Fiji

Renewable Energy Report

APCTT-UNESCAP

Asian and Pacific Centre for Transfer of Technology
Of the United Nations – Economic and Social
Commission for Asia and the Pacific (ESCAP)

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Renewable Energy Cooperation-Network for the Asia Pacific

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List of Acronyms

ADB	Asian Development Bank
ADO	Automotive Diesel Oil
AID	Agency for International Development
CATD	Center for appropriate Technology Development
CDM	Clean Development Mechanism
CER	Certified Emission Reduction
CO2	Carbon Dioxide
CODO	Company-Owned Dealer-Operated
DODO	Dealer–Owned Dealer-Operated
DWR	Directional Wave Recorder
EMA	Environment Management Act
FEA	Fiji Electricity Authority
FINAPECO	Fiji National Petroleum Company
FIT	Fiji Institute of Technology
FSC	Fiji Sugar Corporation
GCC	Government Commercial Company
GHG	Green House Gas
HPSs	Hybrid Power systems
IPP	Independent Power Producers
IRR	Internal Rate of Return
LPG	Liquid Petroleum Gas
NEP	National Energy Policy
NLTB	Native land Trust Board
OTEC	Ocean Thermal Energy Conversion
PIFS	Pacific Island Forum Secretariat
PV	Solar Photovoltaic
PWD	Public Works Department RESCOS Renewable Energy Service Companies
REU	Rural Electrification Unit
SHSs	Solar Home Systems
USP	University of the South Pacific
UNFCCC	UN Framework on Climate Change

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Executive Summary

Fiji lies between 177^{o}E and 178^{o}W Longitude and 12^{o} to 22^{o} S Latitude with a land area of about 18, 333km^2. It is considerably richer in natural resources with extensive forests, rich soils, mineral deposits and fish. For several decades Fiji's economy has been highly dependent on few commodities such as sugar, gold, garment and other agricultural products. Economic growth has been relatively slow. The unprecedented increase in the price of oil in the recent years has propelled inflation level to record highs. The situation has been attributed to increase in local demand and the general increase in world oil prices.

A number of Acts of Parliament provide the legal framework for developments within the energy sector. These includes the Electricity Act which establishes the Fiji Electricity Authority, the Petroleum Act establishing standards for fuel storages and transport, the Public Enterprise Act for restructuring Government Commercial Companies and the Commerce Act which is aimed at promoting competition and sets the tariffs for the electricity Act. In addition there is also the newly adopted Environment Act that ensures the protection of the environment with the respect to any form of development.

Fiji has a wide range of resources that includes;

- Biomass
- Geothermal
- Ocean Energy Resources
- Hydraulic Resources
- Solar and
- Wind

A number of the above resources have been developed to various extent in the form of the following renewable energy project;

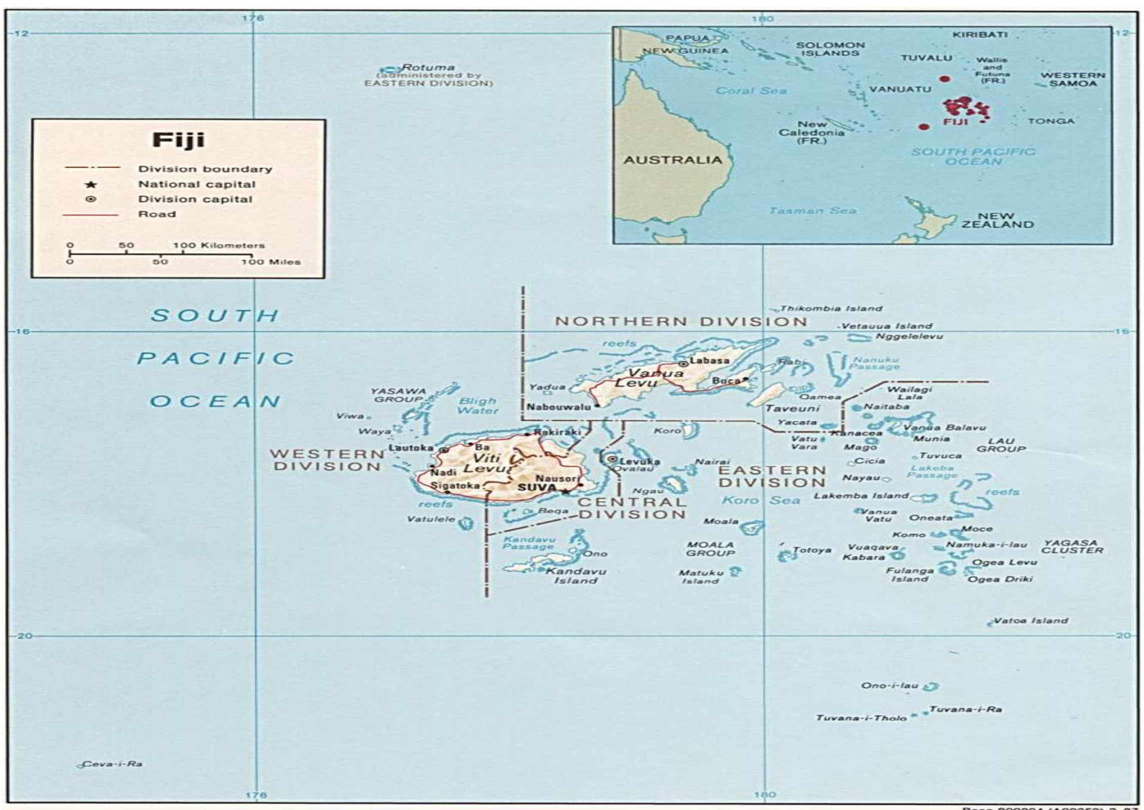
- Monasavu Hydro
- Wainikasou Hydro
- Nagado Hydro
- Nabouwalu Hybrid
- Butoni Wind Farm
- Solar Photovoltaic Installations and Solar Thermal.

