percent of the annual GDP in both Vanuatu and the Cook Islands (Euromonitor 1990).

The Pacific Island countries' national economies are heavily dependent on imports for consumer goods. Imports have ranged between 40 and 70 percent of the GDP in the island economies. Typically, food and beverages have represented about one fourth of the total (Browne & Scott 1989). In most of the island nations, fossil fuels are the single largest import item, usually accounting for 10 to 25 percent of total imports (Rizer & Hansen 1992). These huge imports reflect the narrow range of domestic productive activity and the consequent demand for imported goods.

In the region, almost all states and territories demonstrate trade deficits. In the 1980s, trade deficits have ranged between 30 and 60 percent of GDP for Kiribati, Tonga, Vanuatu and Western Samoa (Browne & Scott 1989). The only state without a trade deficit in 1981 was Nauru that is relatively wealthy from phosphate exports.

Table 3.2 Bilateral aid in the Pacific Island region (1992)

Country and territory	Total aid (US$M)	Aid per capita (US$)
American Samoa	78	1,592
Cook Islands	17.2	882
Federated States of Micronesia	128	1,123
Fiji	54.1	72
French Polynesia	746.4	3,664
Guam	91.7	669
Kiribati	22	284
Marshall Islands	102.5	2,000
Nauru	0.2	10
New Caledonia	630.5	3,542
Niue	4.5	2,823
Northern Mariana Islands	89.6	3789
Palau	10.7	686
Papua New Guinea	442.2	109
Pitcairn*	0.2	1,999
Solomon Islands	27.4	82
Tokelau**	4.7	2,963
Tonga	27.2	280
Tuvalu	4.6	490
Vanuatu	32.4	208
Wallis and Futuna	49	3,528
Western Samoa	53.5	330
Total	2,616.6	1,415

Sources: Euromonitor (1990); Poirine (1995).

* 1986 data; ** 1990 data.

Table 3.3 GDP in the Pacific Island region (1992)

Country and territory	Total (US$M)	Per capita (US$)
American Samoa	294	6,000
Cook Islands	72	3,675
Federated States of Micronesia	217	1,900
Fiji	1,508	2,010
French Polynesia	3,147	15,449
Guam	1,362	9,942
Kiribati	58	750
Marshall Islands	85	1,640
Nauru	123	12,800
New Caledonia	2,668	14,990
Niue	4	1,685
Northern Mariana Islands	574	11,472
Palau	18	1,162
Papua New Guinea	5,185	1,278
Pitcairn	n.a.	n.a.
Solomon Islands	238	710
Tokelau*	1	850
Tonga	107	1,100
Tuvalu	9	1,010
Vanuatu	189	1,210
Wallis and Futuna	21	1,500
Western Samoa	152	940

Source: Poirine (1995).

*1990 data.

Table 3.4 Average growth rate, 1983-93

(In percent per annum)

	Pacific Islands	Caribbean	Africa & Indian Ocean
Real GDP	2.1	3.2	5.4
Population	1.7	0.9	2.0
Per capita real GDP	0.4	2.3	3.4

Source: World Bank (1995a).

A further problem in the region is that there is a high rate of unemployment for young people. The working-age population has rapidly increased but it lacks the vocational and technical skills needed for modern service and production activities. Unemployed youths are mostly found in the national or provincial capitals. For many years, Pacific Islanders have migrated overseas to countries such as Australia, New Zealand and the United States seeking employment. Over the last decade these countries have restricted immigration due to their own domestic difficulties. Accordingly, migration is not a real alternative anymore to unemployment in the region.

3.5 Environmental management

The region's heritage rests with its unique cultures, natural beauty, forests, and marine resources. With unsustainable economic development and population growth, environmental deterioration has increased rapidly in the region.

Like other regions of the world, the Pacific Island region is experiencing rapid deforestation. There has been a lack of land-use planning (Fairbairn & Worrell 1996). Commercial logging, agricultural plantation expansion, cyclones, landslides, mining, infrastructure development, and firewood collection have all contributed to deforestation. In addition, regeneration rates range from slow to nil. Tropical rainforests are rapidly disappearing as a result of this deforestation. If present practices are allowed to continue, the natural forests in the region, and the myriad of species they contain may be gone in 15 to 20 years (World Bank 1995a). Also, deforestation, mining and intensive cash

cropping have resulted in soil erosion and a decline in the natural fertility of soil. It has been estimated that the Solomon Islands' hardwood forestry resources will be depleted by indiscriminate logging practices within eight to ten years (Fairbairn & Worrell 1996).

Mining operations are more likely to lead to destruction of the vegetation cover of land surfaces and geomorphic change in some island states. In the region, the major problem associated with mining is the disposal of tailings rich in heavy metals and toxic chemicals used in ore processing. These heavy metals and toxic chemicals have caused extreme impacts on rivers, ground water and marine resources (SPREP 1992a). Concern has been rising in the region about the quality and supply of potable water; drinking water is contaminated by salt water intrusion, chemical or hazardous wastes, and human and animal faeces (Fairbairn & Worrell 1996). During drought periods, some atoll communities are forced to use polluted groundwater for drinking and cooking (SPREP 1992a).

Coastal degradation is another serious problem. Many activities encroach upon coastal ecosystems, such as the development of infrastructure, housing on the foreshore, coastal engineering, beach mining, erosion from inland areas, pollution from agricultural and industrial chemicals, and disposal of domestic wastes. The collection of firewood has also directly caused the damage of mangroves (SPREP 1992a).

Fisheries both offshore and coastal are an important source of food and income for all Pacific Island countries. In the region, fisheries contribute to the GDP by seven percent in the Solomon Islands and by higher amounts in the Micronesian countries (World Bank 1995a). However, overfishing, habitat destruction and the pollution of lagoon waters has led to a significant decline in fish stocks throughout the entire region (SPREP 1992a).

Increasing urbanisation, stemming both from high population growth and from rural-urban migration, has made health and urban environmental problems more acute than ever (Commonwealth of Australia 1996a). Because most of the Pacific Islands have tiny land areas and many of the low lying islands have very low elevations above sea level; it is extremely difficult to find land for housing and disposal of domestic wastes.

The tropical Pacific region has high levels of fauna and flora species diversity and many endemic species. However, due to destructive forces introduced by humans, such as deforestation, mining and the introduction of non-native animal species, the Pacific Island region's biological diversity and

native species are among the most endangered in the world. Some 75 percent of the mammals and birds that have become extinct in recent history were Pacific Island-dwelling species (SPREP 1992a).

Global climate change is believed to be the greatest threat to these island nations in the future (Edwards 1996). The major predicted impacts of climate change due to global warming on the Pacific Island nations are as follows: rises in temperature and sea-level, land erosion, coral bleaching, associated with depletion of fish stocks and agricultural products, human and animal health being prone to risks associated with salinity contamination of potable water and the distribution of diseases (eg. malaria), as well as possible increases in the frequency and intensity of hurricanes and cyclones (ASPEI Task Team Members 1990; Bualia & Sullivan 1990; Buddemeier & Oberdorfer 1990; Connell & Lea 1992; Sullivan 1991; Taplin 1994a).

Additionally, there is a potential international environmental refugee problem associated with global warming due to the rise of sea levels in the Pacific Island countries. Because of this problem, it has been predicted that most of the people in Kiribati, the Republic of Marshall Islands, Tokelau, Tuvalu and other low-lying islands may be forced in the long term to resettle overseas (Connell 1993; Connell & Roy 1990; O'Collins 1990; Spennemann 1991). In the case of Western Samoa, where 95 percent of the population live in coastal areas, the SPREP has suggested that a one-metre rise in sea level would be likely to inundate about 10 percent of these areas and displace thousands of people (SPREP 1992b). Internal migration may also cause social disruptions due to land tenure, which are potentially as serious as overseas migration impacts.

The region is also extremely vulnerable to natural disasters, such as cyclones, volcanic eruptions and earthquakes. In Tokelau, for instance, cyclones have resulted in waves completely covering the islets of the atolls, washing away topsoil. The residual salt delayed crop growth for some months and contaminated fresh drinking water (SPREP 1992a).

Nuclear contamination is also an issue of environmental concern for the Pacific Island region. The United States, Britain, and France have conducted many nuclear tests in the region. Between 1946 and 1963 the United States conducted 103 tests in the Marshall Islands, Johnson Islands, and Christmas Islands. Since 1967 and prior to 1988, France conducted more than 127 nuclear tests in the Tuamotu Islands of French Polynesia (Mckee & Tisdell 1990).

Concern about nuclear pollution in the region has led to a Nuclear Free Pacific Movement. As a result, the SPF adopted the South Pacific Nuclear Free Zone Treaty in August 1985, and over a year later it came into force. Ironically, by 1990, the former Soviet Union and China had signed the Treaty; however, the US, France and Britain had not (Euromonitor 1990). In 1995, the French re-conducted nuclear tests in the region. After France's six nuclear tests, France, the United States and United Kingdom signed the South Pacific Nuclear Free Zone Treaty on 25 March 1996 (International Atomic Energy Agency 1996).

In order to solve their environmental problems, all governments of the region have placed an emphasis on environmental management. However, due to many constraints, most island governments have small environment and conservation agencies with few staff, often with limited training and experience. In particular, there is a shortage of environmental planners, environmental policy makers and environmental specialists. Implementation of a regional approach to environmental management and protection is urgent and important. Given the limited skilled human and financial resources of the individual island states, many island governments recognised that the best way to tackle their environmental problems was by pooling resources in a regional program.

The SPREP was established in 1980 as a major regional environmental organisation. It has 27 members including 22 island governments and five developed countries (Australia, France, New Zealand, the United Kingdom and the United States). It is under the joint administration of the SPC and the South Pacific Forum Secretariat (the former South Pacific Bureau for Economic Cooperation). Its funding is mainly provided through the United Nations Environment Program (UNEP) and the United Nations Development Program (UNDP) (SPREP 1994). SPREP is also involved in the UNEP Oceans and Coastal Areas Program as a Regional Seas Program.

In 1982, at the Conference of the Human Environment in the South Pacific, in Rarotonga, the Cook Islands, the SPREP was formally established as a separate entity. In order to guide SPREP's future activities, the Conference produced an Action Plan for managing the natural resources and environment of the region. After considering the Action Plan's financial and legal implications, a new agreement was signed by member countries of the SPREP on 16 June 1993. The member countries agreed that the SPREP should become autonomous as an intergovernmental and regional organisation (SPREP 1994). Its annual budget is about US$8~9 million (Devoe, Accountant, Financial Office of SPREP, pers. comm. 25 Feb. 1998).

Since SPREP was established, its main programs and activities have included: conserving biological diversity, global climate change and rise in sea level, environmental planning and management, coastal management and planning, managing pollution and pollution emergencies, environmental education, information and awareness, and regional environmental concern. Progress since the Earth Summit in 1992 has mainly focussed on implementing *Agenda 21* and the Rio Declaration and on supporting Pacific Island participation in a range of international meetings (SPREP 1994).

3.6 Conclusion

With respect to the information given in this Chapter on natural conditions, cultural factors, political independence, socio-economic development and environmental management, it appears that renewable energy should be a suitable energy source for the Pacific Island region. The following chapter examines the energy issues of Pacific Islands in detail.

Chapter 4 Energy: policy and management*

4.1 Introduction

This chapter is to further assess the appropriateness of renewable energy sources and seek effective management strategies for energy sector. In this chapter, the energy issues of the Pacific Island region are discussed from three perspectives: energy resources, policymaking and planning, and management. These are all interrelated and the potential for future energy sustainability in the region can only be assessed by understanding all of these dimensions.

