

An Overview of Renewable Energy Resources in the South Pacific Island Countries

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ABSTRACT

The developing countries of the South Pacific region have small, highly dispersed populations, no conventional fossil or nuclear energy resources and rely almost exclusively on foreign aid in developing new conventional or renewable energy systems to meet increasing energy demands. Fortunately, these countries have renewable energy resources that can be utilized for electricity generation.

A preliminary assessment of these renewable energy resources and their current and potential contribution towards the energy needs of eleven South Pacific countries follow. Various forms of energy usage are discussed, with particular emphasis on electricity generation for rural and remote communities from renewable sources.

BACKGROUND

The countries considered in this paper include Fiji, Tonga, Western Samoa, Cook Islands, Vanuatu, Solomon Islands, Niue, Kiribati and Tuvalu. These countries cover a vast area of ocean, lying between 4 N to 23 S latitudes and 155 W and 155 E longitudes. Actual land area is very small compared to ocean area; sea/land ratio varying from 41 for Western Samoa to 34,615 for Tuvalu.

The number of islands in these countries varies considerably; Niue has one single island, Tuvalu has 9, Vanuatu around 80 and Fiji somewhere around 350. Island characteristics vary from large volcanic and mountainous (Fiji, Vanuatu, Solomon Islands, Western Samoa), to raised coral (Niue, Tonga) and low-lying coral atolls (Tonga, Kiribati, Tuvalu).

Similar conditions which apply in these areas include mainly agriculture-based economies, large rural/village populations, rapid growth in electricity consumption, generally low GNP and heavy reliance on foreign aid. Lack of conventional energy sources (coal, oil, gas), almost total reliance on imported petroleum products for commercial energy uses and little or no expertise in new and advanced technologies of alternative energy sources draw these countries into a common predicament.

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CURRENT AND PROJECTED NEEDS FOR ENERGY

Energy supply is one of the major problems facing these countries. Apart from Fiji, which commissioned a 80 MW hydro-electricity system in 1983, and Western Samoa, which had around 20 MW of hydro-power in 1986, these nations depend exclusively on imported diesel fuel for electricity generation and on imported petroleum products for transportation, commercial and industrial uses. Furthermore, all forms of development invariably go hand in hand with increasing demand for energy. This was the case for most of the last decade, despite increases in diesel fuel prices. Electricity demands have been steadily increasing in most areas (ADB, 1986); over the period 1972 to 1985, growth in electricity generation has been: Cook Islands - 7.5 %; Kiribati - 9.3 %; Solomon Islands - 8 %; Western Samoa - 8.1 %; Fiji-5.5 % (ADB, 1986). In Fiji, moreover, electricity generation increased by 5 % from 1984 to 1985 (FEA, 1986). This increase was due to an increase in the number of consumers as well as an increase in the use of electricity.

Reliance on imported fuels ranges from 22 % in Vanuatu to 77 % in the Cook Islands. Biomass constitutes the bulk of local energy supply, used mainly for domestic and some institutional cooking, water heating, crop drying and, to some extent, steam and electricity generation. The transport sector depends totally on imported fuels.

Supply of electricity is further complicated by the fact that there are numerous (mostly small) islands in each country. Most of the inhabited, small islands are quite remote from the main islands, have small populations (less than a thousand) and the distribution of population does not justify a grid-based electrical network. Of the hundred or so inhabited islands in the Fiji group, for example, only 3 islands have reticulated electricity; these are the two main islands of Viti Levu and Vanua Levu and Ovalau. In 1985, the total domestic and commercial/industrial consumers of grid electricity were 50,319 and 9,288 respectively (FEA, 1986). Less than 40 % of the population have access to grid electricity, even now.

Demand for energy in all its forms is expected to show a steady growth. For electricity, in particular, growth is expected to be larger, due to increasing industrial and commercial developments, as well as stated government policy to electrify more rural and remote areas. For the latter, since extension of existing grids is impossible for various reasons, and since the demand for electricity does not justify construction of large centralized power stations, electrification of large parts of remote and island areas will be possible only by small scale renewable energy-based power systems or by small, diesel generator sets (which usually have a high operational and maintenance cost).