Also the various initiatives that are there to promote renewable energy with its market and industries together with the R&D Work and related institutions were explored. In addition the barriers to the development of renewable Energy with respect to Commercial Viability, Financial Feasibility, Concessionary Loans and Grant Financing and Service for Fee were considered. Capacity development needs was considered as a barrier removal.

1.0 Introduction

The provision of energy supplies not only affects the economy at large but the very foundation of our existence. It affects our homes, our schools and even our freedom of movement. The fact is energy has become one of the most defining issues of this century. For small island states or economies the situation is no longer confined or classified as an energy security situation, but rather it has become an imminent threat to the security of our economy, our livelihoods and our sovereignty as an independent nation. Among a number of strategies adopted by our small island states, one of the most important one is the development of locally available renewable energy resources. This paper intends to focus on the development of renewable energy resources in Fiji.

The Fiji Islands consists of more than 300 islands, only one-third of which are inhabited. Lying between roughly about 177° E and 178° W Longitude and 12° and 22° S Latitude, the islands encompass a region of nearly 1.3 million km² with a land area of 18,700 km^2. Approximately 90 % of the nation's 835,921 people (2003 Bureau of Statistics projection) live on Viti Levu (10,420 km^2) and Vanua Levu (5,556 km^2) the two main islands that total nearly 85 % of the land area.



Annual population growth rate has been around 1.1 %. Presently, the indigenous Fijians comprise 52.6 % and the descendants of indentured Indians, brought to work the sugarcane fields between 1879 and 1916, constitute approximately 41 % of the population. Although about 52 % of the population lives in rural areas, urban growth has been accelerating in recent years. Total population has been about 863, 294 as of 2006. Nonetheless, censuses are conducted every 10-years.

Although most of the Fiji islands are low-lying coral structures with very limited soil and water, the main islands are continental-like, rising to elevations of well over 1,000 m, with "wet" and "dry" areas, and covering a range of ecological habitats. The islands are bordered by an extensive reef system including the Astrolabe Reef, the third largest reef structure in the world. Because of the continental-like main islands, Fiji is much richer in terms of natural resources than its neighbors in Polynesia and Micronesia. Fiji has areas of tropical rainforest containing valuable timbers, alluvial plains rich in soil, cool high uplands for temperate produce, as well as commercially viable mineral deposits, fish, and other marine resources.

Physical Characteristics of Fiji Islands

Island	*Area (km^2)*	*% of Total*	*Features Characteristics*
Viti Levu	10, 420	56.9	Volcanic, well forested with 29 Peaks > 900 m (Highest is 1325m) about 50 rivers (largest is Rewa of which 130 km is navigable. SE is wettest and W/ NW driest.
Vanua Levu	5, 556	30.3	Volcanic, well forested with peaks over 1,000 m about 40 rivers and over 20 thermal springs spread over 3, 900km^2
Taveuni	470	2.6	Volcanic well forested with highest peak of 1230m; numerous waterfalls many inaccessible. One small lake.
Kadavu	411	2.2	Volcanic with highest peak of 835m. Well watered by short streams.
Gau	140	0.8	Rugged, hilly with 550m peak. Well-watered by short streams.
Koro	104	0.6	Rugged with two peaks over 700m and both rainforest and dry zone vegetation.
About 300 others	1, 223	6.6	Vary but mostly low islands, many coral
Total	18, 333	100	

The Fiji Islands is subject to natural disasters including cyclones, flooding, earthquakes and other natural phenomenon. Such events have caused damages amounting over $700 Million in the past ten years.

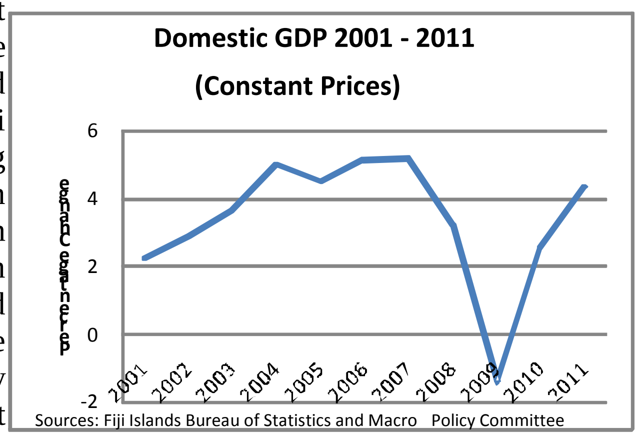
2.0 Economic Development in Fiji

Economic activity in Fiji has remained relatively weak since 2001 averaging only 1.2 percent growth until 2008. The sluggish growth in recent history has largely been a result of underperforming exports, recent declining trend of remittances, lower tourism receipts, reduced investment levels and increasing imports which have affected Fiji's foreign reserve and balance of payments position.

The financial and economic recession experienced worldwide compounded by the high occurrence of natural disasters, including the flash floods in early 2009. Our vulnerability to these situations adversely affected Fiji's economy causing below par performance. A contraction of 0.3 percent is expected in 2009 with modest recovery projected for the medium term.