4.2 Energy resources

4.2.1 Fossil fuel supply and demand

Most of the Pacific Islands countries have limited indigenous commercial energy. These nations rely heavily on imports of petroleum products for energy supply. In the region, the total demand for petroleum is about 50,000 barrels per day, compared to 11 million barrels per day for the entire Asia-Pacific region (Rizer & Hansen 1992). Fossil fuels are typically the single largest import item to these countries. Table 4.1 indicates that: the percentage of petroleum imports relative to total imports is approximately 11.7 percent on average, ranging from a low of 0.8 percent for Nauru to a high of 30 percent for Palau; and the percentage of fuel imports compared to total exports is 115.7 percent, ranging from 0.1 percent for Nauru to over 500 percent for Palau (United Nations 1995; World Bank 1992). According to a World Bank report (1992), 48 percent of imported fuel is used for transportation and 37 percent for power generation (see Table 4.2).

Many island countries are far from the major petroleum markets, for example, Apia, the capital of Western Samoa, lies about 4,500 km from Sydney, Australia (Western Samoa NEMS Task Team 1993). The small market of petroleum products in the region is further disadvantaged by diseconomies of scale in transport, storage facilities, and distribution. For instance, transport costs add five to 10 percent to the cost of fossil fuels at the main distribution centres in Fiji and

* Sections of Chapter 4 have been published in the papers: Yu et al. (1996 & 1997a); Yu & Taplin (1997a).

Papua New Guinea, and 27 to 40 percent at smaller secondary distribution points (Rizer & Hansen 1992).

The high proportion of energy imports in relation to total exports indicates that most of the Pacific Island economies are vulnerable to external economic shocks, such as sharp increases in petroleum prices. The current importation and consumption of fuels is placing a heavy burden on the balance of payments (Republic of Kiribati 1993). Although a tax on petrol and diesel could be used to pay infrastructure, without substantial cash inflows from foreign aid, tourism, and remittances from citizens working abroad, many of the island nations will be unable to pay for their commercial energy imports (Rizer & Hansen 1992; World Bank 1992).

To date, a substantial proportion of the Pacific Island population have been supplied with electricity. More than 50 percent of the population in the Cook Islands, the Republic of the Marshall Islands, Palau, Tonga, Tuvalu, and Western Samoa has been provided with electricity (Liebenthal et al. 1994). However, the supply of electricity to rural and outer islands is very limited, resulting in limited potential for economic development in rural and remote areas.

The growth of energy demand in the region will depend upon population growth and socio-economic development. During the 1980s, the demand for energy grew at an average annual rate of five percent in the Pacific Islands. For the period 1990-2000, the real GDP of these economies is expected to grow at average annual rates ranging from two percent to five percent (World Bank 1991). The growth rate of energy demand is projected to increase consistently to seven percent (Liebenthal et al. 1994). In order to meet the needs of energy demand, it has been suggested that the Pacific Island governments will have to reduce their investments in infrastructure, industrial, fishery and agricultural development, and allocate financial resources to the energy sector (Burnett 1992).

4.2.2 Current status of renewable energy

Since the first major oil price increase in 1973, the Pacific Islands have made efforts towards using renewable energy. Table 4.3 shows the use of hydro, solar, biomass and wind resources in the region.

Table 4.1 Pacific Islands: Petroleum imports and consumption

(All figures 1994 unless indicated)

Country & territory	Petroleum import value (US$M)	Share of total imports (%)	Share of total exports (%)	Per capita consumption (toe/year)
American Samoa	21.7[c]	9.5[c]	12.5[c]	n.a.
Cook Islands	10.1	11.8	242.1	0.93[b]
Federated States of Micronesia	5.6[d]	10.2[d]	32.8[d]	0.56[b]
Fiji	94	12.3	19.1	0.53
French Polynesia	52.2[e]	5.5[e]	47.9[e]	1.44[d]
Guam	202.4[c]	n.a.	235.4[c]	9.47[c]
Kiribati	2.1[d]	7.4[d]	67.7[d]	0.11[d]
Marshall Islands	17.2	22.9	69.6	0.76[b]
Nauru	0.11[a]	0.8[a]	0.1[a]	n.a.
New Caledonia	34.9[e]	3.8[e]	6.9[e]	3.40[d]
Niue	n.a.	n.a.	n.a.	n.a.
Northern Mariana Islands	n.a.	n.a.	n.a.	n.a.
Palau	2.8[b]	30.0[b]	500.0[b]	1.81[b]
Papua New Guinea	155	11.1	5.7	0.24[d]
Pitcairn	n.a.	n.a.	n.a.	n.a.
Solomon Islands	13.5[c]	12.1[c]	13.1[c]	0.16[c]
Tokelau	n.a.	n.a.	n.a.	n.a.
Tonga	8.3	12.4	63.5	0.17[d]
Tuvalu	0.8[b]	17.0[b]	450.6[b]	0.41[b]
Vanuatu	7.0	7.7	27.4	0.28[d]
Wallis & Futuna	n.a.	n.a.	n.a.	n.a.
Western Samoa	11.0[d]	11.9[d]	172[d]	0.43[d]
Total	638.7	11.7*	115.7*	1.38*

Sources: ADB (1995a); Blanc (Project Assistant, South Pacific Commission, 1996, pers. comm. 26 June); Central Bank of Samoa (1994); Statistics Office of the Cook Islands (1994); United Nations (1995); World Bank (1992); World Bank (1995b); World Bank (1995c).

Notes: a. 1988; b. 1990; c. 1992; d. 1993; e. 1995; *unweighted average.

Table 4.2 Selected Pacific Islands: Gross petroleum demand shares by sector (All figures 1990)

Country	Transport (%)	Electricity (%)	Domestic (%)	Gov./Ind./Comm.[a] (%)	Other (%)
Papua New Guinea	34.4	52.6	1.5	11.5	0.0
Fiji	75.8	4.4	7.2	12.5	0.0
Solomon	26.5	17.1	3.4	47.9	5.1
Western Samoa	79.9	15.7	4.5	n.a.	n.a.
Vanuatu	70.9	23.2	5.8	n.a.	n.a.
Federated States of Micronesia	62.0	36.0	2.0	n.a.	n.a.
Tonga	72.0	23.1	4.9	n.a.	n.a.
Kiribati	71.0	19.4	9.7	n.a.	n.a.
Marshall Islands	40.7	53.4	1.4	3.8	0.7
Cook Islands	70.6	26.2	3.1	n.a.	n.a.
Palau	53.1	39.4	0.7	6.8	0.0
Tuvalu	74.0	18.5	7.5	0.0	0.0
Weighted Average	48.3	36.7	3.2	11.7	0.2

Source: World Bank (1992).

Notes: a. this includes governments, industries including agri-industries, and commercials.

Table 4.3 Use of renewable energy resources

Country	Hydro	Biomass[1]			Solar			Wind	
	electricity	burning	gasif.	biogas	water	drying	power	pump	power
American Samoa		@		#	@		#		
Cook Islands		*	†	@	@	*	*	@	#
Federated States of Micronesia	*						#		†
Fiji	* @	*	†	†	*	*	*	@	
French Polynesia	#		†		*		*		
Guam		#							
Kiribati		*				*	*		#
Marshall Islands		@			#	@	*		
Nauru					@		@		
New Caledonia	@				*		*	@	
Northern Marianas		@	†	@			@		
Palau		†	†				@		
Papua New Guinea	*	@	†		*		@		
Solomon Islands	@ #	*	†		*	*	@		
Tonga		†		@	*	@	@	@	
Tuvalu							*		
Vanuatu	*	@	@		@		@		
Western Samoa	* @	*	@		@			@	

Sources: Rizer and Hansen (1992); Yu et al. (1996).

*significant; @demonstration/experimental; #planned; †no longer working; [1] biomass was only for electricity generation.

Hydropower. In some island countries, hydro power has produced a significant amount of electricity in relation to total electricity supply: for example, 90 percent in Fiji, 55 percent in Western Samoa, 35 percent in Papua New Guinea (Rizer & Hansen 1992). The Solomon Islands has a major hydropower project in Guadalcanal. Also, in Tahiti, French Polynesia has planned to use hydropower for 50 percent of its total electricity supply. Papua New Guinea, has the largest micro-hydro program in the region, allocating US$3 million per year. Fiji, Vanuatu and the Solomon Islands have smaller programs (Institute of Natural Resources 1994; Rizer & Hansen 1992).

Solar energy. There are more than 4,000 small-scale household solar PV systems (2-8 panel) installed throughout the Pacific Island region. They provide household electricity for lighting, water pumping and refrigeration. Solar PV systems are also increasingly used in navigational buoys and beacons, street lighting, hospital equipment, telephone relay stations, radio, TV and videos. Rizer and Hansen (1992) estimated that the total installation of solar PV systems in the region could exceed 8,000 units by 1995. Another estimate is that near term demand could reach up to 15,000 units (Liebenthal et al. 1994).

These household systems are probably competitive with diesel generators in the medium power range such as for lighting, refrigeration, video and other low power appliances, particularly in isolated rural areas and outer islands (Institute of Natural Resources 1994; Liebenthal et al. 1994). Moreover, solar hot water systems have been used considerably in the region on a commercial basis (Institute of Natural Resources 1994). Large-scale use of solar energy for higher levels of power application has not been explored.

Biomass energy. Energy from biomass accounts for about 50 percent of the total energy use in the region. Of this some two thirds is used in households for domestic cooking and one third by industry for processing, heat and electricity (Institute of Natural Resources 1994). In most of the Pacific Island nations, in particular, Fiji, Solomon Islands, Vanuatu, Samoa and Tonga, biomass energy is used for almost all the cooking and heating in rural households (Prasad 1993). Reliance on biomass energy for domestic consumption ranges from 60 percent in the Cook Islands to 94 percent in the Solomon Islands (Prasad 1991). In Fiji, over 70 percent of the biomass are used for energy, and biomass contributes to over 50 percent of the total energy needs for the country (Prasad 1993).

In the region, biomass energy mainly derives from mangroves, other coastal vegetation and agricultural residues, bagasse and sawdusts. In many urban and coastal areas of Papua New Guinea, the Solomon Islands, Fiji, Kiribati, Tuvalu and Tonga, fuelwood resources are rapidly declining. Establishing plantations for firewood has had very little success and the efficient use of fuelwood in the household via the introduction of wood stoves has been largely unsuccessful. Also, generating electricity with biomass gasifiers has virtually been a failure. In terms of sustainable development, Takahashi and Woodruff (1990) pointed out that biomass for power production is not an alternative in all situations, since many small islands lack sufficient land for cultivation.

The combination of heat and electricity production, however, has led to some successful operations. A few steam based plants exist in Fiji and Western Samoa. They are large units attached to sugar mills and sawmills (Institute of Natural Resources 1994; Rizer & Hansen 1992; Yu et al. 1996).

Ethanol production from biomass has been studied in the region as a possibility for transportation fuel. Many resources were looked at, such as sugar, molasses, cassava, sorghum, coconuts, breadfruit, and several species of palm. However, none of these have been commercially developed, although some cocohol (from coconuts) and a small amount of ethanol from molasses has been produced (Rizer & Hansen 1992).

Wind energy. Some small wind electric systems have been tried but none currently exist in the Pacific Island countries. Although this technology is improving in the world, little data is available for the region. Rizer and Hansen (1992) argue that the development of wind power systems should be in the near future. However, some wind pumping systems have been operating successfully (see Table 4.3). Since 1994, under the South Pacific Forum Secretariat's Small Energy Project Program, a wind resource monitoring project has been carried out in Fiji, Tonga, Vanuatu, Niue and the Cook Islands (Forum Secretariat 1995).

Geothermal energy. Some possible geothermal resources exist in Fiji, Papua New Guinea, the Solomon Islands and Vanuatu, but there is a lack of current data on the level of resources. None of these resources has been developed in the region as an energy source (Institute of Natural Resources 1994; Rizer & Hansen 1992).