ENERGY FROM RENEWABLE SOURCES

These seven countries do have the option of utilizing various renewable energy resources. Fiji, Western Samoa, Solomon Islands and Vanuatu have considerable hydro-power potential. Cook Islands and Niue have potential for micro-hydro schemes. Biomass energy is already used almost exclusively for domestic cooking and heating purposes in the rural sectors as well as steam and electricity generation for several industries. There is considerable potential for development of biomass-based steam and electricity systems, particularly for small-scale systems utilizing forest, crop and sawmill residues and wastes (Tata Report, 1985; Prasad, 1987). All the island countries have abundant sunshine and solar energy is thus a viable energy source in the rural/domestic sectors for electricity generation (using photovoltaic panels) and hot water (Tata Report, 1985). On

a larger scale, solar thermal generating systems and solar photovoltaic systems can generate electric energy for larger communities. It has been shown (Prasad, 1982) that while the wind energy potential for the islands is not vast, suitable locations have adequate windspeeds for installations of water-pumping and electricity-generating systems. Biogas from animal and vegetable wastes can meet appreciable energy demands of the domestic sector, especially for livestock farmers. Other longer term renewable resources include geothermal energy (for which a few countries have surveys in progress), wave energy, tidal energy and ocean thermal energy.

RESOURCES FOR HYDROELECTRICITY GENERATION

Countries which have potential to develop hydro-electric power stations of capacity greater than 10 MW are Fiji, Solomon Islands, Vanuatu and Western Samoa. Fiji has already developed an 80 MW hydro power station at Monasavu in central Viti Levu, the main island in the Fiji group. The station has enough generating capacity for Viti Levu until 1992 (Fiji-DP9, 1986). Currently, over 90 % of electricity generated by the Fiji Electricity Authority is from the Monasavu hydro-electricity station. The Fiji Electricity Authority has firm plans to install around 5 MW of hydro power using micro and mini hydro electric schemes, ranging from 25 kW to 1 MW. These are to be located in the two main islands as well as in Taveuni and Koro. The government has set aside some 8.3 million dollars for the development of small hydropower plants between 1986 and 1990 (DP9, 1986).

Around 50 % of the electricity generating capacity of Western Samoa was provided by hydro power in 1985 (Development Plan, 1985). With the completion of a 3.5 MW hydro-electric system at Sauniatu, Western Samoa's dependence on imported energy will decrease even further. Currently, hydro-electric power plants have a 70% contribution towards the electricity generating capacity in Western Samoa.

The hydro-power potential in all these countries is estimated to be greater than 1 GW. Micro-hydro (up to 10 kW) and mini-hydro (10-100 kW) power systems can be developed on the mountainous islands, for example Tonga (Eua) and the Cook Islands (Rarotonga). The Solomon Islands government has been considering a 21 MW hydro-electric power system for some time but lack of funds seems to be a major problem, along with the fact that other power systems, notably biomass-electric units, appear to be more attractive economically.

Rainfall variation is similar for Fiji, Solomon Islands, Western Samoa and Vanuatu; the months from May to September having lower than average rainfall. Annual mean rainfall varies in the range 200 to 400 cm per year for all these countries. For an annual average rainfall of 300 cm, and assuming that only 10 % of the rainfall is retained in a catchment area of 1 square kilometre, the potential energy stored per year is 4×10^{11} J/yr for an average height of 100 m.

BIOMASS ENERGY RESOURCES

Substantial amounts of biomass energy are available in the majority of the South Pacific island countries being considered. These resources are in the form of natural forests and vegetation, coconut and timber plantations and the wastes and residues from agricultural crops and forest industries. From the sawmills of Fiji, for example, around 108,000 tonnes of wastes in the form of sawdust, shavings, wood chips and waste timber are generated every year (Fiji Forestry Depart-

ment, 1984). This figure is expected to increase as the pine plantations are harvested and milled. At present, there are no commercial uses of sawdust, shavings and the logging residues, yet the energy contained in these resources is considerable.

