Renewable Energy Potential in Fiji: A Path for Sustainable Development?*

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Abstract

The main sources of energy in Fiji are petroleum products, hydropower and biomass. All petroleum products are imported. They consist of aviation fuel, coal, diesel, greases, industrial diesel oil, kerosene, liquid petroleum gas, lubricating oil, motor spirits, residual oil and other petroleum oils. Total energy demand in Fiji increased by over 20% from 1980 to 2000. This paper presents the energy situation in Fiji with the objective of highlighting the potential for use of renewable energy in the country's efforts to develop sustainably.

INTRODUCTION

One of the most significant challenges for sustainable development is that emerging from energy needs of the human society. Energy is needed not only for human survival, but also for, as Johanson and Goldemberg state, for empowering human beings by reducing drudgery, increasing productivity, transforming food, providing illumination, transporting water, fuelling transportation, powering industrial and agricultural processes, cooling or heating rooms and facilitat-

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* The views expressed in this paper do not necessarily represent the views of either the University of the South Pacific or the South Pacific Applied Geoscience Commission, where the authors, respectively, work.

ing electronic communications and computer operations (2002: 1). It is well recognized now that an adequate supply of energy is necessary for poverty alleviation. The challenge, however, is to ensure that the production and supply of energy in adequate quantities is done in a sustainable manner, so that it does not threaten the prospects of future generations. Johansson and Goldemberg argue that Conventional sources of, and approaches to providing and using, energy are not sustainable as they are linked to significant environmental, social, and health problems while in many cases, posing threats to future generations. They propose that the expansion of energy supply must be achieved in ways that are environmentally sound, as well as safe, affordable, convenient, reliable and equitable (2002: 1-2).

Energy is an important issue in addition to others such as health, agriculture, education, poverty, etc., in achieving sustainable development[1] for the Pacific Island Developing States (PIDS). Balancing the gains of development against the detrimental effects of growth on the natural environment is an ongoing challenge for the PIDS. One of the most difficult elements of this dilemma is managing energy supply and consumption, as it is crucial to all aspects of development, including the aspirations to industrialise and eradicate poverty. The impact of its production, distribution and consumption varies as the demand increases.

The Pacific Islands Energy Policy and Plan 2002[2], identifies a number of key features and challenges in respect of the energy sector in the region:

- Demography – small, remote population centres; rapid population growth as in PNG and very rapid urbanisation on small atolls as in Majuro and Tarawa;
- Markets – small, thin and without significant economies of scale;
- Access to electricity – 70% of regional population without elec-

[1] Sustainable Development, as defined in the Pacific Islands Energy Policy and Plan, is a process of change in which the exploitation of resources, the directions of investment, the orientation of technological change, and institutional change are all in harmony and enhance both current and future potential to meet human needs and aspirations.

[2] Pacific Islands Energy Policy and Plan was developed by the Council of Regional Organisations of the Pacific (CROP) Energy Working Group. It is a guideline for use by CROP and as a starting point for national energy policies for the PIDS.

tricity, with a large regional variation[3] between 10% and 100%;
- Ecosystems – diverse and influenced by marine systems and with significant environmental impacts; and
- Energy resources - most countries have no known indigenous petroleum resources and limited hydropower and wind potential.

Most PIDS have special concerns in relation to the energy sector. These include:
- High environmental vulnerability through climate change and sea level rise;
- High vulnerability of habitats and ecosystems due to pollution from use of fossil fuels;
- Supply uncertainties due to low storage capacity, high prices and relatively insignificant market sizes;
- Limited scope for market reforms due to the size and density of markets;
- Limited human and institutional capacity; and
- Limited participation of women in matters of energy policy, planning and development.

At the World Summit on Sustainable Development (WSSD, Johannesburg, 2002) the PIDS launched a regional energy sector umbrella initiative, Pacific Islands Energy for Sustainable Development, with the main objectives of:

(i) Increasing availability of adequate, affordable and environmentally sound energy for the sustainable development of all Pacific islanders; and

(ii) Accelerating the transfer and adoption of clean and renewable energy technologies into the Pacific region.

New and renewable as well as cleaner and more efficient energy technologies have been introduced in the region, yet the effects due to the rise in energy consumption outweigh the benefits brought by these improvements. The challenge lies in finding a way to reconcile the necessity and demand for energy supply with its impact on the natural resource base in order to ensure a sustainable path for development.

This paper examines the energy situation in the Fiji Islands as a case study to show the trends in energy demand and how the demands were met over the last two decades. With the current development

[3] The percent of households electrified is actually very high in a few PIDS and somewhere well over 50% if PNG is excluded.

plans for the country, it is expected that the increasing energy demand will continue over the current decade. The paper will also look at the options Fiji can consider in its search for sustainability in the energy sector in the future.

Energy Supply And Demand

The main sources of energy for the Fiji Islands are petroleum products, hydropower and biomass. No oil refining takes place locally, therefore all petroleum products are imported. The petroleum products consist of aviation fuel, diesel, greases, industrial diesel oil, kerosene, liquid petroleum gas, lubricating oil, other petroleum oils, motor spirits, and residual oil.