Wave energy. There is little data available on wave energy in the Pacific Island region. In the early 1990s, the South Pacific Applied Geoscience Commission (SOPAC) designed a program for

measuring sea-wave potential. A 2 MW sea-wave energy project was proposed for Tonga. However, owing to huge capital costs and technological issues, it is unlikely be developed in the near future. To date, tidal power is not seriously considered as an energy option in the Pacific Islands (Institute of Natural Resources 1994; Rizer & Hansen 1992).

Ocean thermal energy conversion (OTEC). This technology is still only at the research stage worldwide. In the region, there is only limited hydrographic data for OTEC. In the 1970s, a small (100 kW) system was tested on Nauru but operated for only a few years (Rizer & Hansen 1992). In recent years, a small cooperative OTEC research effort has been underway between the University of the South Pacific and the Fiji Department of Energy and Japan (Institute of Natural Resources 1994).

4.3 Energy policy and planning

The South Pacific Regional Environment Program (SPREP) (1992b) highlighted that the Pacific Islands' greatest need is for economically sustainable, clean, renewable, moderate scale energy production technology to initially complement, and eventually replace, existing sources of energy.

SPREP (1992b) suggested that energy policy strategies for the Pacific Island region should focus on: (i) further development and implementation of energy conservation programs, especially for the outer islands; (ii) supplementing diesel energy, by storing solar power to reduce peak demand; (iii) raising the price of fuel used in vehicles and the cost of fossil-fuel based electricity; (iv) public education campaigns on energy conservation; (v) phased removal of energy subsidies to consumers; and (vi) facilitation of research and development of practical alternative forms of energy.

In the Cook Islands, more than 90 percent of all imports are fossil fuels; these are used for commercial energy supplies. Thirteen of its 15 islands have been supplied with diesel generating electricity with the exception of Pukapuka and Nassau. The Cook Islands Government has actively sought to promote renewable energy sources and to reduce the country's dependence on imported fuels (SPREP 1993a).

The solar electrification program has been established for the northern group of the Cook Islands; the Cook Islands Government aims to install solar PV systems on Pukapuka, Penrhyn, Manihiki, Rakahanga and Palmerston, and to upgrade an existing old system on Nassau. The Government

also aims to extend such technology to isolated outer islands where the cost of imported diesel for electricity generation is prohibitive due to economic and environmental reasons (SPREP 1993a).

Recently, a demand-side management (DSM) project has been initiated in the Pacific Islands region. The project was aimed to increase the awareness of DSM and encourage energy end-use efficiency among the electric utilities in the region. The project is funded by the UNDP, and administered by the Energy Division of the (South Pacific) Forum Secretariat. Ten Pacific Island electricity utilities participate in this project, namely: the Papua New Guinea Electricity Commission, the Fiji Electricity Authority, the Marshall Islands Energy Company, the Palau Public Utilities Corporation, the Solomon Islands Electricity Authority, the Tonga Electricity Power Board, the Western Samoa Electric Power Corporation, the Cook Islands Te Aponga Uira O Tumu-Te-Varovaro, the Kiribati Public Utilities Board, and the Tuvalu Electricity Corporation.

As a result of this project, the ten participating island electric utilities are projected to save 90, 000 MWh and reduce peak demand by over 21,000 kW by the year 2000. By the year 2000, the project will also reduce 81,000 tonnes of CO_2 emissions per year in the region. The total reduction of CO_2 emissions from the 10 Pacific Island countries over the 20-year period of 1994-2013 is projected at almost 2.4 million tonnes (SRC International Pty 1995).

In most Pacific Island countries, however, there is a lack of well-structured and coordinated energy policies, particularly in relation to rural electrification. For instance, their electricity is not priced on a full cost basis. The prices offered are often below real costs, and either explicit or implicit electricity subsidies exist (Wardrop 1994).

Since the early 1970s, following the conventional wisdom of the time and encouraged by donor interest, the Pacific Island governments' energy strategies have prioritised the reduction of dependence on the imports of fossil fuels via the development potential of indigenous and renewable energy resources. Due to the fact that this approach to energy policy was not successful during the 1980s, the energy strategies of the region have re-focused on management and regulation of conventional energy. The island governments have tended to place the highest priority on the power sub-sector. The management of petroleum supply and conservation programs have received the second and the third priority in resources. Rural electrification and renewable energy is the fourth highest priority and based on funds from foreign aid.

Renewable energy policy currently only receives a very low priority. Energy policies and planning for renewable energy are dependent on foreign aid for funding and expertise (Rizer & Hansen 1992; World Bank 1992). In 1996, for example, the Kiribati Government's development budget for renewable energy was US$745; this was only about 0.88 percent of its total energy budget (US$85,700) (Ministry of Finance and Economic Planning of Kiribati 1995).

Energy conservation is a low priority throughout the region. Although many nations consider that conservation is important, "budget allocations are directed towards other expenditure items, including basic operating costs" (Rizer & Hansen 1992, p31).

In the 1970s and 1980s, island governments allocated already scarce personnel to assist foreign aid programs trying to promote gasifiers and OTEC resource assessment without receiving much in return. During the 1990s, the Pacific Islands have had to carefully decide how to allocate their scarce skilled human and financial resources. Thus, there are few resources available for experimental energy technologies and no resources available for unproven technologies (Rizer & Hansen 1992).

4.4 Energy institutions and management

There are many government and private agencies involved in energy policy, planning and management in the Pacific Island nations. Most countries have four departments, ministries or agencies to deal with energy issues in some capacity. Table 4.4 shows the institutions involved in energy policymaking, planning, and implementing management in electricity generation, rural electricity supply and fuel price controls.

In the small nations, national energy policymaking and planning is generally carried out within an economic planning office or public works department. However, in the larger nations, such as Fiji and Papua New Guinea, there are separate departments specifically for energy policymaking and planning. Most of the small energy planning offices is overshadowed by the much larger power utilities. In some nations, the power utilities have very broad responsibilities, for example, in the Marshall Islands, the Marshalls Energy Company operates the power plant for Majuro atoll, manages a fuel supply tank farm, and plays a key role in negotiating oil supply contracts. More

typically, a power authority is responsible only for electricity. In some nations, it is only in charge of electricity production for the main island and/or urban centres.

In Nauru, the Nauru Phosphate Company mainly generates the electricity supply. In Papua New Guinea, all of the large mines generate their own electricity. Some mines also provide electricity to surrounding areas. In Fiji, some of the hotels, the large sawmill/woodchip plant, the sugar mill, and occasionally the gold mine all generate their own power (Rizer & Hansen 1992).

Several nations have rural electrification programs, which are usually based on small diesel generators and/or solar PV systems. Some countries have also introduced micro-hydro power schemes (less than 100 kW). Due to the fact that solar and hydropower programs have substantial initial capital costs, rural electrification programs largely rely on foreign aid (Institute of Natural Resources 1994). In almost all of the Pacific Island nations, the energy offices play key roles in rural energy planning, aid coordination, and implementation. It is quite common for a public works department to play a major role in rural energy supply as is shown in Table 4.4. There are various other agencies that manage rural electrification projects, such as the Tuvalu Solar Electric Cooperative Society (TSECS), the Kiribati Solar Company, and the Cook Islands Renewable Energy Directory (CIRED) (Liebenthal et al. 1994).

In most of the Pacific Island nations, fuel price controls have been imposed, as a part of national energy strategies, in an attempt to compensate for the lack of competition in the small and limited marketplace. It is said that price controls allow for reasonable profits, but limit high mark-ups (Rizer & Hansen 1992).

Table 4.4 Energy institutions in selected Pacific Island nations

Nation	Energy policy and planning	Electricity generation	Rural energy supply	Fuel price controls
Cook Islands	Economic Planning and Development	Cook Islands Electric Power supply	Public Works CIRED	Finance
Federated States of Micronesia	Resources and Development (R&D)	Public Works	R&D and Public Works	none
Fiji	Energy	Fiji Electricity Authority (FEA)	Public Works	Finance
Kiribati	Public Works	Public Utilities Board	Public Works, Solar Company	Finance
Marshall Islands	Planning and Statistics	Marshall Islands Energy Company	Public Works	none
Niue	Finance	Niue Power Supply	n.a.	Finance
Papua New Guinea	Minerals and Energy	Electricity Commission	Minerals and Energy	Treasury
Solomon Islands	Natural Resources	Electricity Authority	Public Works	Price Tribunal
Tonga	Lands, Survey and Natural Resources	Tonga Electricity Power Board	Public Works	Competent Authority
Tuvalu	Public Works	Tuvalu Electricity Utility	Public Works TSECS	Finance
Vanuatu	Energy Office	UNELCO	Public Works	Finance
Western Samoa	Finance	Electric Power Corporation	Public Works	Finance

Source: Liebenthal et al. (1994); Rizer and Hansen (1992); Yu et al. (1996).

During the last decade, the establishment of national energy offices in the region was largely driven by the need to administer donor assistance in response to the oil price rise in the 1970s, rather than from an understanding of the needs of the energy sector (World Bank 1992). A disproportionately small amount of effort has been devoted to the planning and management of renewable energy. Because of the availability of donor assistance, governments in the region have tended to decline support for energy offices (World Bank 1992).

In March 1984, for example, at the United Nations Pacific Energy Development Programme (UNPEDP) Second Review Meeting held in Rarotonga, the Cook Islands, the delegates from Pacific Island countries pointed out that UNPEDP had concentrated on short-term consultancies and placed its emphasis on equipment during complementing the energy programs (South Pacific Bureau for Economic Co-operation 1984).

They stressed that UNPEDP should pay attention to advice on the relation of government to the power sector, and training of local staff, especially on a long-term basis. However, this was not considered as a top priority (South Pacific Bureau for Economic Co-operation 1984).

The adequate administration of a rural electrification program in the planning, construction and operating stages requires a suitable institutional framework (UNPEDP 1988). Although different agencies involved in energy supply responsibilities are defined, some overlap still occurs. In general, there is lack of coordination among energy institutions and agencies. This has resulted in a failure to address energy policy, planning and management issues, particularly regarding project implementation, such as in providing electricity to rural areas (Rizer & Hansen 1992).

In many of the island nations, analysis of energy demand and supply means that an energy officer only collects data on the volume and value of fuel imports and pays little attention to the prediction of energy supply and demand. In many cases, energy audits are conducted without a systematic analysis of energy supply and usage (Rizer & Hansen 1992). There is a lack of information on indigenous energy resources, and the analysis of energy conservation is limited (see Table 4.5). No systematic analysis on the supply and demand for firewood has yet been undertaken in these island nations, except for a detailed study conducted on Tongatapu (Rizer & Hansen 1992). This is a cause for concern because firewood is the main energy source for household cooking in rural and in

many urban areas. Moreover, depletion of this resource could have considerable negative environmental effects in coastal areas where the sources of firewood protect the island from the destructive forces of waves and wind.

Owing to lack of availability of financial resources, there is a lack of public education programs through radio and other media programs in the Pacific Island region, which can help people to use energy more wisely. In many of these nations, energy audits and energy conservation have had a low priority.

With respect to improving island nations' energy management functions, the World Bank (1992) strongly suggested that power authorities should be privatised and governments should not be involved in the direct administration, implementation or maintenance of energy projects. Governments streamline their involvement in the energy sector by only defining energy policy frameworks and ensuring that the objectives of energy projects are met in an efficient, sustainable and socially equitable manner.

Some nations have considered privatising their power authorities. However, some people consider that privatisation is more of a "flavour of the month" concept than a realistic option for introducing renewable energy systems because of the current subsidies for energy users. Therefore, commercialising the power utilities could be the first step. Even where this has already been accomplished, removing subsidies through tariffs and dividends for shareholders still appears to be a politically difficult decision (Rizer & Hansen 1992). It is clear, the management of energy sector in the region still remains in questions and should be further discussed.