The Reserve Bank devalued Fiji's currency in April 2009 to protect the foreign reserve position and improve the competitiveness of our exports and services, particularly tourism. In addition, it was to encourage use of local goods to substitute foreign produce which would have become expensive. The Reserve Bank also made interest rate policy announcements on the weighted average interest rate and interest rate spreads for commercial banks. Subsequently, commercial banks lending and interest rates have started to fall, deposit rates have risen and banking system liquidity, that is, the amount of money available for banks to lend, has increased considerably to around $200 million from very low levels early in the year. This itself will see credit conditions easing up further in the coming months and will assist greatly in businesses being able to borrow additional amounts to grow their businesses and to start new projects.

In the tourism industry, visitor arrivals are recovering. Tourist numbers are expected to improve in coming months assisted by the devaluation of the Fijian dollar and strong marketing which have made Fiji a competitive destination. Exports of gold and fish have increased. However, performances of other industries, such as garments, timber and mineral water have been affected by the weak demand from our trading partner economies.



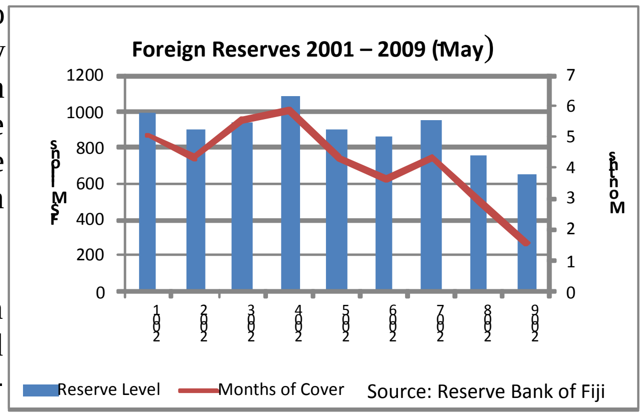
Sources: Fiji Islands Bureau of Statistics and Macro Policy Committee

Investment which is around 15 percent of GDP is expected to rise with the recent investments by Government and public enterprises such as the Fiji Electricity Authority and the Housing Authority. Government has given increased priority to the implementation of its capital programme for the year, in addition to meeting the flood rehabilitation demands. The Reserve Bank has made allowances for priority sector lending, as well as for export finance. The Bank has also established a Flood Rehabilitation Facility to assist businesses recover from the effects of the floods.

The planned infrastructure upgrading through the EXIM Bank China, EXIM Bank Malaysia and Asian Development Bank will further boost investment. Greater infrastructural support from Government and restructuring of the public sector, which essentially transfers assets and business opportunities to private sector, will also induce higher levels of private investment.

Exports have been less that $1 billion; however, imports in recent years have exceeded $3 billion resulting in trade deficits in excess of $2 billion. Imports have been rising continuously, mainly due to Fiji's low production based and exacerbated by the growing demand from the tourism industry as well as rising food and fuel prices.

Foreign reserves have steadily risen to around $770 million (as at 31 July 2009), from around $440 million before the devaluation. However, the foreign reserves position must be improved to meet the medium term target of 3-5 months of import cover.



As a result of the devaluation, an increase in the inflation rate is expected in the coming months, with the year-end inflation forecast at 9.5 percent. However, prices are expected to start easing after April next year, towards an inflation of around 2 percent by the end of 2010.

The key macroeconomic issues that need to be addressed include maintaining macroeconomic stability; increasing exports, raising domestic production, raising foreign and domestic investment; and making more land available for social and economic development.

3.0 Energy Situation in Fiji

Fiji, like many other fuel importing countries in the world has felt the pinch of the increase in refined fuel prices as the world price of crude oil has continued to rise. The prices of these products have fallen beyond local control as the prices of crude oil are determined in international commodity markets. The price of this important commodity is influenced by demand and supply conditions, as well as speculation or expectations about the future.

3.1 Imports

The value of Fiji's imports has been increasing and reached the $3 billion mark in 2006. A major contributing factor to this increase has been the importation of mineral fuel, which has increased in value from around $400 Million in 2004 to about $1.2 Billion in 2008.

Figure 1:

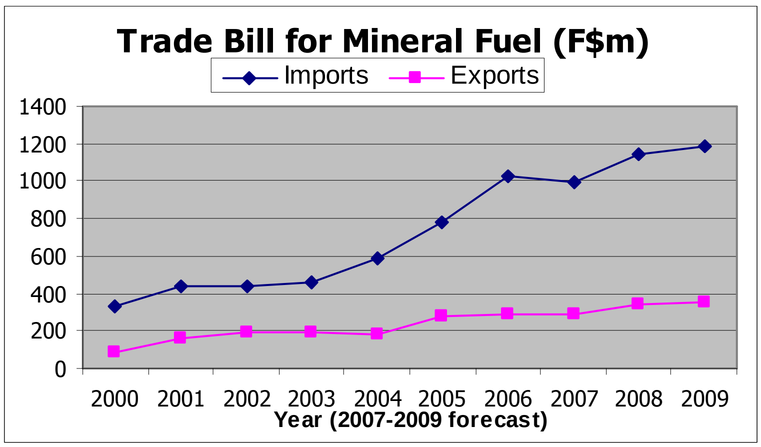
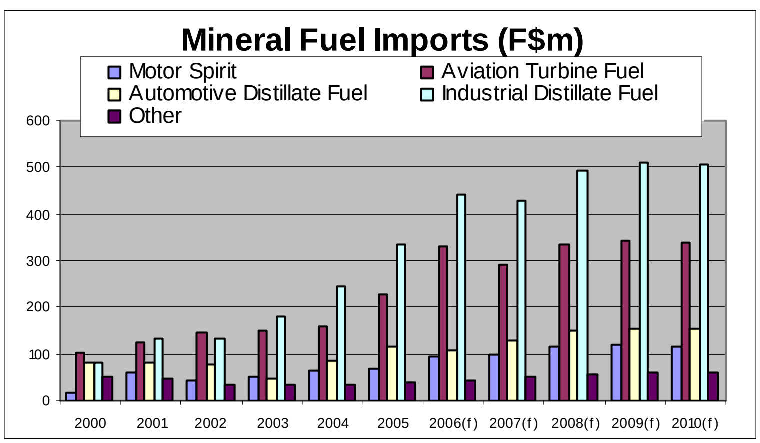