Figure 1 shows the pattern of energy consumption over the past two decades. There was a relative increase in petroleum use, although the trend seems to have been reversed since 1999, when the proportion of renewable resources - bagasse, wood and hydro - shows an increase. It should be noted that petroleum supply is based on known imports or sales whereas much of the biomass use is estimated. Also, there was a serious downturn in the economy in 2000-2001 following political upheavals, which, no doubt, affected patterns of energy use.

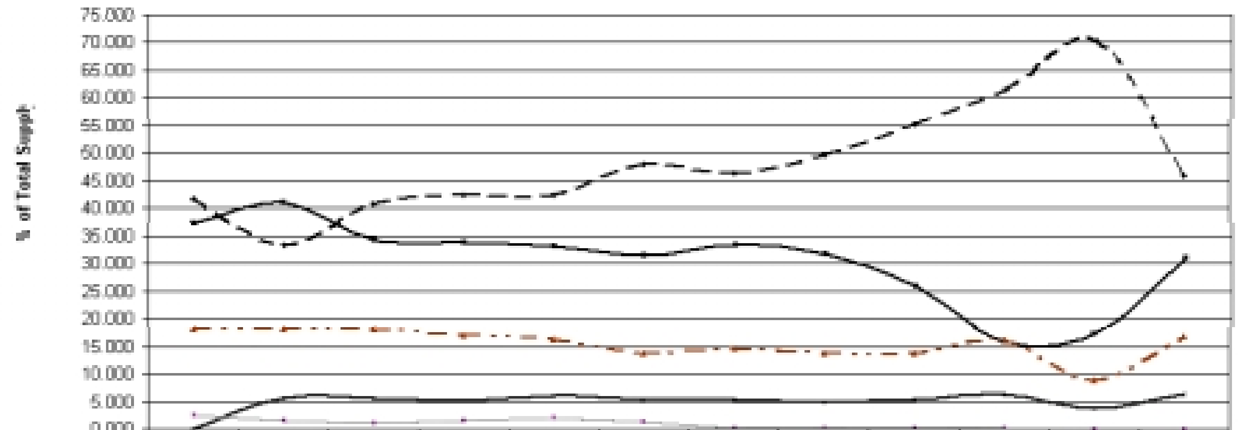
As shown in Figure 2, there has been an increase in energy demand by nearly 25% between 1980 and 2000. During the 1990’s increases in energy demand range from 10% to 43%.

In terms of energy consumption by sector, the transportation sector, which dominated consumption over the last two decades, accounted for more then 50% of total consumption in 1999. As Table 1 shows, industrial & commercial, residential, agriculture and government sectors have showed a relatively decreasing trend. A graphical representation of Table 1 is given in Figure 3.

Table 1: Energy Consumption by Sectors, 1980-1999

Sectors	% of Total Contribution		
	1980	1990	1999
Industrial & Commercial	17	17	13
Transport	41	36	60
Residential	32	32	20
Agriculture	8	9	3
Government	n.a.	5	2
Others	2	2	1

Fig. 1: Total Energy Supply by Source, 1980-2000



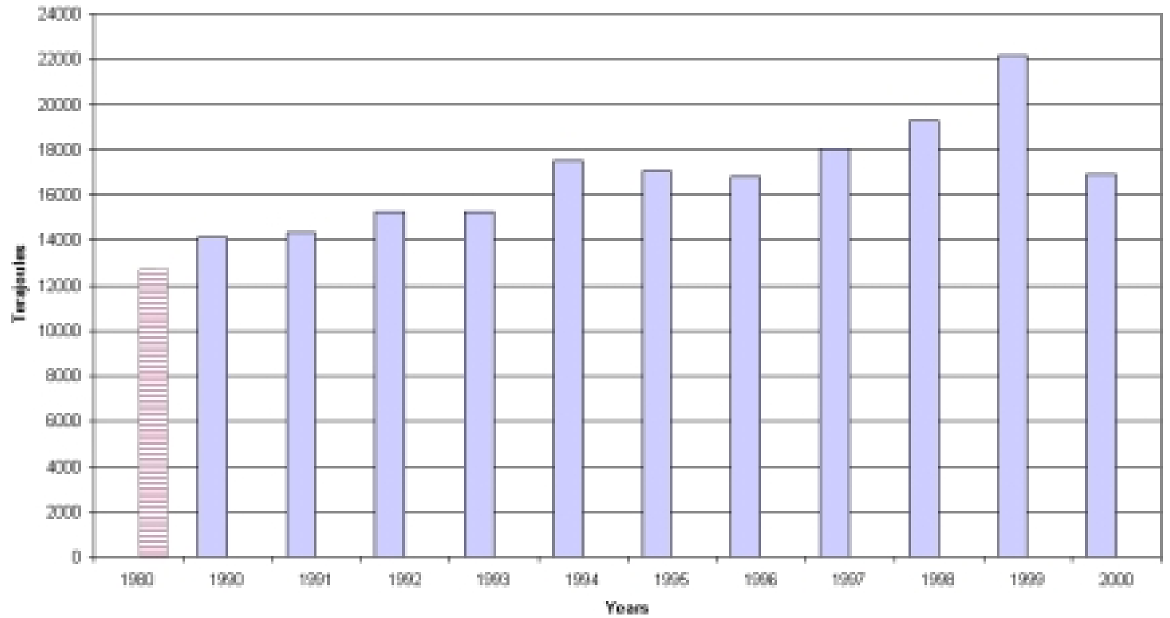
	1980	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Petlrm Pdts	41.801	33.414	40.873	42.479	42.408	47.978	46.338	49.853	55.181	61.556	70.278	45.781
Bagasse	37.381	41.072	34.343	33.784	33.004	31.523	33.363	31.714	25.781	15.723	17.145	31.081
Wood	18.220	18.264	18.175	16.946	16.361	13.762	14.613	13.686	13.649	16.094	8.795	16.752
Hydro	0.000	5.589	5.524	5.047	6.135	5.246	5.448	4.819	5.248	6.326	3.688	6.393
Coal	2.598	1.661	1.086	1.744	2.094	1.493	0.237	0.128	0.140	0.301	0.094	0.003