Table 4.5 Pacific Island energy issues

Nation	Indigenous energy resource assessment	Analysis of energy supply sources	Potential or use for renewable fuels	Conservation programs
Cook Islands	Few assessments, low priority	Petroleum, solar	Solar in outer islands limited biomass	Limited
Federated States of Micronesia	Hydro potential, low priority	Petroleum, solar hydro	Solar in outer islands hydro on Pohnpei	None
Fiji	Hydro potential, medium priority	Petroleum, hydro, solar, biomass	Hydro, solar, biomass	Government program
Kiribati	Few assessment, low priority	Petroleum, solar	Solar	Limited
Marshall Islands	Few assessment, low priority	Petroleum, solar	Solar in outer islands	None
Niue	Few assessment, low priority	Petroleum, solar	Solar	Unknown
Papua New Guinea	Hydro and oil, high priority	Hydro, petroleum	Hydro, solar and biomass	Government program
Solomon Islands	Hydro potential, medium priority	Hydro, petroleum	Hydro, biomass	Limited
Tonga	Few assessments, low priority	Petroleum, solar biomass	Solar, biomass	Limited
Tuvalu	Few assessments, low priority	Petroleum, solar	Solar	Limited
Vanuatu	Hydro potential, low priority	Petroleum, solar	Solar, biomass	Limited
Western Samoa	Hydro potential, medium priority	Petroleum, hydro	Hydro, biomass	Limited

Source: Rizer and Hansen (1992).

Chapter 5 Current limitations on further introduction of renewable energy systems in the region: five national studies*

5.1 Introduction

In order to develop a better understanding of the most appropriate means for facilitating investment in renewable energy systems, promoting energy planning, energy management and human resource development in the region, case study research was carried out in five island states: Fiji, Kiribati, Nauru, Western Samoa, and the Cook Islands. Fieldwork, visiting renewable energy installations and conducting face to face interviews in these nations, was conducted in March and April 1995 (see Tables 5.1 & 5.2 for background information on these nations). Interviews focused on the future potential of renewable energy resources in each country and current foreign aid support for renewable energy systems from a recipient country's point of view.

In each nation, people with interests in energy production and use such as government officers, energy planners, engineers, members of environmental groups, and energy consumers were interviewed. Also the Pacific Islands' based representatives of regional and international organisations were interviewed about their perceptions about the potential for further introduction of renewable energy systems in the region. These included the South Pacific Forum Secretariat (SPFS), South Pacific Regional Environment Program (SPREP), and the United Nations Development Program (UNDP). Also, Australian High Commission officers in Western Samoa were interviewed. This field research has provided a considerable amount of first hand information for identifying barriers to expansion of renewable energy systems in the Pacific Island nations.

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* Chapter 5 comprises part of the published paper: Yu et al. (1996).

Table 5.1 Background information on the five case study countries (1992 figures unless otherwise indicated)

Country	Land area (km^2)	Sea area (000 km^2)	Population (000)	Cultural & geographic groups	Political status
Cook Islands	240	1,839	19.5	Polynesia	Self-governing free association with New Zealand (1965)
Fiji	18,272	1,290	771[a]	Melanesia	Independent (1970)[b]
Kiribati	690	3,550	75.2	Micronesia	Independent (1979)
Nauru	21	320	9.6	Micronesia	Independent (1968)
Western Samoa	2,935	120	162	Polynesia	Independent (1962)[b]

Sources: Institute of Natural Resources (1994); Liebenthal et al. (1994); Ministry of Information, Broadcasting and Telecommunications of Fiji (1994); Poirine (1995); Rizer and Hansen (1992); United Nations (1997).

Notes: [a] 1993 data; [b] Member of United Nations.

Table 5.2 Development indicators in the five countries (1992 figures unless otherwise indicated)

Country	Total GDP (US$M)	Per capita GDP (US$)	Total imports (US$M)	Total exports (US$M)	Imported energy (US$M)	Percentage of total exports (%)
Cook Islands	71.7	3,675	66.9[a]	3.8[a]	7.9[a]	204.7[a]
Fiji	1,507.5	2,010	615.0[a]	432.7[a]	86.1[a]	19.9[a]
Kiribati	58.1	750	28.4[a]	3.1[a]	2.1[a]	67.7[a]
Nauru	122.9	12,800	13.9[b]	80.3[b]	n.a.	n.a.
Western Samoa	152.3	940	92.4[a]	6.4[a]	11.0[a]	172.0[a]

Sources: Institute of Natural Resources (1994); International Monetary Fund (1995); Poirine (1995); United Nations (1995).

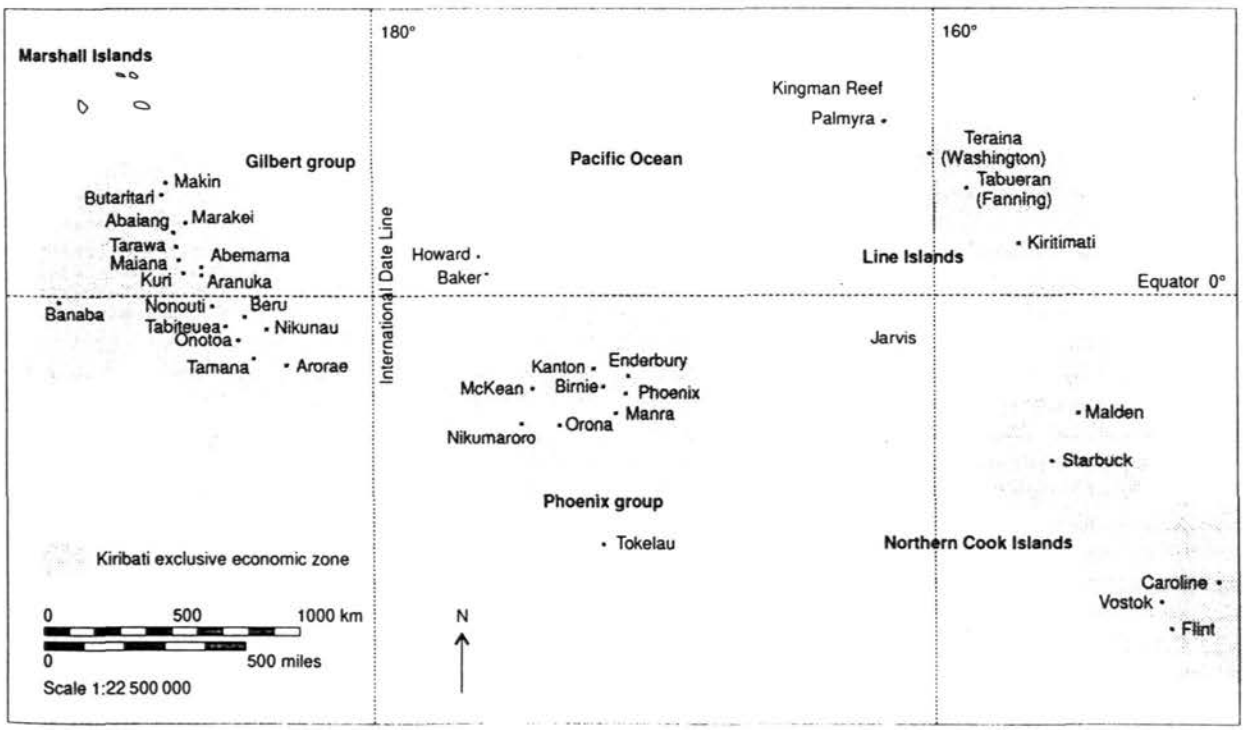
Notes: [a] 1993 data; [b] 1989 data.

5.2 Renewable energy in selected countries

5.2.1 Kiribati

The Republic of Kiribati is made up 33 low-lying coral islands and atolls located in the central Pacific (see Map 5.1). It is divided into three main groups: the Gilbert Islands, the Phoenix Islands and the Line Islands. The islands of Kiribati are isolated and fragmented, extending some 3,870 km from Banaba on the west to Kiritimiti (Christmas Island) in the east; and 2,050 km from Teraina (Washington Island) in the Northern Line Islands to Flint in the Southern Line Islands (SPREP 1993b). A 1992 estimate for the population was 75,200 (see Table 5.1).

Map 5.1 Kiribati



Source: SPREP (1993b).

Kiribati is a Micronesian country. Its history of human settlement began with the arrival of Micronesians between 200 and 500 AD. On 12 July, 1979, Kiribati became a fully independent country (Kiribati Visitors Bureau 1994). The country's economy is predominantly subsistence based and exports are mainly fish and copra (SPREP 1993b). Kiribati's energy supply is heavily reliant on imported energy (see Table 5.2).

Solar energy is the main renewable energy resource used in Kiribati. The Energy Planning Unit (EPU) is the main institution for energy planning and renewable energy administration (National Planning Office 1992). The EPU was established within the Ministry of Works and Energy in 1984. It is responsible for providing advice and assistance on energy matters especially in the areas of petroleum and electric power supply, renewable energy sources, energy conservation and coordination of energy projects.

The Solar Energy Company (SEC) began operations in 1984 with initial support via assistance from the Foundation of the People of the South Pacific (FPSP) and funding from the United States Agency for International Development (USAID) and with the long term goal of raising revenue and becoming a self-financing organisation. The SEC is responsible for the marketing of solar energy products to private users on outer islands for lighting and other utilisation.

In 1993, the SEC became independent of sponsorship and began operations on a commercial basis. The SEC's functions have included installation of solar systems, provision of a maintenance service for customers, and collection of fees for service. Solar energy systems provided by the SEC operate more efficiently and reliably, and are more affordable than those installed before the SEC's inception. This has come about mainly because the solar PV systems are professionally installed, proper maintenance is provided on a full time basis, and a tariff is paid monthly by users (Loteba, Energy Planner, Ministry of Works and Energy, Kiribati, 1995, pers. comm. 15 March).

The island of North Tarawa in the Gilbert Group, has 156 solar PV systems. Of these, the European Union funded 100 systems; the rest of were funded by the Japanese International Cooperation Agency (JICA). There are two technicians to maintain them. The SEC monthly tariff covers the replacement of all equipment (including storage batteries) and maintenance. Each month, the householder only has to pay A$9 that is affordable for most Kiribatians. At

Abaokoro and Noto, villages in North Tarawa, users are very satisfied with the quality of solar PV systems, maintenance service and tariff. If it is possible, in the future they hope to run televisions, videos and refrigerators on solar power (Akura, General Manager of the Solar Energy Company, Kiribati, 1995, pers. comm. 20 March). The Catholic High School of North Tarawa is a boarding school with 245 students and 18 teachers. In 1987, a solar refrigerator system manufactured by BP Solar Australia was installed at the school. The system has worked very well since it was installed (Kaiuea, Principal of the Catholic High School, North Tarawa, 1995, pers. comm. 16 March).

To date, solar PV systems have been installed in all the island health centres of the Gilbert Group (19 islands) to provide power for vaccine refrigeration, lights, and an emergency two way radio. Schools in North Tarawa, Abemama and Abaiang, and many *maneabas* (community meeting halls) have been electrified using solar PV systems. Water supply for ten rural communities in Kiribati are provided by solar water pump systems and ten more systems are due to be installed in 1995. At present, a total of 310 solar home systems have been installed in Kiribati. Other solar PV power systems have been installed on many of the 26 inhabited islands of Kiribati for communication purposes (Akura, General Manager of the Solar Energy Company, Kiribati, 1995, pers. comm. 20 March). A solar hot water system is used at the Otintaal Hotel in Tarawa, which was made by Solahart Australia (Wardrop, Adviser for Renewables, Energy Division, the South Pacific Forum Secretariat, 1995, comm. 12 June).