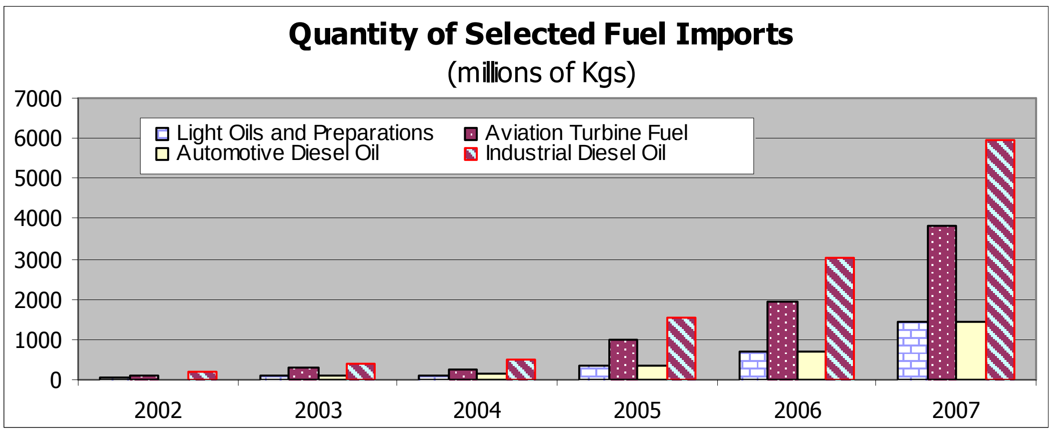
Figure 2:



Source: Macro Policy Committee

Figure 1 shows a clear increasing trend to the demand for a selected number of fuel imports, these include: light oils and preparations, automotive diesel, industrial diesel oil and aviation turbine fuel. While the demand for industrial diesel oil and aviation turbine fuel has clearly increased drastically since 2002, demand for the other classes of mineral fuels has grown at lesser rates.

Figure 3:



Source: Fiji Islands Bureau of Statistics

The above illustration clearly shows the heavy dependence of industry on imported fuel and highlights the vulnerability of the economy to rising fuel prices. This is of particular concern considering that the increase in demand for power over the last decade has exceeded the Monasavu Hydropower Station capacity and resulted in the FEA supplementing its energy capacity with diesel generation. As of December 2006 FEA had a total installed capacity of about 170MW of which 57 percent came from diesel generation (of which the Department for Energy has installed 500 diesel based systems throughout rural Fiji) and 43 percent from hydropower. While some smaller hydropower facilities have come on line in recent years at Wainikasou and Vaturu, the total hydropower capacity in Fiji is unable to meet current energy demand (refer below).

Additionally, if the price of aviation turbine fuel increases this may have negative implications for the tourist industry as airfares and other costs of transport rise to cover the additional costs.

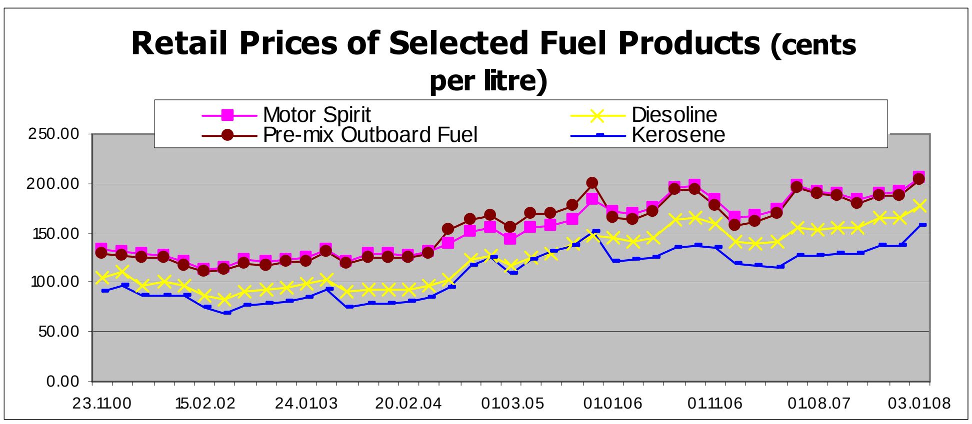
3.2 Exports

As a regional hub for the distribution of mineral fuel products to the rest of the Pacific Island nations, Fiji is able to recoup some of the costs involved in importing fuel through its re-export earnings. As can be seen from figure 1 above, at the beginning of the period the value of re-exports was increasing in line with the value of imports, although at a lower level. However, from 2004 the growth in the value of fuel imports of mineral fuels into Fiji far surpassed the growth in the value of re-exports. This deviation shows that the bulk of the value of imports will be borne by the domestic economy and opportunities to recover some of this expenditure in terms of re-exports are rather limited.