Years

Petlrm Pdts — Bagasse — Wood — Hydro — Coal

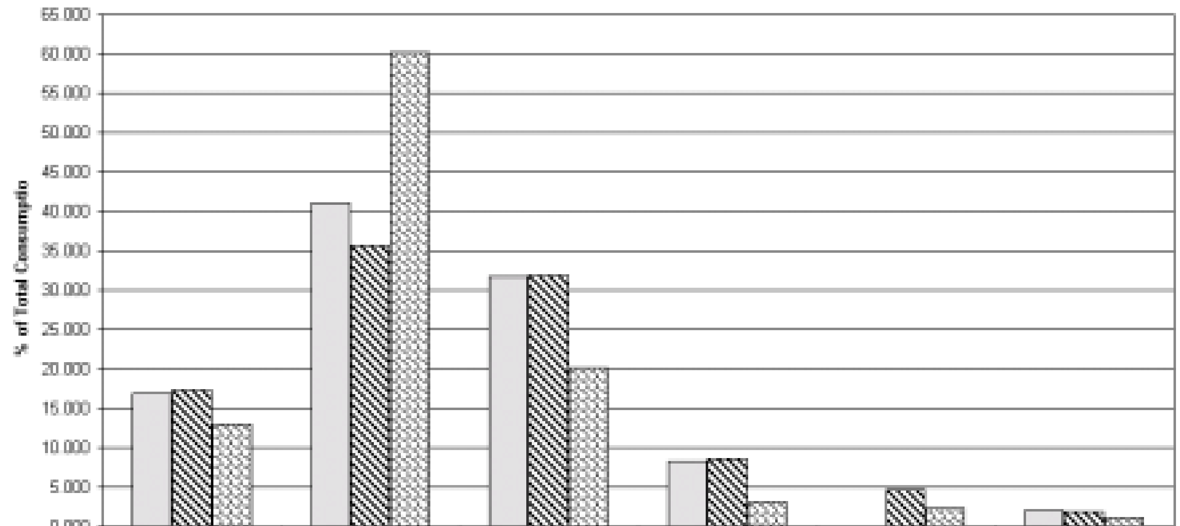
(Source: Fiji Department of Energy, Energy Statistics Yearbooks 1991, 1992 & 1993-2000)

Fig 2: Total Energy Demand, 1980-2002



(Source: Fiji Department of Energy, Energy Statistics Yearbooks 1991, 1992 & 1993-2000)