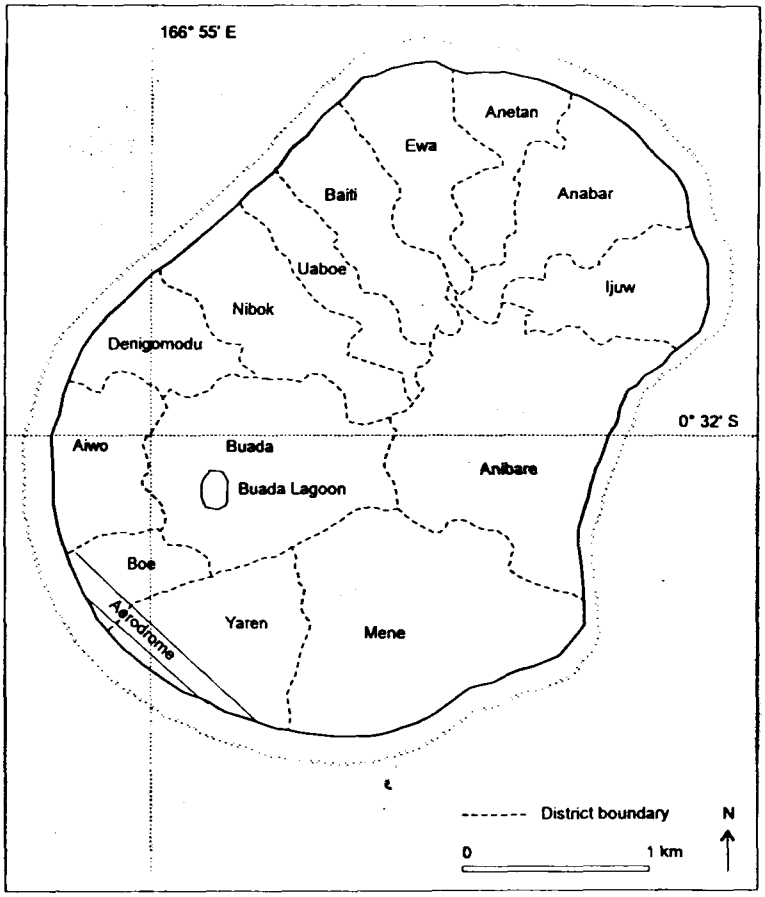
It is estimated that there are a total of 5,000 houses in the Gilbert Group. In 1996, the French Government gave aid for an A$1.3 million project for installation of a further 300 solar home PV systems; in 1998, the UNDP will possibly fund a further 1,000 solar home systems at a cost of A$3 million dollars; also it is proposed that 500 solar systems for house lighting and radio will be installed in the Line and Phoenix Groups including Kiritimiti. According to Mr Akura, General Manager of the SEC, funding is likely to be sought for this from Japan. A further SEC venture involves the establishment of a solar light manufacturing facility in Kiribati in 1997 with German Government funding. At present, the solar lights used in Kiribati are made in Australia and New Zealand. Future planning is also being undertaken via a joint project looking into the feasibility of running refrigerators, televisions and videos using household solar PV systems in Kiribati. This is being undertaken by the SEC and a French

company (Akura, General Manager of the Solar Energy Company, Kiribati, 1995, pers. comm. 20 March).

5.2.2 Nauru

Nauru is a tiny coral island nation situated in the South Pacific 3,000 km to the northeast of Australia. Its land area is only 21 km^2. Its nearest neighbour, 250 km to the east, is the island of Banaba, part of Kiribati (see Map 5.2). The people of Nauru are Micronesian. From 1888, Nauru was annexed to Germany until World War I. Then it was entrusted to the tripartite administration of Australia, New Zealand and the United Kingdom. During World War II, Japanese occupied Nauru. After World War II, the United Nations assigned it as a trust territory to the Australia, New Zealand and the UK until 1968, the year of Nauruan independence (Weeramantry 1992). Nauru's population was 9,600 in 1992 (see Table 5.1).

Map 5.2 Nauru



Source: Viviani (1970).

Nauru is rich in phosphates of high quality and is one of largest exporters of phosphates in the world. Phosphate mining and export is Nauru's main economic base (Viviani 1970; Weeramantry 1992). The country's energy supply is based on imported petroleum and, in particular, diesel. The development of renewable energy in Nauru is in its infancy.

The Nauruan Department of Island Development and Industry is responsible for energy affairs at the government level. The Nauruan Government has not yet formed an energy planning and management authority. A senior officer of the Department of Island Development and Industry speculated that there are potential ocean energy resources that could be exploited for Nauru. He pointed out that if OTEC is proven to be viable economically it could become a major alternative source of energy for Nauru in the future. As mentioned in Chapter 4, in the 1970s, a small OTEC system (100 kW) was tested in Nauru by the Japanese and the pilot project operated successfully for a few months until rough seas damaged the plant beyond repair.

Nauru currently has a handful of solar hot water and lighting systems. For instance, at Kayser Church College in the Ewa District, an eight panel solar PV system is used for lighting six bedrooms as a back up to diesel based electricity generation. This system was installed eight years ago.

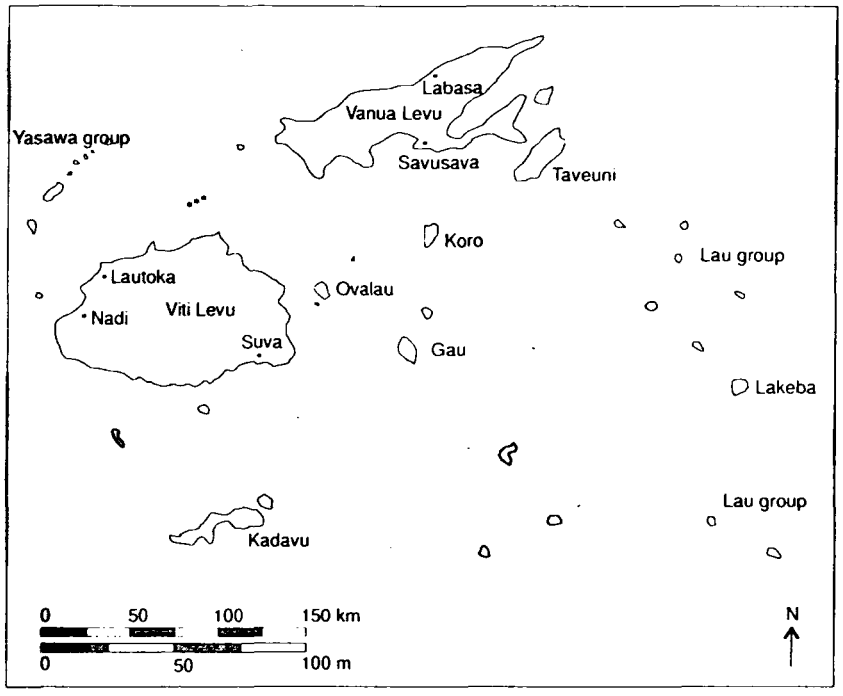
In Nauru, the Nauru Phosphate Corporation (NPC) generates 60 percent of the electricity supply. Each day, 40,000 litres of diesel is used for generating this electricity, which costs NPC about A$10,000 dollars. The NPC is starting to think of using renewable energy to reduce diesel consumption (Ellis, Services Superintendent of the Nauru Phosphate Corporation, 1995, pers. comm. 23 March). In 1995, the NPC ordered a solar street lighting system from Sunlight Solar Systems Australia Pty Lt, Geelong, Australia.

5.2.3 Fiji

Fiji lies in the heart of the South Pacific Ocean. It is 1710 km northeast of Sydney and 1,164 km north of Auckland (Ministry of Information, Broadcasting and Telecommunications 1994). Fiji is made up of about 332 islands (see Map 5.3). About one third of these islands are inhabited. The population was 771,104 at the end of 1993 (Ministry of Information, Broadcasting and Telecommunications 1994). Ethnic groupings include indigenous Fijians, Indians, Europeans, Chinese and many Pacific Islanders from other Pacific Island nations

(Ministry of Information, Broadcasting and Telecommunications 1994). Fiji was first settled about three and half thousand years ago by the Melanesians. In 1643, the Dutch explorer, Abel Tasman, discovered it. In 1874, Fiji was ceded to Great Britain. In 1970, Fiji became an independent nation. Fiji has a diverse economy. Its economic base is mainly the sugar industry, copra milling, tourism and secondary industries (Ministry of Information, Broadcasting and Telecommunications 1994).

Map 5.3 Fiji



Source: Australian International Development Assistance Bureau (1992).

The Fijian Department of Energy is the main government institution overseeing the development of renewable energy. The Department is responsible to the Minister of Lands, Mineral Resources and Energy (Department of Energy of Fiji 1994a). Major foci of the Department of Energy are development of regulations, energy conservation, development of renewable energy resources, and expansion of rural electrification (Ministry of Finance and Economic Development of Fiji 1995). Currently, Fijian Government policy on renewable energy is directed towards researching the potential for the economic use of renewable energy resources such as hydro power, biomass and wind energy (Government of the Republic of Fiji 1993).

In Fiji, energy requirements are met from mixed sources including hydro electricity, fuelwood, bagasse, and coal and petroleum products. Coal and petroleum fuels are mainly imported from Australia, New Zealand and Singapore. Australia in particular has been the major source for Fiji's imported fuel over the last ten years (Department of Energy 1994a). Prior to 1982, Fiji's energy demand was met by diesel based generators. In 1982, a major hydro scheme (80 MW) at Monasavu on Viti Levu came into operation. Monasavu now supplies 97 percent of all electricity in Fiji (Government of the Republic of Fiji 1993). By 1990, 65 percent of total energy requirements were met from local renewable energy sources and 35 percent were imported (Government of the Republic of Fiji 1993).

Hydropower. There are a number of mini and micro hydropower projects in Fiji[1] (Table 5.3). These include the 100 kW Bukuya mini hydro project that was completed in 1989. Also in Savusavu, an 800 kW Wainikeu mini hydro project has been completed and connected into the grid on Vanua Leva, the second biggest island in Fiji. The People's Republic of China, as part of an interest-free loan of F $8.6 million funded both of these projects. In 1993, a 3 kW micro hydro project was put into operation in Vatukarasa, which was funded and constructed by the US Army Corps of Engineering (USACE) (Department of Energy of Fiji 1994a). Another hydro plant installed by USACE is the 20 kW Kadavu Koro hydro plant that was commissioned in 1994.

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[1] There are no uniform definitions with respect to the scale of hydro capacity, but, it is generally considered that hydro capacity spans five categories: micro (less than 100 kWe), mini (100 kWe - 1,000 kWe), small (1 MWe - 10 MWe), medium (10 MWe - 100 MWe), and large (above 100 MWe).

In late 1992, Fiji also sought F$4.5 million from the European Community for funding of the Somosomo hydro project. The Department of Energy has identified 80 potential sites for small hydro systems on the two main islands of Fiji: Viti Levu and Vanua Levu. Also some potential sites for medium sized hydro systems (10-20 MW) have been identified in Viti Levu (World Conservation Union 1992). Other sites on Taveuni have also been identified. In 1994, a river/hydro engineer from Japan's International Cooperation Agency surveyed and assessed all potential mini/micro hydro sites in Fiji. This assessment work has been useful for Fiji in terms of planning for long term hydropower development (Department of Energy of Fiji 1995).

Table 5.3 Mini/micro hydro schemes in Fiji

No.	Name of scheme	Head of scheme	Installed capacity	Installation date	Cost (F$000)
1	Marist Training Centre, Tutu	~ 165 m	20 kW	1975	n.a.
2	Nasoqo	~ 30 m	4 kW	1984	40
3	Wairiki Catholic Mission, Taveuni	~ 50 m	8 kW	1930*	n.a.
4	Bukuya	~161 m	100 kW	1989	900
5	Wainikeu	~ 122 m	800 kW	1992	4000
6	Vatukarasa	~ 10 m	3 kW	1993	150
7	Kadavu Koro	~ 40 m	20 kW	1994	80
8	Somosomo	n.a.	n.a.	n.a.	~ 4500

Sources: Department of Energy of Fiji (1994 & 1995).