3.3 Household Expenditure

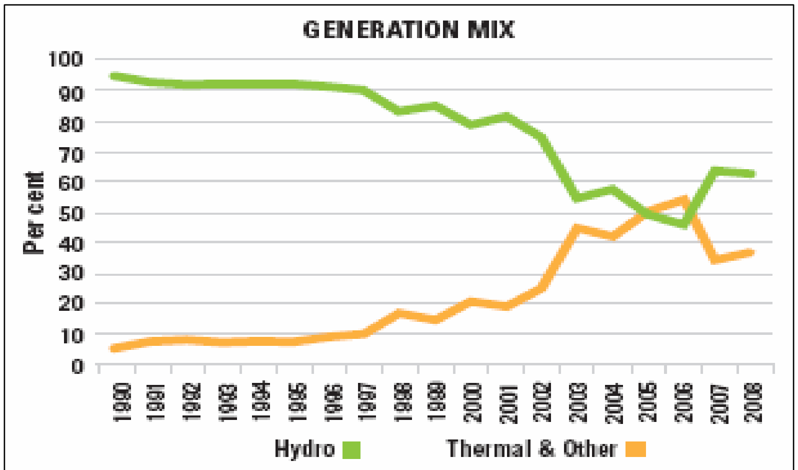
It is noted above that the wholesale and retail prices of motor spirit, diesoline, pre-mix outboard fuel and kerosene as regulated by the Prices and Income Board (PIB). Over a period of three years from January 4 2005 to January 3 2008, the price of diesoline increased by 40 percent, motor spirit by 31 percent, kerosene by 26 percent and outboard fuel by 21 percent.

Figure 4



Source: Prices and Income Board

Figure 5



The average generation mix for 2008 was 62.1 per cent hydro, 33.8 per cent diesel, 0.6 per cent wind with the other 3.5 per cent provided by the two independent power producers; Tropik Woods and Fiji Sugar Corporation. In comparison, 64.8 per cent was generated from hydro in 2007, 32.5 per cent from diesel, 0.4 per cent from wind with the other 2.3 per cent from the two independent power producers.

As electricity is a basic input for all industry, increases in the cost of generating energy is likely to affect the operations and profitability of business in Fiji. Further, in terms of domestic electricity consumption, 80 percent of all Fijians have access to electricity in their homes, with 92 percent of people in urban areas[1]. Therefore increases in the cost of energy that arise due to oil that is more expensive will have wide reaching effects throughout the economy. As noted on figure 5 above that demand has continually increased over the years and the utility the Fiji Electricity Authority has now been forced to use more diesel generate electricity as compared to the previous year.

The 2002-2003 Household Income Expenditure Survey noted that 24 percent of the population posses cars and trucks, and 11 percent of total income is spent on transport. So regardless of whether an individual actually owns a car, almost the entire population will be affected by an increase in the price of fuel, which will increase the price of transport. If the percentage of income spent on a particular sub-group increases then this will automatically lead to less money being allocated for other areas or else a decrease in demand, thus affecting a household's purchasing power. In fact this has already been experienced with the recent increase in taxi and bus fares of 50 percent and 10 percent respectively that took place early in January 2008.

[1] Household Income and Expenditure Survey (HIES) 2002-2003

4.0 Institutional Background

Fiji does not have laws that deal specifically with energy however, moves are underway to have an Energy Legislation in place by around 2011. At the moment, there is a National Energy Policy that provides the guiding principles with respect to the energy sector. Fiji also has an Environment Management Act (EMA – 2005) that deals with issues pertaining to the protection of the environment. The EMA 2005 is further elaborated below.

There are prospects for moving towards greater self-reliance through the implementation of renewable energy projects. Government, continues to develop the infrastructure that would remove barriers that hinder the adoption of renewable energy systems. On the same note and equally important is the removal of barriers with respect to the importation of renewable energy technologies into the country.

The reform of the power industry is a Government priority. The FEA internal restructuring has begun to improve operational efficiency and provide better services. Reforms also include the encouragement of private sector participation through Independent Power Producers (IPP's) and Renewable Energy Service Companies (RESCOS) in electricity generation. A further study is currently being pursued to look at valuation of assets and liabilities, further corporatisaton, partial private sector participation and ownership of shares in the entity. In addition the merit of looking at the transfer the regulatory role is also being explored.

The Department of Energy is responsible for Rural Electrification and also performs energy audits of Government buildings and subsequently implements energy efficiency measures. In addition the Department has also put in place initiatives aimed at making people become aware of the energy use. This is expected to intensify for years to come. However, much of the role being undertaken by the Department of Energy is specified within the National Energy Policy.

Existing Legislations relation to Energy

The following is a list of current laws (Acts) that are in place dealing with Energy:

- Land Conservation and Improvement Act (Cap. 141)

- Native Land Trust Act (Cap. 134) and Crown Lands Act (132).

  The use i.e. leasing of native and crown land in Fiji for any purpose other than agricultural must be done in accordance with the provisions of the above pieces of legislation.

- State Acquisition of Lands Act (Cap. 135)

  Under this Act the state is empowered to acquire any lands in Fiji for public purposes – an explanation of the relationship between this Act and the Native Land Trust Act is needed.

- Electricity Act (Cap. 180)

  This Act establishes the Fiji Electricity Authority as a corporate body responsible for energy[2] supply in Fiji whose general functions include the promotion and encouragement of energy generation in Fiji with a view to the economic development of Fiji, to secure the supply of energy at reasonable prices and to advise the Energy Minister on all matters relating to the generation, transmission, distribution and use of energy.