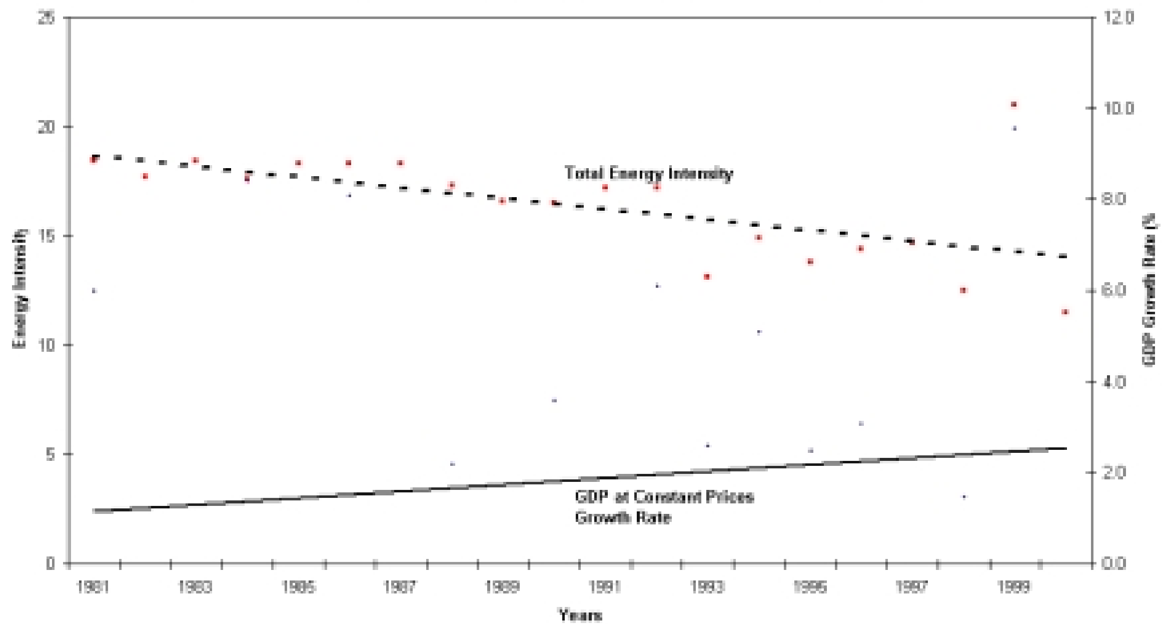
Figure 3: Sectoral Energy Consumption, 1980-1999



	Industrial & Commercial	Transport	Residential	Agriculture	Government	Others
1980	16.829	41.078	31.707	8.356	0.000	2.030
1990	17.350	35.613	31.946	8.572	4.672	1.848
1999	13.029	60.163	20.280	3.168	2.356	1.083

(Source: Table 1)

Fig 4: Trends in Total Energy Intensity and Real GDP Growth Rate



Source: Fiji Department of Energy, Energy Statistics Yearbooks 1991, 1992 & 1993-2000)

According to the Asian Development Bank, Fiji's real GDP dropped by nearly 10% in 2000. At the end of 2002, electricity accounted for 3.7 percent of GDP. The census of 1996 revealed that 87% of the total number of urban households had access to electricity supply as compared to 75% in 1986. In terms of rural access, 49% of the total number of rural households had access to electricity supply in 1996, compared to 31% in 1986 (BPOA+10, National Submission).

The ratio of total energy consumption (TJ) to real GDP, which is the total energy intensity, is shown in Figure 4. It shows a declining trend between 1981 and 1999. The average growth rate for total energy intensity for the period was -0.5% while real grew on average at 1.9%. This indicates that while the economy has been growing, there is a relative reduction in energy consumption.

Energy Resources

Fiji has a major hydroelectric scheme at Monasavu that serves the bulk of the population on the main island of Viti Levu. Bagasse, a by-product of sugar production from sugarcane, is used for power generation in sugar manufacturing, and wood wastes are used for energy generation for saw milling. Firewood remains the leading fuel for domestic cooking in rural areas. In 2002, 73% of the energy supply was from domestic sources, if the transportation sector, with its dependency on imported petroleum fuels, is excluded.

The Fiji Electricity Authority (FEA), a wholly Government-owned commercial statutory authority, is responsible for the generation, transmission and distribution of electricity in Fiji, while three oil companies - Shell, Mobil and British Petroleum - purchase, store and distribute petroleum products throughout the country. LPG is imported by two other companies (Fiji Gas and Blue Gas). Government, through the Department of Energy (DOE), is responsible for national energy policy and planning, promoting the development of renewable energy resources and renewable energy service companies (RESCOs), energy conservation and efficiency, and the coordination of rural electrification activities through its Rural Electrification Unit (REU).

The bulk of Fiji's electricity is generated from the hydro resource. In 1990, for example, 490 GWH of electricity was supplied to the national grid by the FEA. Of this 81% was derived from hydro, 16% from diesel and 3% from biomass. In 2002, FEA had a total installed capacity of 197.8 MW. Of this, 83.4 MW was generated by hydropower and 114.4 MW was generated by diesel engines, mostly for reserve capacity. The gross electricity generation in 2002 was 579.75 GWh, of which hydro generation accounted for 448.25 GWh (77.3%), and diesel generation 131.5 GWh (22.7%) of the total. In addition, FEA purchased approximately 4.5 GWh from Fiji Sugar Corporation in 2002 (IIEC, 2003).

There is renewed focus on the development of renewable energy through the use of wind, solar, hydro, wave, biomass and geothermal resources, in an effort to reduce the dependence on imported fossil fuel. After a long and regrettable lapse, FEA has become serious about renewable energy, something that was largely ignored for most of the past 20 years. For the last 2 or 3 years, there has been a more meaningful approach to renewable energy, particularly hydro & wind, for grid-connected large-scale power. There isn't really a 'focus' on ocean-based renewable energy; the DOE has continued to promote small renewable energy projects over the years for rural communities.