*Repaired in 1986.

Biomass energy. Biomass energy resources contribute significantly to the energy supply in Fiji (see Table 5.4). Major sources of biomass are wood, wood waste, and bagasse from the sugar industry. Although not yet exploited, waste from sawmilling operations also has considerable potential for energy generation in Fiji. There are a significant number of sawmills and the Department of Energy considers that Fiji would benefit greatly from use of sawmill wastes for power generation. Also it is considered that there may be potential for cogeneration of power utilising steam from sawmills (Kumaran, Director of Energy, Fiji, 1995, pers. comm. 27 March).

In 1992, according to statistics collected by the Department of Energy, 50.7 percent of Fiji's energy was provided by biomass. Of this, bagasse contributed 33.8 percent, and wood contributed 16.9 percent (Department of Energy of Fiji 1994b). The major generator and user of biomass energy in Fiji is the Fiji Sugar Corporation (FSC) which produces heat, steam and electricity. Smaller amounts of biomass are used for cooking (Department of Energy of Fiji 1994b). With regard to cogeneration facilities (such as generating steam and electricity; or generating heat and electricity), there is scope for these in association with the running of boilers, steam engines or turbines, crop dryers, sawmills and kilns.

The Department of Energy would particularly like to promote the installation of cogeneration facilities in association with the milling of community owned pine plantations which are starting to mature and are nearly ready for harvesting (Kumaran, Director of Energy, Fiji, 1995, pers. comm. 27 March). To ensure adequate resources are allocated and skills developed and retained for the operation and maintenance of such technology, the promotion of cogeneration technology by the Department of Energy will be aimed at commercially based projects (Kumaran, Director of Energy, Fiji, 1995, pers. comm. 27 March).

The Department of Energy in the last decade has promoted several biomass energy projects. Firstly, in order to ensure a sustainable fuelwood supply, a joint forestry project is being undertaken by the Department of Energy and Gesellschaft fuer Technische Zusammenarbeit - a German international aid organisation. Under the project, 3,000 fuelwood seedlings are being planted every year from 1991 to 1996 (Department of Energy of Fiji 1994a). Secondly, in Fiji, many institutional stoves (cooking stoves in schools and government agencies) use fuelwood. To promote biomass use efficiency, an Institutional Stove Program is being carried out by the

Department of Energy, together with the University of the South Pacific and a number of non-government organisations such as the Komiti for the Advancement of Nutrition and Agriculture. The program is to modify and downsize the current design of stoves and their energy consumption (Department of Energy of Fiji 1994a).

Also, a carbon sink-farming project has been proposed. The aims are to mitigate greenhouse gas emissions through the planting of 129.5 hectares of forest per year for a period of 20 years, which is anticipated to create a sink for over 600,000 tonnes of carbon, and to provide other benefits such as sources of income and fuelwood for local people. Project funding is being sought from the UNDP and other organisations (Department of Energy of Fiji 1994a).

Wind energy. In order to assess the potential of its wind energy resources, a large wind monitoring assessment program is underway in Fiji. The Department of Energy carries out wind monitoring at five locations in Sigatoka (Gamu, Serua, Korotogo, Olosara, and Waibogi). In addition, more than two years of wind data information has been obtained from monitoring stations at the University of the South Pacific Lower Campus in Suva and at Naitonitoni in Navua. Fiji has also participated in the South Pacific Forum Secretariat's Regional Wind Monitoring Program since 1994.

Solar energy. Since 1983 more than 350 PV systems and solar water the Fiji Government has installed pumps in remote rural areas where there is no grid electricity. Due to the relatively high initial cost of solar PV systems, their purchase and installation has been subsidised by the Government or by aid funds. Also about 200 radiotelephone systems in Fiji are run using solar PV systems. Solar energy is also used via solar hot water systems which are common both in urban areas and government buildings.

Recently, some trial and demonstration projects have been undertaken by the Department of Energy to test applications of solar PV lighting and TV/video applications in rural areas. An example of this is the Solar PV Demonstration Project at Ovea village, Suva. The project was initiated in 1990 and funded by the Department of Energy of Fiji. At this village, the community house uses solar energy for lighting and television. An eight panel, eight batteries and eight light capacities solar lighting system is also installed at the local church. About 300 people attend this church on Monday, Wednesday, Friday and Sunday evenings.

Table 5.4 Primary energy supply in Fiji (1981-1992)

	Wood		Bagasse		Hydro		Coal		Petroleum		Total	
Year	TJ	%	TJ	%	TJ	%	TJ	%	TJ	%	TJ	%
1981	4021	16.0	9440	37.5	0	0.0	584	2.3	11138	44.2	25183	100
1982	4073	16.5	9714	39.4	0	0.0	711	2.9	10126	41.1	24624	100
1983	4220	22.2	5201	27.4	127	0.7	480	2.5	8983	47.3	19011	100
1984	4240	18.3	10137	43.7	1047	4.5	605	2.6	7190	31.0	23219	100
1985	4380	20.7	7108	33.6	1094	5.2	463	2.2	8082	38.3	21127	100
1986	4430	19.1	9689	41.7	1195	5.1	464	2.0	7434	32.0	23212	100
1987	4382	22.5	7402	38.1	1178	6.1	190	1.0	6295	32.4	19447	100
1988	4526	21.7	7488	35.9	1225	5.9	215	1.0	7426	35.6	20880	100
1989	4482	19.4	9917	43.0	1292	5.6	302	1.3	7087	30.7	23080	100
1990	4529	18.3	10185	41.1	1386	5.6	412	1.7	8286	33.4	24798	100
1991	4537	18.2	8573	34.3	1379	5.5	271	1.1	10203	40.9	24963	100
1992	4576	16.9	9123	33.8	1363	5.0	471	1.7	11471	42.5	27004	100

Source: Department of Energy of Fiji (1994b).

The Department of Energy for the use of this solar PV system charges no fee. One local technician looks after the system. The panels were made in Japan, the batteries in USA, and the controllers are made in France and Kiribati. The controllers were originally designed by a French company, but simplified by the Kiribati Solar Energy Company. They are cheap, stable and easy to repair. At the moment, solar PV systems have not been used in Ovea households, as local people still use kerosene for lighting. Ovea villagers are hoping to have access to solar PV systems for lighting, TV/video, and refrigerators in the future.

In an attempt to smooth failures in solar energy systems, the Department of Energy is carrying out a monitoring program. Also, a training course was organised in 1994 by the Department of Energy for solar PV system technicians from villages in Fiji. The course focused on installation, operation and maintenance of solar PV lighting systems. It is planned that the responsibility for maintenance and repair of solar energy systems will be gradually handed over to village technicians from the Department of Energy.

Other renewable energy projects in Fiji. A number of research projects have been conducted into the viability for Fiji of other renewable energy technologies. These include wave energy, geothermal energy and OTEC.

In 1991, under the South Pacific Applied Geoscience Commission's Regional Wave Energy Assessment Program, Fiji carried out wave height and period measurements southwest of Kadavu. As a follow-up to this in 1994, the Department of Energy hired two monitoring buoys and collected additional wave data from southwest of Kadavu and Muani, and wave directional data from near the coast of Kadavu. The Norwegian Government and regional agencies as part of a Pacific Regional Energy Program (Department of Energy of Fiji 1994a) have supported this wave energy research.

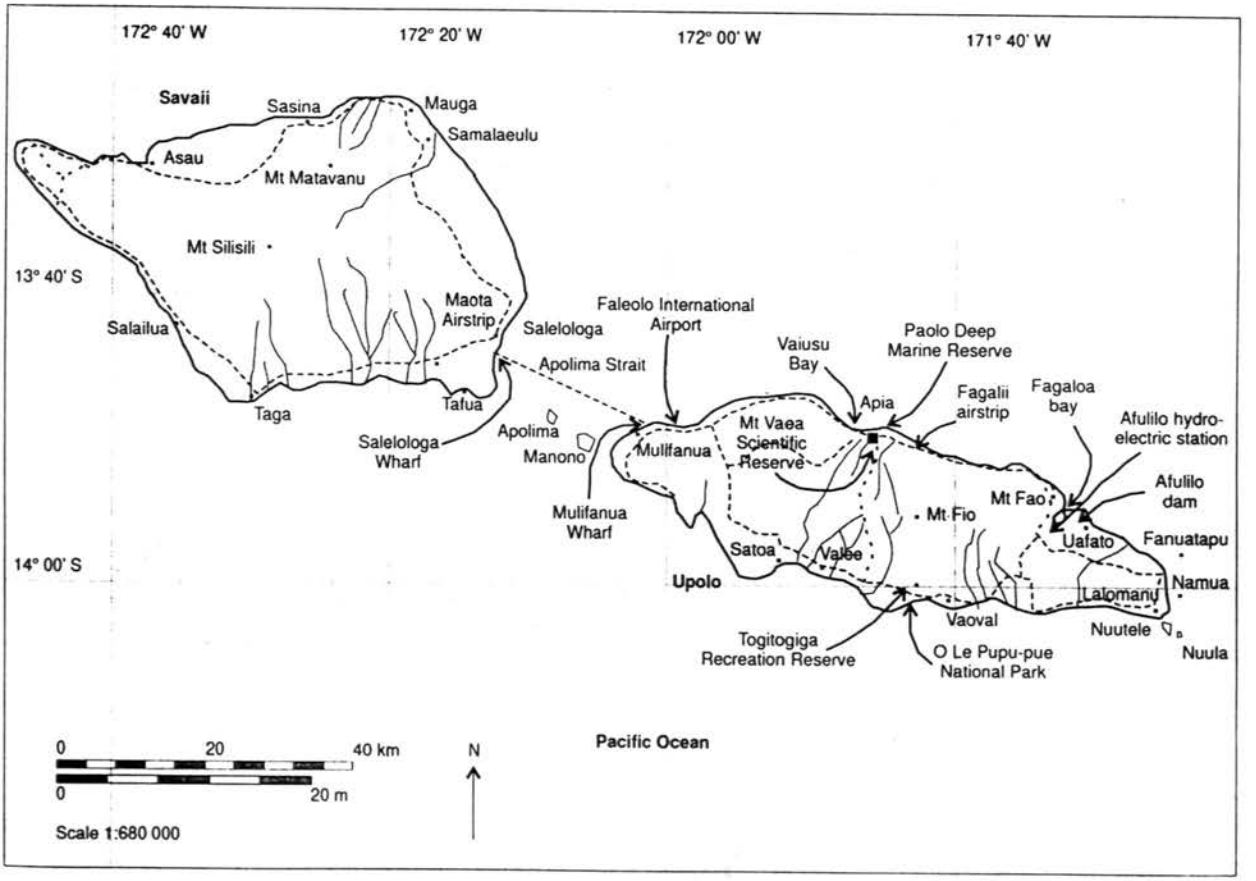
Two New Zealand companies, KRTA Ltd and Geothermal Energy New Zealand Ltd, have taken an interest in geothermal energy research in Fiji. Surface surveys and studies have been conducted on geothermal prospect sites in Savusavu and Labasa. Now they are working towards a deep drilling program (Department of Energy of Fiji 1994a). Also, a small OTEC joint Japanese-Fijian research project is underway in Fiji funded by Japan (Institute of Natural Resources 1994).