  NB: Electricity Regulations made under the Act provide for standard systems and voltages for the supply of electricity and for the licensing of electrical contractors

- Public Enterprise Act (1996):

  The Public Enterprise Act focus is on the efficiency and accountability of a Government Commercial Company (GCC). Under s43(1), FEA as a GCC will have the principal objective of operating "as a successful business and ..... to be as profitable and efficient as comparable businesses which are not owned by the State". s43(2) requires that this objective "is to be achieved through the application of the key principles of public enterprise reform", with the key principles, as listed in Schedule 1, including the principle that "the role of Ministers in relation to [FEA] will be clearly defined."

- Commerce Act (1998):

[2] 'Energy' is defined under the Act to mean 'electrical energy when generated, transmitted, supplied or used for any purpose except the transmission of any communication or signal.

The Commerce Act complements the Public Enterprise Act in that it empowers the Commerce Commission to control FEA's prices but does not explicitly authorise it to look at efficiency and planning (though this may be a factor in the choice of pricing model it uses).

The Commission is established under s11 of the Commerce Act which specifically limits the Minister's influence over the Commission to certain prescribed powers. The provision states: "Except as provided by this Act, the Commission is not subject to the control or direction of the Minister or any other referring authority in the performance of its functions."

- Petroleum Act (Cap. 190)
  This Act regulates the storage and carriage of petroleum into and throughout Fiji.

- Fuel and Power Emergency Act (Cap. 191)
  This Act provides for the regulation of the supply, distribution and use of fuel and power in Fiji during emergencies relating to fuel and power.

- Petroleum (Exploration and Exploitation) Act (Cap. 148)
  This Act provides for the regulation of exploration and exploitation of petroleum in Fiji.

Apart from the above legislations another very important Legislation with respect to the energy sector is the Environmental Management Act (EMA – 2005). A small brief on the EMA – 2005 together with a commentary on the work undertaken with regards to environment in Fiji outlined below;

4.1 The Environment Management Act (EMA) 2005

The EMA 2005 provides the legislative framework for the sustainable development of land and water resource management. However, there have been a number of constraints in implementing EMA such as inadequate resourcing of the Department of Environment, outdated subsequent legislations and regulations, the absence of accredited laboratories and poor coordination among agencies.

Achieving sustainable development, while overcoming environmental challenges such as deforestation, land degradation, logging of watersheds, over-exploitation of terrestrial and aquatic biological resources, improper waste management and pollution control, impact of climate change, and the attitude of people in terms of the unsustainable use of their resources, is a central challenge of this plan.

Fiji's economy and its people, like other small island states, are also susceptible to the impacts of climate change. Since ratifying the UN Framework Convention on Climate

Change (UNFCCC), policies adopted by Government in successive Development Plans have recognized the critical importance of managing the environment and natural resources, to ensure social and economic prosperity in the present and for the future. The implementation of these policies, however, has not been adequately supported with the required budget. As a developing nation with scarce resources and competing priorities and obligations, the Government has preferred to rely predominantly on foreign aid and assistance to finance 'environment' projects.

Climate change is beginning to have substantial and widespread impacts on Fiji, affecting sectors as varied as health, coastal infrastructure, water resources, agriculture, forestry and fisheries. As a predominantly agricultural based economy, the impact is being felt more by the rural populace who depend on the agriculture sector for their livelihood. The increasing incidence and intensity of droughts, cyclones and flooding is taking its toll on the economy and the lives of ordinary citizens.

The sea-level rise is leading to coastal erosion. With the majority of villages and settlements in Viti Levu located along the coast, there is a noticeable infiltration of the sea into the village compound during high tide. The increase in the frequency and intensity of tropical cyclones over the past decade is fueling coastal inundation and erosion. Intensive urban development along the coast, as well as deforestation of catchments has also contributed to exposing large coastal areas to flooding and erosion.

Continuous coastal erosion is also taking its toll on inshore fisheries on which the villages rely for food. The drop in the size of the catch is attributed to the build up in sedimentation. Coastal populations and their assets are exposed to higher vulnerability to extreme events such as storm surges, tsunamis, and high tides. The erosion of coastal areas is also now slowly leading to the movement of villages away from low lying areas.

The most recent flooding occurred in late December 2008 and early January 2009. Experts conceded that these floods were the worst in Fiji's recorded history with 11 lives lost, and a conservative estimate of F$76million[3] worth of damages to public assets and agriculture. Damage to crops and loss of livestock from the recent flooding in late December 2008/early January 2009 was estimated at F$40million. Around half of these losses are attributed to the sugar industry, the backbone of the agriculture sector and the economy. The aftermath of floods increases the risks of exposure to water borne diseases, leptospirosis, and contamination of water sources. The floods directly affected about 150,000 people, almost a fifth of Fiji's population. While tropical cyclones are expected at this period, what has been noted is the increasing intensity of these natural hazards, particularly over the past decade.

A critical tool in the fight against Climate Change is the Kyoto Protocol. The Kyoto Protocol is an international agreement linked to the UNFCCC. The major feature of the Kyoto Protocol is that it sets binding targets for 37 industrialized countries and the European Community for reducing greenhouse gas emissions. These amounts to an average of 5% against 1990 levels over the five-year period 2008-2012. The major

[3] Losses to private businesses and emergency relief and ration costs are not included in the $76m.

distinction between the Protocol and the UNFCCC is that while the Convention encouraged industrialized countries to stabilize GHG emissions, the Protocol commits them to do so.