A number of assessment programmes to explore and exploit these indigenous energy resources have been implemented and have proved to be successful. These include mini/micro/pico hydro, solar lighting, solar powered video & TV system, woodstoves, solar water pumps, solar water heaters, biogas plant, steam co-generation plant and copra biofuel. Appendix II lists some of the renewable energy based electrification projects implemented over the last decade.

Potential For Renewable Energy

Biomass

It is estimated that the biomass resource supplies approximately 64% of the energy consumed in the Fiji Islands. Rural households use mainly firewood for domestic cooking. There is also some trade in firewood in urban areas. Coconut residues are also used for copra drying. The bulk of the bagasse (~93%) available at the sugar mills is used to produce heat and electricity for internal use. In 2002, the FEA purchased approximately 4.5 GWH from the Fiji Sugar Corporation, which generates electricity using bagasse. This accounted for about 0.8 % of FEA's total generation of 580 GWH. Even accounting for FSC's own use, the conversion of bagasse to electricity must be of reasonably low efficiency.

Prasad (2003) estimates that by using a combination of bagasse gasification and gas turbine, and the use of a second conventional steam turbine system, the Fiji Sugar Corporation (FSC) could realise a 60MW power generation system that could operate all year round, and generate some 428 GWH of electricity.[4] This would be over 70% of the total electrical energy that is currently generated by the FEA. The combined total installed capacity at the FSC mills is 48MW, of which bagasse accounts for 40.5MW. In 2001, the total power used by FSC amounted to 13.7 – 15.2 MW, with a seasonal average of 7MW exported to the FEA grid (Reddy, 2003). If this bagasse resource was supplemented with by-products from timber processing such as saw dust and hog fuel, there is potential for continuous power generation using biomass resources.

The government has an active forestation programme with pine and mahogany plantations in many parts of the group. There is a huge potential for utilising wood waste for electricity production. Presently sawmill waste is underutilised. In short, Fiji's vast forest resources could be used to develop sustainable energy production system.

Biogas technology was introduced to the country in the 1970s. However, the technology suffered from inappropriate designs, and lack of suitable waste material, although there have been several long-running success stories such as the Sahadeo Piggery farm in Vuda. More recently, several small units have been set up around the country and are working satisfactorily as integrated systems utilising waste and producing gas for cooking and fertiliser as a by-product. There is also the Public Works Department's recent investment to produce biogas from the Kinoya sewage plant.

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[4] It ought to be noted that the sugar industry currently faces significant reduction in production of sugar cane due to the non-resolution of the problems relating to the property rights regime, as well as mill efficiencies (see Narayan and Prasad, 2003). Thus the potential for expansion of the use of bagasse for electricity generation is correspondingly constrained.

Biofuel

Interest in coconut oil grew over the years with Vanuatu taking a lead role in promoting its use as transportation fuel, known as 'Island Fuel' (Pacific Islands Report, 2003). With no modifications to diesel engines required, there are more than 70 vehicles currently using coconut oil as fuel in Port Vila.

Through the Rural Energy Development Unit of the Secretariat of the Pacific Community, projects in Vanuabalavu and Taveuni were established to demonstrate the use of coconut oil for generating electricity. The project in Vanuabalavu consists of a 80 kVA generator and supports 198 households in three villages. A 45 kVA generator in Welagi, Taveuni supports 60 households. A preliminary survey for the island of Rotuma shows that several of the generators in Rotuma that currently supply all the electricity needs, could be switched to coconut oil, making use of the currently under utilised coconut resources on the island (Sakimi & Kumar, 2002). The projects in Vanuabalavu and Taveuni also demonstrated the economical and social benefits through employment and the increased recycling of money within the respective communities (Pacific Power Association Magazine, 2002). There is a huge potential for use of coconut as a substitute for diesel. However, there are certain technical and social issues that need tending to as they underestimate the potential benefits from using coconut oil as a substitute for diesel.[5] On the other hand, with the recent decrease in price of coconut oil, the difficulty of markets, particularly for copra from remote locations, there is significant potential for coconut oil to be converted into fuel and other by-products for use as feed and fertilizer.

It may also be timely to revisit the issue of ethanol in the current discussions on the sugar industry. With the industry undergoing major structural changes, and the need for it to diversify, the production of ethanol, as an alternative fuel for motor vehicles, may provide a win-win option for all stakeholders in the industry. An assessment of the potential for ethanol production from sugar in Fiji done many years ago revealed that its economic viability was marginal (FSC, et al,

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[5] Such issues include the availability of spare parts for the generator(s) and sustainable supply of coconut oil.

1980). But that was when the Fiji Islands continued to enjoy good markets and preferential prices and oil prices were high, which are due to cease in the near future. It may be timely for a more detailed technical, financial and economic assessment. The technology of ethanol production and the experience of using ethanol in vehicles have progressed considerably over the last three decades.

Geothermal

There is some evidence of geothermal resources on the two major islands, Viti Levu and Vanua Levu. Preliminary assessments by DOE and the Mineral Resource Department in the early 1980s indicate that there is potential for steam generation and electricity production at two sites in Labasa and Savusavu on Vanua Levu, the second largest island in Fiji. The sub-surface temperature at 500m depths has been estimated at 130^0C and 220^0C for the two sites respectively.