An overall assessment of progress in Fiji. Arguably a greater focus on exploiting renewable energy has occurred in Fiji in comparison to other island countries in the Pacific Island region. Apart from policy development, planning and management by the Department of Energy, a major factor contributing to this progress has been assistance via international aid. Fiji has received human resource and technological assistance, and financial aid from numerous foreign governments and international organisations for the renewable energy sector. This includes assistance that the Department of Energy has received from the SPF Secretariat.

5.2.4 Western Samoa

Western Samoa is located east of the International Dateline. It is about 1,200 km northeast of Suva, Fiji (Western Samoa Visitors Bureau, 1994) (see Map 5.4). It comprises two large islands and seven very small islands. Western Samoa is an oceanic volcanic archipelago with its land areas dominated by rugged mountain ranges. The islands are still volcanically active and earth tremors are frequent (SPREP 1993c).

Map 5.4 Western Samoa



Source: SPREP (1993c).

The Samoan culture is Polynesian in origin (Browne & Scott 1989). Human settlement in Samoa first occurred about 1,000 BC. Europeans initially came to Samoa in 1722 in an exploratory voyage for the Dutch West India Company (Holmes & Holmes 1992). Last century, a struggle for the colonial control of Samoa went on between the Americans, the Germans, and the British. After 1899, the Samoan Islands were divided between Germany and the United States. The western islands, which were under German power, are now Western Samoa; the eastern islands are now American Samoa. In 1914, New Zealand occupied Western Samoa. After World War II, Western Samoa was placed under the trusteeship of the United Nations. In 1962, Western Samoa became the first Pacific Island nation to gain independence from colonial rule (Browne & Scott 1989; Holmes & Holmes 1992).

Agriculture is the mainstay of the Western Samoan economy. Tourism is also of increasing importance. The nation's economy is also dominated by external aid and remittances from Samoans working overseas (SPREP 1993c) (see Table 5.2 for other development indicators).

The Energy Unit of the Treasury Department is the main government body that deals with energy policy matters in Western Samoa and the Electric Power Corporation (EPC) oversees energy supply, electricity generation and maintenance. The EPC is a privatised commercial body. At the moment, hydro, solar and biomass energy (not including biomass based electricity generation) are the main renewable energy options in Western Samoa. The Government's general renewable energy policy (Roebeck 1995a, p5) is to:

> Develop and maintain an awareness of Western Samoa's renewable energy resource potential through rigorous assessments, maintain a readiness to utilise renewable energy technologies when they are technically and commercially proven, provide the least cost solution to the demand requirements; require only low human resource and financial investment; be environmentally sustainable; and provide the technical capability regarding operating and maintaining the technology.

Hydropower has been successfully developed in Western Samoa. Since 1959, five hydropower stations (Alaoa, Fale-Ole-Fee, Samasoni, Lalomauga and Taelefaga) have operated in Upolu. Their total installed capacity is 13.4 MW. In 1994 total hydropower generation in Western Samoa was more than 53.6 GWh and contributed 87.5 percent of the nation's total electricity

generation. The highest level of hydropower generation in 1994 was 93 percent of total electricity output for May 1994 (Rathod 1994).

In remote areas, solar systems have been used in hospitals for lighting and in power supplies for telecommunications since the 1980s. The demand for solar hot water systems is gradually increasing. In Savaii, the largest island of Western Samoa, there may be potential for exploiting solar and hydro energy resources (Roebeck 1995b).

Wave and other renewable energy resources have not been considered as alternative energy sources for Western Samoa as yet. However, wave energy is under consideration to the extent that Western Samoa conducted a wave monitoring program in conjunction with the Norwegian Government in 1993 as part of a Pacific Regional Program (Roebeck 1995b).

5.2.5 The Cook Islands

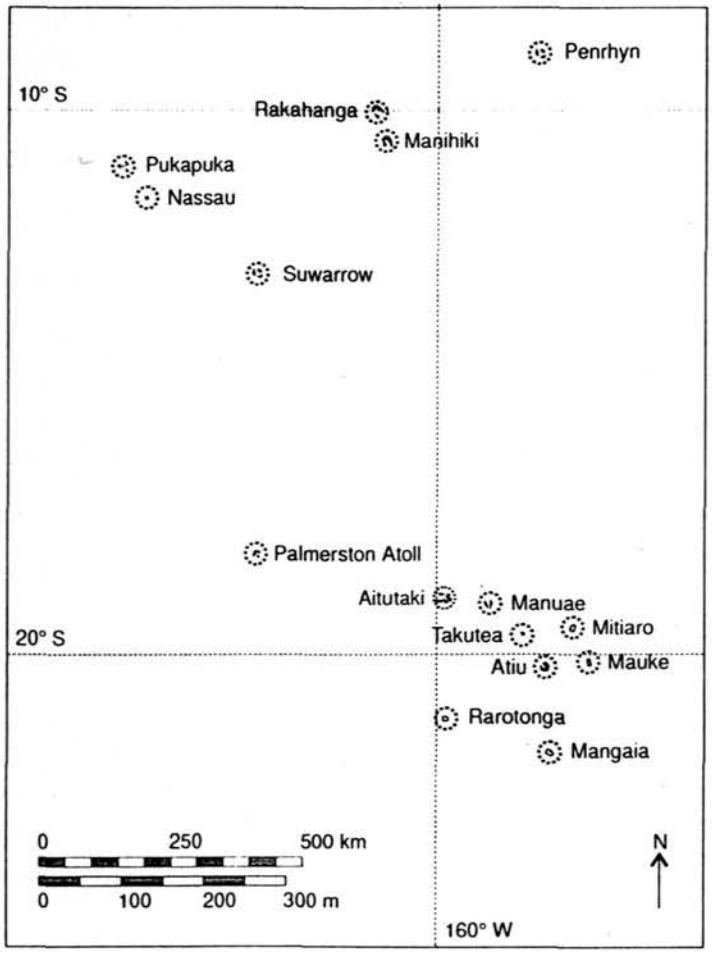
The Cook Islands comprise 15 small islands scattered over some 1.8 million km^2 of the South Pacific Ocean between Western Samoa/Tonga on the west and French Polynesia on the east. The land area of the Cook Islands, however, is only 240 km^2. Geographically, the Cook Islands are divided into the Northern Group (six islands) and the Southern Group (nine islands) (see Map 5.5) (SPREP 1993a).

The Cook Islands are Polynesian in cultural origin. The people are Maori and share with the indigenous people of French Polynesia and New Zealand a bond of history and culture. Cook Islanders are also citizens of New Zealand. The Cook Islands were under New Zealand authority until 1965 when they became a self-governing country. Agriculture, tourism, offshore fisheries and the cultivated pearl industry have become important contributors to the national economy (SPREP 1993a) (see Tables 5.1 and 5.2 for other development indicators).

Electricity is supplied to most inhabited islands and most electricity generation is currently based on diesel power. Diesel fuel has to be imported at a high cost each year. For instance, US$1.3 million worth of diesel fuel was used for electricity generation in 1990 (World Bank 1992). This is a heavy burden for the national economy of the Cook Islands. Also at times an uncertain supply of diesel due to shipping delays has resulted in periods of no electricity generation for the outer islands. Every year, the Cook Islands Government gives heavy subsidies to its citizens for the operation of diesel generating systems, especially in the Northern

Group. Unfortunately, as a consequence, pollution and environmental hazards resulting from diesel generation have had adverse impacts on the fragile ecosystems of the Northern Group (Tereapii 1995).

Map 5.5 The Cook Islands



Source: Davis et al. (1979).

The Cook Islands are potentially rich in indigenous energy resources, such as solar, wind, OTEC and small hydropower. Recognising this, the Cook Islands Government has placed great emphasis on the employment of renewable energy systems for meeting its future energy requirements, particularly in the outer islands (SPREP 1993a).

The major energy policies of the Cook Islands Government for the next decade are to: ensure a stable energy supply for the energy consumers in the outer islands; ensure energy supply for industry, agriculture, tourism and commerce at a reasonable cost; ensure adequate power supply for improvement of social services, living standards and the quality of life; develop renewable energy resources; promote energy conservation; and work towards self-sufficiency in the areas of technician training, energy accounting and energy management (Tereapii 1995).

The following specific policy goals are expected to be achieved. They are to: improve generation capability and reticulation systems; increase hours of supply in the outer islands; to cut down the expenditure on diesel oil, engine parts, and overall maintenance by installation of hybrid systems (renewable and diesel); encourage the use of solar lighting, solar refrigeration, solar water pumps, solar hot water systems, solar cookers, and biomass energy from organic wastes; and encourage renewable energy technology research in solar desalination, solar fish and fruit dryers, wind power and biogas digesters (Tereapii 1995). Within the Cook Islands Ministry of Energy, the Renewable Energy Directorate is responsible for the development, research and implementation of renewable energy systems.

The Pukapuka Solar PV Project. In the Cook Islands energy history, the Pukapuka Solar Electrification Project has been a significant venture. It started in 1991 and was completed in 1993. Pukapuka is one of the islands of the Northern Group and more than 700 people live there. Before solar PV systems were installed, the people of Pukapuka did not have any electricity supply. The Cook Islands' Government received a NZ $1.65 million loan from the French government in 1991 to implement this project (Tereapii 1995). The South Pacific Institute of Renewable Energy (SPIRE), a Tahitian based research agency, carried out the work. A total of 121 PV systems have been installed to provide energy to 143 homes and buildings. More than 900 light fixtures and 18 streetlights have been installed. The designed

installation capacity is to provide 1,000 Wh of electricity per day. Each family can use up to 4 lights, a video, a TV, a refrigerator or a small freezer (Quentin & Pujol 1993).

It is interesting to compare energy usage on Pukapuka with Atiu, an island of the Southern Group, which has a population less than that of Pukapuka. Atiu uses only diesel generation, based on supplying electricity 12 hours per day. For the 1993 to 1994 financial year, the total expenditure on diesel generation was NZ$212,600 in Atiu (Wichman 1995). According to a conservative estimate, for the next 10 years Pukapuka can save diesel fuel costs of about NZ$2.126 million (Wichman 1995). Also, in Pukapuka solar PV systems can provide electricity 24 hours a day. If it is assumed solar PV systems per day provide six hours more electricity than diesel does, then, each year, NZ$318,900 worth of diesel fuel could be saved in Pukapuka (Wichman 1995). Taking this into account, in less than six years the NZ$1.65 million for initial cost of the solar PV systems will be recovered (Wichman 1995).

Hybrid systems. Development of hybrid energy systems to cut down the costs of diesel generation is an important aspect of energy policy in the Cook Islands. In 1995, the Ministry of Energy was planning to introduce solar and diesel power systems to Palmerston Island where there is currently a 24 hours per day electricity supply by diesel generation (Wichman 1995).

Wind power. In the Cook Islands, wind power research has been carried out for many years. Recent research initiatives include: a two year wind monitoring project started in November 1994 at Ngatangiia village, Rarotonga, funded by the SPF Secretariat and an expression of interest by the Danish Government and Danish companies in 1995 in jointly establishing a wind trial station at Rarotonga (Wichman 1995).

Energy conservation. Energy conservation policy implementation efforts have been successful according to the Cook Islands' Renewable Energy Directorate (Wichman 1995). The Mitiaro Island Energy Saving Light Bulbs Project is an example. With an energy demand increase, Mitiaro Island required a new larger diesel generator. In March 1995, energy saving compact fluorescent lights were provided free to energy consumers by the Cook Islands Government.[2] The maximum power saving is up to 80 percent (Ministry of Energy of the Cook Islands 1994).

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[2] The 11W, 16W and 20W compact fluorescent lights can generate the same brilliance as 60W, 75W and 100W incandescent light bulbs.

Wichman, Acting Director of the Renewable Energy Directorate, observed that the demand for energy in Mitiaro Island dropped from 21 kW to 5.6 kW (pers. comm. 13 April 1995). The SPF Secretariat supports the project. The compact fluorescent lights are made in Australia and can last up to five years. Interestingly, the Cook Islands Ministry of the Energy is considering a proposal to ban incandescent light bulbs (Wichman 1995).