One of the 3 mechanisms open to industrialized countries to meet their commitments under the Protocol is called Clean Development Mechanism (CDM). The CDM, defined in Article 12 of the Protocol, allows a country with an emission-reduction or emission-limitation commitment under the Kyoto Protocol to implement an emission-reduction project in developing countries. Such projects can earn saleable certified emission reduction (CER) credits, each equivalent to one tonne of CO_2, which can be counted towards meeting Kyoto targets.

A CDM project activity might involve, for example, a rural electrification project using solar panels or the installation of more energy-efficient boilers. The mechanism stimulates sustainable development and emission reductions, while giving industrialized countries some flexibility in how they meet their emission reduction or limitation targets. Fiji has so far registered two CDM projects through the FEA – the Wainikasou and Vaturu Hydropower Plants. More technical work is required to identify other opportunities, particularly in the area of renewable energy.

4.2 **National Energy Policy** (2006)

The development and approval in 2006 of the National Energy Policy(NEP) by Cabinet has provided a common framework for both the public and private sector to work towards the optimum utilisation of energy resources for the overall growth and development of the economy. The policy focuses on four key strategic areas that include;

i) National Energy Planning,
ii) Energy Security,
iii) Power Sector and
iv) Renewable Energy Development.

With challenges confronting the sector, summarily the approach intends to strengthen our supply sources and simultaneously manage our demand for energy. With the above, Government further plans to develop an energy legislation based on the NEP.

Around 66.8% of the country's electricity requirements are met from renewable energy sources which include; 62.1% hydro, 0.6% wind and other renewable resource 4.1% biomass. This is provided largely through the FEA's grid network on the two main islands and Ovalau. Imported petroleum for diesel back-up generators, meets the remaining balance of 33.2 %. The Department of Energy (DoE) has also installed about 600 diesel based systems in various rural communities.

The amount of electricity generated and sold by FEA reflects the level of economic activity in the country. Currently, the contribution of the electricity sector to GDP is about 3.6%. This is projected to increase as a result of greater access to electricity in rural areas under the Government's Rural Electrification Programme which, apart from the extension of the grid networks and diesel schemes, also encourages the utilization of solar home systems in rural communities.

In terms of final energy consumption, the Transport sector has continually consumed a little over 40% of the total energy supplied. This is followed by the Commercial sector, Industrial and Domestic sector. Some of the important measures that have been identified to address the situation are outlined;

i) addressing consumption of our transport sector through the development and use of bio-fuels locally and other legislative measures;
ii) diversifying the current energy mix through the use of LPG in the industrial, transport and domestic sectors; and
iii) improving the efficiency of energy use in all sectors of our economy.

4.3 Rural Electrification Policy

In 1993, the Cabinet endorsed a revised Rural Electrification Policy. Under the Policy, any rural village or settlement is entitled to request Government assistance for electrification. A Rural Electrification Unit (REU) was set up within FDoE to facilitate the implementation of the Policy. Since 1993, approximately nine hundred villages[4] have applied to FDoE for electrical services. Allocations for rural electrification have varied but largely has been so limited that only 50 to 100 communities can be electrified each year such that it would take 20 to 30 years to meet demand.

Two concepts appeared to have wide applicability in locations that cannot be served by FEA line extension. The vast majority of villages and settlements that have expressed interest in rural electrification could be served with solar-home-systems (SHSs) and the government stations and surrounding villages and settlements with hybrid power systems (HPSs). In addition, there are a few villages with appropriate hydro resource and relatively modest needs, which could also be provided service using the model under evaluation for SHSs.

Under the 1993 Policy there are three service choices:

(1) extension of the FEA grid or government station mini-grid to provide 24 hours per day service;

(2) a diesel generator with mini-grid system for evening lights and small electrical appliances; and

(3) renewable energy systems: solar photovoltaics (PV) or small hydro for evening lights.

[4] For convenience throughout this report the term village is used to encompass both traditional villages (pre-contact) and new settlements.

Applicants are required to pay upfront 5% (that was recently revised from 10%) of the total capital costs for the provision of electricity, while the Government subsidizes the remaining 95%. Consumers are expected to pay a tariff for actual consumption under the first choice or fixed monthly fee under the other two choices. The tariff or fee is supposed to cover operation and maintenance costs.[5]

Under the second and third service choices, a village committee is supposed to collect monthly fees and is responsible for paying for operation and maintenance. The Policy (June 1994) lists fees ranging from $F8.5 to $F15 (≈ 0.5 $US/$F). They represent a best guess estimate of what consumers would be willing to pay for the services and were not determined on a cost basis. In actuality villagers are asked by their committees to only pay between $F2 and $F5, which is well below actual operating and maintenance cost. When a large maintenance or repair cost is incurred, the committee typically has a fund raising project or requests a one-time high payment from users.

The other grid scheme, listed above under the first service choice, uses diesel generators (gensets) operated by the Public Works Department (PWD) at four of the five government stations in Kadavu (Vunisea), Lakeba (Tubou), Rotuma (Ahau) and Taveuni (Waiyevo). These gensets supply electricity to government offices, community hospitals, public institutions, stores, icehouses, and nearby villages. Electricity is supplied through mini-grids of a few kilometres in length. Since January 1998, the fifth government station in Vanua Levu (Nabouwalu) uses a hybrid power system to generate electricity using solar and wind renewable resources as well as a minimal amount of diesel fuel. Unfortunately major damages have been sustained on the plant that now awaits to be repaired or replaced.