Given this information, the FEA, in March 2004, has called for expressions of interest from potential researchers to carry out a full feasibility study on the mentioned sites.

Deep drilling, which is an expensive exercise, with a full feasibility study is required to further substantiate the geothermal potential in the Fiji Islands.

Hydro

In 2002, the FEA had a total installed capacity of 197.8 MW of which 42% was from hydro and the rest from diesel, the latter being mostly for reserve capacity. The demand for electricity is currently growing at 8% per annum. There are several additional sites at scales of 5 to over 50MW, which have the potential to be major suppliers of electricity. With a combined potential resource of 300 MW in the main islands, hydropower is likely to provide the bulk of increased electricity generating capacity over the next several decades.

There is growing interest in micro-hydro development. This is not only more environmentally sustainable but would seem to meet the needs of rural, isolated communities. The total micro-hydro capacity installed for the group is 960 kW, and 4 additional sites that are being proposed as monitoring sites represent a combined potential of over 500 kW.

Wave

The wave potential around the Fiji waters varies considerably, satellite data shows potential of approximately 29 kW/m. On the northern facing reefs and shores of Viti Levu and Vanua Levu, the resource is estimated at 9 kW/m. Assessment for wave energy potential at Kadavu was undertaken during 1986 – 1995 by the South Pacific Applied Geoscience Commission (SOPAC). Preliminary data indicates a potential wave energy resource of about 296 kW, with a long term average of 23 kW/m. Currently the DOE is conducting a site-specific survey near Muani Village (in Kadavu) where preliminary analysis indicates the possibility of a 50 kW Wave Energy Module project. Plans for wave energy resource assessments in other sites around the Fiji Islands have also been considered. However, more exposed islands are likely to have a wave power potential similar to Kadavu.

Ocean Thermal Energy Conversion (OTEC)[6]

A number of feasibility studies have shown potential thermal resource suitable for OTEC systems. A Japanese study revealed average temperature differential of 22°C between the surface and at depths of 800m, off the Coral Cost area in Viti Levu. There was a proposal by the Japanese government to build a land-based 1MW OTEC plant for Taveuni that could provide electricity and fresh water, this however has not materialised as yet.

Solar

Solar resource can be estimated by correlating solar-radiation-satellite data with ground based measurements obtained using pyranometers. Solar insolation levels vary marginally between certain centres in the Fiji Islands with an average of 5–6kWhm^{-2} day. In Fiji, solar energy is used mostly in thermal applications such as solar water heaters, and photovoltaics to generate electricity for lighting. The lat-

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[6] The OTEC technology is still in experimental stage. The technology has also been tried for agricultural purposes and for producing fresh water.

ter forms a major component of the government's renewable energy for rural electrification under the solar home lighting systems. In addition, there is a 10 kW grid-connected system at the FEA Navutu depot in Lautoka. The total installed capacity in Fiji from solar PV systems is estimated to be over 70kW (PV Projects in the Region, SOPAC, 2001).

Stand-alone solar photovoltaic systems will continue to be a major component of the Government's rural electrification programme.

Whilst the potential for solar in the country can be described as excellent, the major barrier in its continued use, particularly for electricity generation and use in lighting, refrigeration etc, is the current high cost of PV panels. Whilst PV is expensive, for small isolated communities what matters is not the initial cost but lifetime cost. For a well-designed system with ongoing training and maintenance and a sound institutional basis, PV can be cheaper than the alternative diesel power systems. It is hoped that Fiji will be able to work in partnership with other PIDS to provide that economy of scale to make solar PVs more affordable. The use of solar energy should also be a good candidate for Clean Development Mechanism (CDM) projects under the Kyoto mechanism.

Wind

The Department of Energy, as part of its wind resource assessment programme, has evaluated wind resources in three locations. Unfortunately, the resource required for commercial development has not yet been identified. Wind regimes corresponding to annual averages of around 6m s^{-1} are required to produce electricity at rates that are competitive with those that are available through the FEA grid. A value of approximately 5.5 ms^{-1} is cost competitive for rural electrification in remote locations (Kumar, 1999). As part of a regional wind resource assessment programme in the mid 1990s it was revealed that the coral coast in Viti Levu had yearly averages in the range of 5–6 ms^{-1} at 21m height and a monthly variation ranging from 4–8 ms^{-1}. At present, the only major wind system in the Fiji Islands is at Nabouwalu in Vanua Levu with eight 6.7 kW wind turbines.

However, there is continued interest in wind and the FEA has embarked on a major programme of monitoring wind resources. It hopes to provide 20 MW from wind farms by 2011 (FEA, 2002).

There are various activities currently underway, aimed at enhancing training and awareness of wind power. A project funded by the Danish and French Governments has seen the installation of a 20kW wind turbine at a site in Suva that is connected to the FEA grid. The USP has already begun to offer postgraduate courses in wind power and wind power engineering, and the turbine will provide valuable hands-on experience for small grid-connected systems.