Biomass is the most widely used energy source for domestic purposes in many developing countries and more so in the South Pacific island countries. Reliance on biomass energy for domestic consumption ranges from 60 % in the Cook Islands to 94 % in the Solomon Islands. Biomass in the form of animal wastes (cow dung, pig and chicken excretions, etc.) and plant wastes such as sawdust, sugarcane tops, rice straws and husks, maize straws and husks, coconut husks, shells and leaves and many more plant residues, has a significant energy potential. The available energy in these wastes can be used in two ways:

- 1) by direct combustion for cooking, hot water or steam generation for industries and electrical generation and
- 2) by conversion into biofuels such as biogas (methane), ethanol, methanol and other fuels.

The availability of waste biomass varies considerably in nature and amount from country to country. However, significant amounts of plant wastes are available in most South Pacific countries, especially coconut husks and shells. Animal wastes are available in considerable amounts in Fiji, Solomon Islands, Vanuatu, and Western Samoa where livestock are present in substantial numbers. Fiji, which is the only South Pacific country to grow sugar cane, has large amounts of cane tops which are either burnt on farms or are simply left on farms as manure. A good portion of this material could be used for direct combustion.

The conversion of sugar cane, cassava and oil palms to biofuels, for example ethanol and methanol has attracted much interest in Fiji, Vanuatu, Solomon Islands and elsewhere. In Fiji, sugar cane and cassava are being used to produce alcoholic drinks and similar plans are underway in Vanuatu and the Solomon Islands.

Direct combustion of biomass in open fires for cooking, heating (water) and other domestic chores is very inefficient and wasteful – the efficiency of open-fire stoves can be as low as 1 % and generally falls in the range of 5 to 10 %. A considerable portion of biomass energy goes towards drying crops, principally copra; in Vanuatu, almost 3 times more biomass was used for copra drying than for cooking in 1981, according to Country Reports, 1982. In Fiji around 35 % of the total energy used is supplied by bagasse, a waste product from the sugar mills.

While biomass energy resources at present are adequate to supply current needs for many years (at the current rate!), there is concern regarding this increasing depletion of standing biomass. The growing demands for biomass energy are due to increasing population, better living conditions (with associated demands for more energy), and the increasing costs of other forms of energy, viz. kerosene, benzine and electricity. Furthermore, the forests and plantations are being removed at very rapid rates by the timber and sawmill industries. It is, therefore, imperative that this increase in the rate of depletion is matched by similar rates of replanting. Equally importantly, it is vital that there be a trade-off between the use of forest resources for timber and fuel, the conservation of soils and ecology, and for parks and animal reserves.

DIRECT SOLAR ENERGY RESOURCES

There is a general abundance of solar energy resources in the South Pacific region. Even though the land compared to the sea area is quite small, the energy from the sun falling on the land area is vast since most of the islands enjoy a good sunny climate. There are local variations in insolation values over large islands through variations in cloud cover due to dense forests. The

annual mean daily insolation values range from 17 MJ/m²/d in Vanuatu to 24 MJ/m²/d in Kiribati. Annual sunshine hours range from 2000 to 2500 per year (5 to 7 hours of sunshine per day on the average). As most of these island countries consist of many islands scattered around a large ocean area, and are not connected to electricity networks, solar energy can be a viable alternative to diesel generated electricity and heat. This is especially true when one considers the very high costs of transporting expensive diesel fuel.

Solar energy is beginning to make inroads into the domestic energy consumption. In Fiji, several thousand urban homes in Suva, the capital city, have solar water heating systems and some 10-20 % of new homes being built have provisions for solar hot water systems. The Telecommunications Department of the Ministry of Works and Communications in Fiji (and indeed similar departments in other countries) make extensive use of solar photovoltaic (PV) panels to power remote communications and navigational facilities, including telephone repeater stations and lighthouses.