In addition, there other renewable energy research and development projects which are continuing in the Cook Islands, such as solar water pumping of sewage water for irrigation, solar cooking stoves, solar hot water systems, and a solar desalination and biogas project.

It is worth pointing out that there is a close relationship between the Ministry of Energy and the environmental authority, the Cook Islands Conservation Service, in the development of renewable energy systems in the Cook Islands. Renewable energy projects proposed by the Ministry of Energy are always given full support by the environment authority.[3]

5.2.6 Energy Division of the South Pacific Forum Secretariat

The South Pacific Forum Secretariat's Energy Division has played an important role in the implementation of regional energy development programs in the region. The programs involve provision of regional and in-country technical assistance and training activities. These programs cover all major energy sectors, such as electric power, petroleum products usage, renewable energy use, energy policy and planning, energy conservation and efficiency, and general management. The programs are aimed at maximising the ability of Forum Island Countries (FICs) to plan and manage their own energy sector. The FICs include 15 countries, they are: Australia, the Cook Islands, the Federated States of Micronesia, Fiji, Kiribati, the Marshall Islands, Nauru, New Zealand, Niue, Papua New Guinea, the Solomon Islands, Tonga, Tuvalu, Vanuatu, and Western Samoa.

Under these programs, principal activities include regional coordination, energy policy and planning, development of country energy databases, demand side management, manpower training, institutional improvement, setting of industry standards, demonstration of new (proven) technologies, resource assessment, and contract negotiation skills. These programs

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[3] In April 1995, at the Berlin Climate Conference, a Cook Islands environmental officer made a request to the Danish Government regarding assistance for a wind power generation project.

are funded by the European Union (EU), the United Nations Development Program (UNDP), Gesellschaft fuer Technische Zusammenarbeit, Australia, New Zealand and Japan. Feedback is provided by FICs at the Regional Energy Committee Meetings held every two years. There are ten professional staff members at the Energy Division.

5.3 Issues

Although the development of renewable energy systems in Kiribati, Fiji, Western Samoa and the Cook Islands has been a considerable success since the 1980s, a range of difficulties still remain. In Nauru, renewable energy has not been taken up commercially at all. The three major problems for these countries are: a scarcity of financial resources; shortage of skilled human resources; and lack of appropriate institutions related to energy planning, energy management and technologies. These problems have seriously impeded the progress of renewable energy systems in these nations.

5.3.1 Shortage of skilled human resources and lack of appropriate energy institutions

Lack of energy policymakers, energy planners, project organisers, energy economists, energy system managers, engineers and technicians is a perennial problem for the Pacific Islands. Even for the more industrialised countries in the region, such as Fiji, the issues of regulatory planning and control, and human resource development in the energy area have not been properly resolved. Of course, the extent of the problem varies with each country.

In Nauru, at the government level, only two staff work in energy administration. The Nauru Phosphate Corporation handles petroleum supply and diesel electricity generation. There is no national energy policy, plan or strategy as yet.

In Western Samoa, the national Energy Unit employs two and a half-staff, and they focus on conventional energy supply. Due to an insufficiency of qualified staff, the Energy Unit is not capable of carrying out energy policy formulation, energy planning, energy management, energy project design and technician training, as a government energy authority should. This encourages dependence on fossil fuels. For example, in Savaii, there is great potential for the exploitation of solar energy and some hydropower; however, its electricity supply totally depends on diesel power plants. Mr. Tautulu Roebeck (1995b), a Chief Executive Officer of the Treasury-Energy Unit, said:

> Our institution for energy should be improved. At this stage, we expect two or three experts from Australia or other foreign donor countries and international organisations, such as UNDP to help us promote capabilities for energy planning, energy management, project organisation and technician training. Otherwise, the development of renewable energy in Western Samoa will be very difficult. For instance, we need financial support from outside for renewable energy projects. However, at the moment, we are not too sure how and where we can seek financial aid. We really need some qualified people to carry out this sort of work.

The Energy Unit in Kiribati is made up of three staff, whose work loads are heavy. Although all of them have completed tertiary education, they are in need of special training in energy policy, energy planning, and energy management and energy economics. They are looking towards foreign donors and international organisations to send some experts to work at the Energy Unit for three or six months to provide this training. In addition, the Solar Energy Company in Kiribati needs one or two experts to help for more than six months to improve project management and technician training.

In the Cook Islands, the government is keen to develop renewable energy resources. Many renewable energy projects need management expertise, such as that needed to implement a wind power project. The Cook Islands government is enhancing its human resource development. However, it will take some time. As a temporary measure for dealing with the shortage of skilled human resources, the Renewable Energy Directorate of the Cook Islands would welcome expert visitors from overseas to carry out energy planning, project management, and technician training.

In Fiji, the situation is different to that of other Pacific Island countries. There are about 26 staff in the Department of Energy. This is due to the fact that Fiji is more developed, and is endowed with better technological and industrial infrastructure. The Department of Energy has received much support from the University of the South Pacific. Also, three British energy advisers and Japanese hydro engineers have worked with the Department for different periods of time. Currently, the promotion of energy planning, management and training of technicians remains an important target of the Department. For example, hybrid systems for remote area power supply are of interest to the Department of Energy. They have undergone development in Australia, and have potential widespread application in Fiji (Kumaran 1995). However, hybrid systems are relatively new in Fiji and the region. The funding of demonstration projects

and training of personnel in this area would contribute a lot to promotion understanding and application of the technology.

The Renewable Energy Sector of the Energy Division of the SPF Secretariat has done excellent work in the establishment and improvement of renewable energy systems in the Pacific Island region. Each year, the Renewable Energy Sector undertakes many projects. At present, however, there is only one full time staff member in this sector, with other staff members being involved in renewable energy work on a part-time basis.

5.3.2 Scarcity of financial resources

For many years, most of the Pacific Island nations have experienced extreme financial problems. For instance, Kiribati is a predominantly rural society with a subsistence-based economy. After phosphate mining ceased in 1979, Kiribati's GDP declined by 45 percent, government revenue by 55 percent and export earnings by 80 percent (National Planning Office 1992). Now copra and fisheries are the main source of foreign exchange earnings. Additionally, licensing of foreign vessels fishing in the Kiribati Exclusive Economic Zone (EEZ) contributes some A$2-3 million per annum (Kiribati Visitors Bureau, 1994). Due to a high dependence on imports, trade deficits have increased over the years since 1980. Kiribati is classified as a least developed country (LDC) by the United Nations (National Planning Office 1992).

The Pacific Island governments have high expectations of renewable energy systems. They hope that they will result in reducing petroleum import bills and thus promote their people's quality of life and living standards. In the long term, renewable energy is cheaper than conventional energy, but at this stage, the initial cost of renewable energy systems, such as solar PV, hydro power and wind electricity generation is markedly higher. For instance, hydropower establishment is costing about US$10,000 to $80,000 per kW depending upon the location of the hydro power plant (Rathod 1995). The development of hydro electricity schemes is extremely expensive for these small island countries.

Experience has shown that to provide high quality and reliable energy supplies for the Pacific Island region, capital investment in renewable energy systems is essential. Due to shortages of capital, many users pursued alternative energy equipment with unreasonably low capital costs in

the early days of development of renewable energy systems in the region. As a consequence, the energy systems installed did not supply stable power supplies and this made them a failure. This was a waste of money and gave a bad reputation to renewable energy systems in the Pacific Island region. One academic commentator has said, "the South Pacific is littered with the equipment of failed alternative energy projects" (Todd 1995).

Given the economic situation and financial capability of the Pacific Island nations, it is quite evident that not many countries can afford the very high capital costs of effective renewable energy systems. In order to promote more widespread use of renewable energy in the region, international aid to contribute to the capital costs of renewable energy is very important.

5.4 Conclusion

The case studies of the five Pacific Island nations have revealed that: a scarcity of financial resources; shortage of skilled human resources and lack of appropriate energy institutions are three main barriers to adoption of renewable energy in the region. If renewable energy is really going to be the main energy source for the Pacific Island countries, these barriers have to be removed.

Plate 5.1 A two panel household solar PV lighting system in North Tarawa, Kiribati

Source: Author, 17 March, 1995.

Plate 5.2 An eight panel solar PV lighting system at Kayser Church College, Nauru

Source: Author, 24 March, 1995.

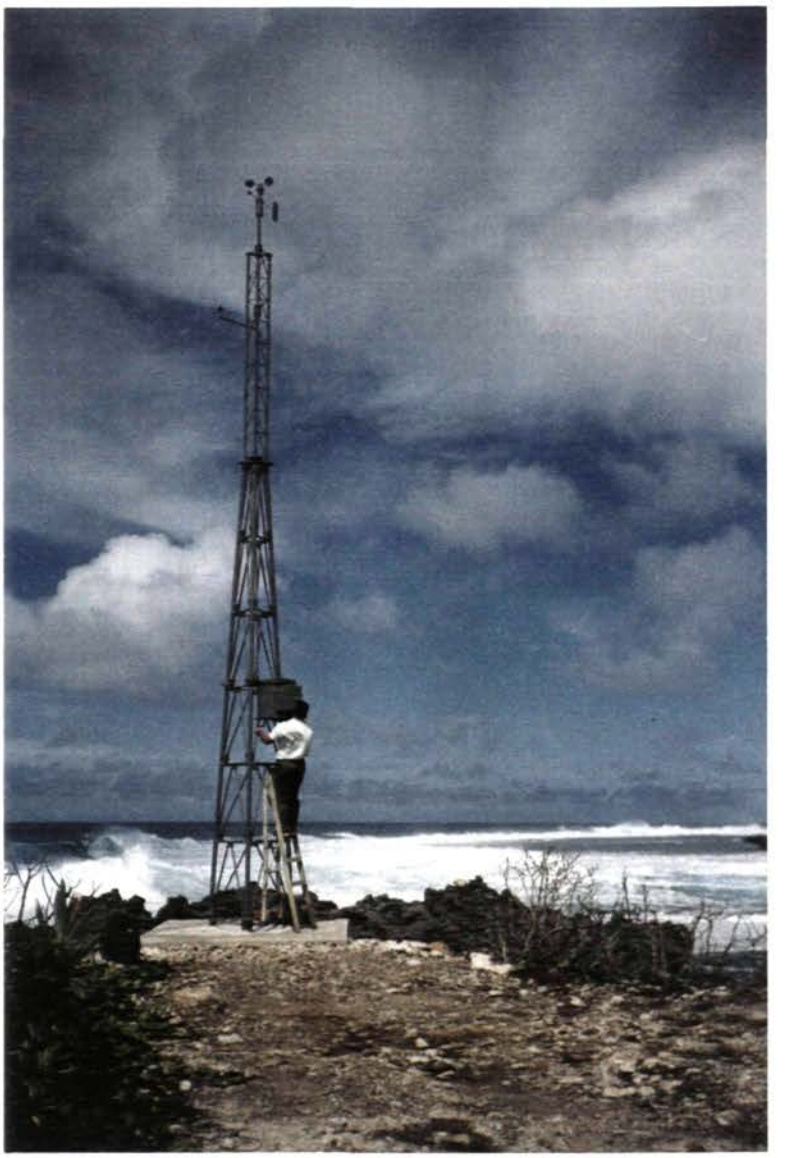
Plate 5.3 At Ovea Village, Suva, author with local people, and energy officers and a technician of the Energy Department of Fiji

Source: Author, 27 March, 1995.

Plate 5.4 A hydro electric head pond at Upolu, Western Samoa

Source: Author, 1 April, 1995.

Plate 5.5 A wind power monitoring station in Rarotonga, the Cook Islands



Source: Author, 14 April, 1995.