A pilot training regional workshop on wind power was recently offered by the USP. The workshop, aimed at personnel from Energy Departments, NGOS and Power Utilities, provided exercises in resource assessment, physics of wind power, financial/economic analysis and wind energy conversion systems.

An important application of wind energy in the Fiji Islands, and indeed other PIDS, will be to provide power for isolated grids, and for small remote area power systems. Whilst the general level of technology and cost effectiveness of small turbines has lagged behind that of large turbines, there is increased evidence of development of turbines with low cut-in wind speeds and high efficiency in variable wind speed regime. In the long term, small-scale systems for isolated communities may be the answer to the twin issues of energy availability and poverty eradication.

Current Initiatives

Fiji's 2001 Development Plan states that access to energy constitutes a major barrier to development of rural areas (Ministry of Finance and National Planning, 2001). The Government continues to accord priority to assist rural communities have access to energy through its rural electrification programme under a cost-sharing scheme where the rural communities pay 10% of the total capital costs and Government pays the balance.

The Government, through the Department of Energy, secured funding from the Global Environmental Facility to develop a regulatory framework, which will remove barriers to the implementation of renewable energy systems for rural electrification. The framework will provide guidelines to facilitate the establishment of RESCOs. The project resulted in the preparation of draft legislation in 2003 for the establishment and oversight of RESCOs. Clearly, an appropriate legislative framework is imperative to facilitate the enhanced usage of renewable energy in Fiji.

There is also the resource assessment activity of the DOE, which has continued to be a valuable activity in determining the potential for renewable resources as an energy source.

In addition, the FEA has revealed its long-term vision of a 'substantially renewable energy' company by 2011. The short-term objective is for 15MW of additional power based mainly from hydro and wind by the end of 2004. To this end, FEA is already working on hydro projects for Vaturu, Wainikasau and Korolevu (Ba). It is also working on a couple of major wind farms, to be based in the coral coast area of southwest Viti Levu (Patel, 2003).

In the region, Fiji is a participating country in the Pacific Islands Renewable Energy Project (PIREP) and the forthcoming Pacific Islands Energy Policy and Strategic Action Planning Project (PIEPSAP). The former identifies barriers to implementing and commercialising renewable energy projects while the latter is a new initiative that will address the development of practical energy policies and strategic action plans and their implementation. These initiatives will assist in formulating the necessary framework for promoting the use of renewable energy resources.

The training and awareness in renewable energy and renewable energy technology has seen several new initiatives. The courses at undergraduate and post-graduate levels at USP provide graduates, specialising in physics, with much needed emphasis on renewable energy. Apart from the project on capacity building on wind, jointly implemented by USP and SOPAC, the University has embarked on a model demonstration Renewable Energy Park for teaching and raising awareness.

The local and regional organisations are also working with international agencies such as the United Nations Economic and Social Commission for Asia and Pacific (UNESCAP), United Nations Educational, Scientific and Cultural Organisation (UNESCO) and Global Network on Energy and Sustainable Development (GNESD) to integrate the training activities in renewable energy.

Conclusion

Available information and data on renewable energy resources indicate that Fiji has the capacity to meet all its energy needs from renewables. The discussions on hydro, biomass, solar, wind, etc demonstrate that a combination of the various resources could indeed provide the answer to sustainable energy sources for most sectors assuming that these are economically and commercially viable. Work on the technical assessment of resources is ongoing. The numbers point to targets that are attainable, particularly in the provision of electricity, and energy for cooking, heating and agricultural uses. The main challenge, however, is in the transportation sector, which is showing increased use of imported fossil fuels. Whilst biofuels such as coconut oil may provide a partial solution, it seems the long to medium term reliance on fossil fuels for the land, sea and air transportation is set to continue.

Compared to many small island nations, it seems that Fiji is pretty advanced in terms of policies on renewables, including RESCOs, as well as in terms of policy on rural electrification. The Government could introduce incentives such as tax rebate on renewable energy and energy efficient equipment and higher taxes on large vehicles and industries utilising fossil fuels. It could also consider different tariffs on different islands and its capital cost formulas for adequate maintenance programmes, alongside appropriate RESCO legislation.

The important dimension of capacity building and training seems to be addressed by institutions like USP and SOPAC. It is vital to have the cadre of people with knowledge and experience in renewable energy, if this was to be given the necessary emphasis in its policies supporting sustainable development.

One of the important barriers for Fiji, and indeed for other PIDS, in their effort to develop sustainable energy sources is the access to relevant technology.

The current cost of providing electricity from renewable energy systems still remains much higher, especially from small stand-alone decentralised systems, compared to those powered by fossil fuels. This is certainly true for renewable energy fed into a power grid or for households, which are close to a grid. For remote or isolated households which require basic services such as lighting, radio, and perhaps a fan, it is often the case that renewable energy, properly designed and managed, could be cheaper over a 5 to 7 year period than diesel systems (Johnston, 2004).