The cost of production of PV panels has dropped from \$1000 per peak watt in 1958 to around \$5 per peak watt in 1989. By the end of this century, the production costs are expected to drop to \$2 per peak watt.

The Department of Energy (DOE) in Fiji has used small PV units to provide electricity for lighting and other small appliances in remote villages and islands having adequate insolation levels. A hundred such units at a unit cost of \$450 were bought by the DOE in 1984. It is noted that an increasing proportion of the population in the remote and rural areas relies on PV panels for its lighting and entertainment uses. A few companies rent such units out for around \$15 per unit for a month. A remote village in Rakiraki in Fiji has recently been provided with solar electricity through PV panels.

In the Cook Islands, the government has granted substantial subsidy for the installation of photovoltaic lighting units on islands which do not have electricity. Solar power is used in the Solomon Islands for water heating, desalination plants and for copra drying. Most of the countries are showing interest in renewable energy resources, in particular solar energy for the rural and remoter islands. This is reflected in the latest development plans in which sizeable sums of money are set aside for research, development and demonstration of solar energy systems. However, most efforts are directed towards solar electrification for individual homes in rural areas and remote islands as well as for hot water for individual homes and community installations.

An EEC funded PV lighting project provides 230 households with lighting (150 in Tuvalu and the rest in Tonga). PV refrigerator systems were also installed in Tuvalu, PNG and the Solomon islands. The Energy Studies Unit of the University of the South Pacific has been actively involved in the energy field for 6 years and has carried out a lot of work on PV and wood gasification systems, among others.

For the next 10 to 15 years governments are expected to promote the use of solar energy for domestic lighting, cooking and heating and for industrial hot water systems. Other important uses of solar energy can include refrigeration, water-pumping, salt production, crop drying, battery charging for telecommunications and lighthouses and space heating.

WIND ENERGY RESOURCES

The power in the wind varies as the cube of the windspeed. The power is given by half of the products of density of air, cross-sectional area through which the wind passes and the cube of the windspeed. Thus, across an area of 10 square metres, the power in the wind is 6500 W for a steady

windspeed of 10 m/s. All this energy cannot, of course, be extracted and there is a theoretical upper limit of 59.3 % as the maximum fraction that can be extracted by a wind energy conversion system.

In general, the wind energy potential in the areas covered is not great, particularly for electricity generation. According to available meteorological records, the annual mean windspeed of all the nine countries range from 2 to 6 m/s. However, most of these data are recorded at sites such as airports and major urban centers, places which are less than noted for their wind resources. Thus, without more valid information, and pending its availability, no firm conclusions can be reached regarding the potential of wind energy.

For wind-driven generators, windspeeds above 4 to 6 m/s are needed for cost competitiveness relative to other energy sources. It would thus appear that wind-driven generators would not be suitable for use in the wind regimes in these countries. However, sites may exist where the windspeeds are enhanced and may be several times higher than those of the surrounding areas. The tops of smooth hills, for example, and the coastal areas might have windspeeds of a magnitude adequate for the economic generation of electricity. In Fiji, for example, some areas such as Udu Point, have recorded hourly windspeeds of between 6 and 10 m/s on a regular basis.

Wind energy is currently used in several islands for pumping water for irrigation and for livestock. Water-pumping windmills operate well with lower windspeeds than their electricity-producing counterparts. For rural areas and remote islands, windmills could be used to generate electric power if electricity is not readily available or if its costs are too high from conventional sources. When used with a micro or mini hydro-electricity generating system, wind-powered generators could be used to pump water from a lower to an upper reservoir whenever there is enough wind for the generator to generate, forming a pumped-hydro electricity generation system.

It is noted that the Cook Islands, for instance, reportedly have higher mean windspeeds than elsewhere. The annual mean windspeed in Aitutaki has been determined (by the New Zealand Meteorological Service to be between 5 and 7 m/s). Preliminary results obtained from the electronic wind monitoring system installed by the University of the South Pacific in 1982/83 suggest that the average annual windspeed could be between 6 to 8 m/s. The windspeeds also seem to be fairly well distributed throughout the year. In short, the wind regime at the site seems suitable for installing a wind-driven generator.