The role of the private sector and the international community in providing affordable renewable energy systems cannot be overemphasised. Until such time that renewable energy enjoys subsidies and an even ‘playing field’, compared to those enjoyed by fossil fuels (or the many hidden subsidies for fossil fuels are removed) the technology will still remain out of reach of most people. There is a need for enhanced research and development efforts in renewable energy by the international community, including the private sector, to assist in the quest for the path of sustainability.

Appendix 1: Acronyms Used

BPOA+10	10-year Review of the Barbados Programme of Action
CROP	Council of Regional Organisations of the Pacific
DOE	Fiji Department of Energy
FEA	Fiji Electricity Authority
FSC	Fiji Sugar Corporation
GDP	Gross Domestic Product
GEF	Global Environment Facility
GNESD	Global Network on Energy and Sustainable Development
GWh	Giga-Watt-Hours
kVA	kilo-Volt Ampere
kW	kilo-Watts
kWh	kilo-Watt-Hours
PIDS	Pacific Island Developing States
MW	mega-Watts
RESCOs	Renewable Energy Service Companies
REU	Rural Electrification Unit
SOPAC	South Pacific Applied Geoscience Commission
TJ	tera-Joules
UNESCAP	United Nations Economic and Social Commission for Asia and the Pacific
UNESCO	United Nations Educational, Scientific and Cultural Organisation
USP	University of the South Pacific
WSSD	World Summit on Sustainable Development

Appendix II: Renewable Energy Projects In Fiji

Project Type	Place / province	Year	Description	Status / Comments
Hybrid System	Nabouwalu, Bua	1998	Solar (40 kW), wind (8 by 6.7 kW) & diesel (2 by 100 kW) hybrid system.	Currently has a problem with its auto-relay switch. Thus for the wind and solar to charge the batteries, it has to be switched manually. Also some of the wind turbines are having technical problems.
Hydropower	Nasoqo, Naitasiri & Kadavu (Kadavu Village)	1983 & 1994	3 kW (150 customers) and 20 kW (250 customers), respectively	Still in operation
	Muana, Cakaudrove	1999	30 kW (136 customers)	
Solar Powered Video and TV system	Naqarawai, Namosi	1991 – 1996	Solar powered video installed and monitored as alternate power source to diesel generators.	The solar component of the system is still in operation. The controllers and the inverter are two components that currently need servicing / replacement.
Woodstoves	Tutu Training School & Bucalevu School, Taveuni	1993	Construction of woodstove with the assistance of a USP Technology student. Two stoves constructed for Tutu Training School, Taveuni and Bucalevu School.	The woodstoves are still being used at a number of boarding schools. Maintenance of the woodstoves has not been carried out regularly thus the reason for some woodstoves not been operational.
	Fiji-wide	1994 – 1997	Training of KANA workers and construction of 20 woodstoves; funded by the Pacific Islands Forum Secretariat.	

Project Type	Place / province	Year	Description	Status / Comments
Solar Water Pump	Fiji-wide	1993 – 1998	Assisted PWD Rural Water Supply in providing training on installation, operation and maintenance of twelve PV water pumps.	Some of the pumps installed currently needs repairs.
Solar Water Heaters	FIT, Suva	1997	A solar water heater was fabricated and operated by FIT students.	
Biogas plant	Waidalice, Tailevu	1997	A pilot 15.3 m^3 biogas plant installed at Hari Ram Lakhan's farm.	The biogas plants are still in operation.
	Waila, Naitasiri Natabua, Ba	1998	Another 2 biogas plants were installed in Waila and Natabua.	
Steam co-generation plant	Navakawau, Cakaudrove	1987 – 1999	Installation of plant to provide lighting for villagers and heat for drying copra and yaqona.	General overhaul were undertaken in 1996 with plans to relocate the plant did not eventuate.
Solar Hot Water system	Suva/Nadi	1998	Installation of four solar hot water monitoring equipment – two in Suva and two in Nadi.	This was carried out to verify the field operation efficiencies of locally manufactured and imported solar water heater systems. It was revealed that the field operational efficiencies were not exactly as stated by the manufacturers.

Project Type	Place / province	Year	Description	Status / Comments
Copra biofuel system	Lomaloma, Lau	2000	Installation of copra biofuel system that utilises coconut oil to provide lighting to three villages and two schools in Vanuabalavu	Currently having a problem with the solenoid. Spare parts are due to arrive in April 2004.
	Welagi, Taveuni	2001	Installation of copra biofuel system that utilises coconut oil to provide lighting to Welagi, Taveuni.	
Solar PV for Lights	Namara, Kadavu Moala, Lau Vunivau & Nasuva, Bua Vasasivo & One-Lake, Cakaudrove	1994 1999 2000 & 2002 2002	These are all stand-alone systems.	These systems are still in operation. The ones in Vunivau & Nasuva are currently being maintained by RESCO.

(Source: Fiji Department of Energy, 1993-2000)

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