GEOHERMAL ENERGY

There appears to be little or no geothermal energy potential in the South Pacific countries. However, interest in the search for geothermal resources has been stepped up recently and surveys are underway in Fiji, Solomon Islands, Vanuatu and Western Samoa. Vanua Levu in Fiji has several hot springs, the hot water from which is being used for domestic purposes. There do appear to be significant geothermal energy resources in Fiji (Country Report on Fiji, 1982). One problem appears to be that geothermal energy sources are remote from electricity demand areas, especially in Vanua Levu (ESCAP, 1985). However, little or no hard data are yet available in terms of the electricity-generating potential of the resource, although this may change as survey results come in.

ENERGY FROM OCEAN WATERS

If the countries lack anything, it is not ocean area. Possible energy sources from the oceans include wave, ocean thermal and tidal energy. While the available ocean resources are truly vast, the resources are widely scattered, the technology for their conversion is still in the research and development stages and is suitable for large systems where economy of scale applies, and their economics not known well enough for these island countries to contemplate harnessing at this stage. Tonga, however appears to be looking closely at a 2 MW wave power system (Islands Business, 1988).

Of the three different forms, tidal energy would appear to be most attractive for locations where high tidal ranges are available and natural basins exist. However, the very huge costs and generally large sizes of such systems could rule this out for use in the next ten to twenty years. However, the resources exist and simply wait to be tapped. Perhaps when the technologies and economics of such systems are widely proven and readily available, these countries might seriously consider using the ocean resources for their energy uses.

It is noted that ocean thermal gradients are similar for the countries concerned and may be useable where deep sea beds are close to shore. The tidal ranges have not been measured, and a similar situation exists for wave energy.

CONCLUSIONS

While the majority of the South Pacific countries are almost entirely dependent on imported fuels for their commercial energy uses in transportation, industry and electricity generation, there is a good chance to reduce this reliance by as much as 50 % in some areas. It will be impossible in the foreseeable future to reduce the dependence on petroleum fuels for transport except by drastically limiting the number of vehicles or by putting a ceiling on the amounts of fuel used. However, for electricity generation and industry, appreciable fractions of energy used could be met from renewable energy resources. Short-term alternatives to imported fuel include biomass energy from fuel plantations, energy from wastes, fuels from crops such as sugar cane and cassava, solar and wind energies. Electricity from hydro-power stations and solar thermal generating systems form a longer-term prospect, together with geothermal energy (Fiji, Vanuatu and Solomon Islands), and wave power (Fiji).

While some data exist on renewable energy resources such as insolation, cloud cover, sunshine hours, rainfall, windspeed and direction, biomass, geothermal gradients, wave heights and tidal ranges, a much more has to be done to acquire data sufficient to make meaningful assessments of the potential for these renewable energy sources for meeting energy needs, particularly for rural and remote communities. This aspect should be given top priority by governments, research institutions and funding agencies. The data available in most cases are for airports, meteorological stations and other places and have not been gathered specifically for the utilization of renewable energy.

For the next ten to twenty years, biomass energy, hydro-power (large, small and micro installations), solar energy, energy from wastes, ethanol from suitable crops and wind energy should play very strong roles in increasing energy self-sufficiency. Much depends on the future

costs of conversion devices such as solar cells and collectors; advances in technologies such as wave power harnessing; economic growth and the demand for energy in its various forms. For the overall growth of a developing country, it is inevitable that the demand for commercial energy will grow also. The best hope for these countries is to utilize the renewable energy resources to the fullest extent.

The need to utilize renewable resources sensibly and carefully cannot be overstated. Resources are renewable only if they are sustainable. Depletion of any natural resource, for example the over-exploitation of forests, will only lead to a further, usually worse, set of problems.

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