PWD operates the government station schemes under a yearly budget. The fees collected from consumers are forwarded to the central government and not correlated to the cost-of-electricity production. Towards the end of the budget cycle, with the possibility of service curtailment looming, the local residents and provincial officials manage to reach their central government representatives and somehow additional fuel funds are made available. Unfortunately, maintenance, repairs and replacements are typically postponed. There are documented cases where replacement parts that represented less than 1% of the original capital investment, were postponed for 6 to 12 months. Thus, the current institutional framework does not provide incentives to charge true costs, to endeavour to optimise the operation of the equipment or to provide reliable service.

FEA Line Extensions into Rural Communities

Every year, after the government budget is allocated, the REU selects villages and settlements from the list of applicants for extension of the national grid. A site visit is made by FEA to carry out a preliminary design of grid extension. On completion of the

[5] With the exception of the 252 Solar Home Systems installed in Vanua Levu since December 2000 nobody in the rural sector pays a tariff that covers recurring costs.

design work an estimate is prepared and a quotation letter is issued to the site spokesperson. As described above, this scheme works on a 10% (applicant) 90% (government) contribution of total capital cost. The final design is carried out on receipt of the total required capital contribution and construction work is then carried out as per fully paid construction schedule.

In addition, FEA has a grid extension policy for customers able to forfeit the government contribution and, therefore, avoid waiting for extension predicated on government funding. In this case, the capital cost of the scheme is calculated and the Internal Rate of Return (IRR) calculated. If IRR is above 15%, the scheme is considered viable and no contribution is required from the applicants. If IRR is between 0% and 15%, then the cost of the scheme is shared between FEA and the applicants. If IRR is negative, the potential customers then must meet the total cost of the scheme.

Extension of the FEA distribution grid, to as many locations as budget permits, is ongoing under the existing Policy.

Renewable Energy Based Rural Electrification

There are hundreds of remote un-electrified villages and settlements for which FEA line extension is not cost effective. The great majority of residents in these locations have modest energy needs for evening lights and small appliances. FDoE has determined that solar-home –systems (SHSs) can be used in most locations as an alternative to the present situation. This evaluation led to the implementation of a project to establish the legal, regulatory, financial, economic and technical infrastructure required for renewable-energy-based rural electrification with strong participation of energy service companies (Section 4).

A Charter for "*Renewable Energy Based Rural Electrification with Participation of Private Enterprise*" was approved in February 2003 by Cabinet. It is envisaged that the draft bill will now be part of the proposed Energy Legislation.

The new Charter incorporates measures to stimulate private sector participation and the use of indigenous renewable energy resources in the provision of rural electrification services as well as the availability of funding from international institutions. This is required to expedite the relatively slow pace of rural electrification in Fiji. The Bill and ensuing Act, under review at FDoE, will facilitate and guide the establishment of renewable-energy-service-companies (RESCOs) for the rural sector. The Act will also address asset evaluation, ownership and liability transfer or equipment lease; land acquisition; issue of licenses; management autonomy and authority, and local involvement in RESCOs; investment application procedure, and competitive bidding procedure; import duties, and other taxes.

In addition, the Act will define the role of FDoE as a technical regulator by setting up quality and safety standards, establishing technical specifications, and conducting equipment testing to ensure the quality of the procured systems.

Specifically, the Act will incorporate RESCO model presently used in Vanua Levu for SHSs. This service model is applicable not only to solar-home-systems but also hybrid -power-systems, systems using other forms of renewable energy as well as diesel schemes. This RESCO model can be summarized as follows:

- Technical design, purchasing, and system ownership by DoE;
- Users are self-selected and clustered in groups of a size that is appropriate for economically reasonable periodic maintenance by the RESCO;
- Users are required to pre-pay a monthly fee that covers an appropriate portion of the capital cost of the installed system and the full cost of operation, maintenance and repair of the systems;
- Maintenance and repair services are to be provided by private contractor RESCO operators with technical support, evaluation, certification and regulation by the FDoE;
- Financial controls and technical controls will be put into place and administered by the FDoE to ensure continuing financial and technical responsibility by the RESCO contractors;
- FDoE will establish a continuing technical and business training process for personnel of the RESCOs.

It is hoped that this would be a major feature of Rural Electrification in Fiji. It is envisaged that the rural people will benefit through an improved ability to study and work during evening hours. In addition there will be health benefits through improvement in household air quality and household safety through the reduction in kerosene and benzene lighting and through improved lighting for the care of children and ill persons. There is expected to be improved communications with rural areas through radio and perhaps television powered by solar energy.

Rural employment will be increased due to the need for RESCO support personnel in the rural areas. Moreover, it is expected that implementation of RESCOs will lead to other applications in support of cottage industries. These benefits will be provided with minimal environmental impact. Both the local and global net environmental benefits are positive.

4.4 Fiji Department of Energy

The FDoE was established in 1981, tasked with the responsibility of safeguarding through planning and developing strategies, for the nation's energy sector following the oil crises of the late seventies.

The FDoE is responsible for the overall National Energy Policy and for off-grid rural electrification. The Ministry of Trade and Commerce is responsible for establishing and enforcing maximum petroleum fuel prices but private oil companies import and distribute fuel products.

The FDoE comprises of four Sections; i) the Research and Development, ii) the Rural Electrification Unit, iii) the Biofuel Unit and iv) the Accounts and Administrative Section. The FDoE has a total of 21 Established Staff, 23 Project Staff and 6 Government Wage Earners. A considerable amount of DoE staff time is spent on planning, seeking funding for, and implementing RE projects including microhydro electricity, solar photovoltaics (PV), biofuels, wind, biogas and resource assessments for RE development.

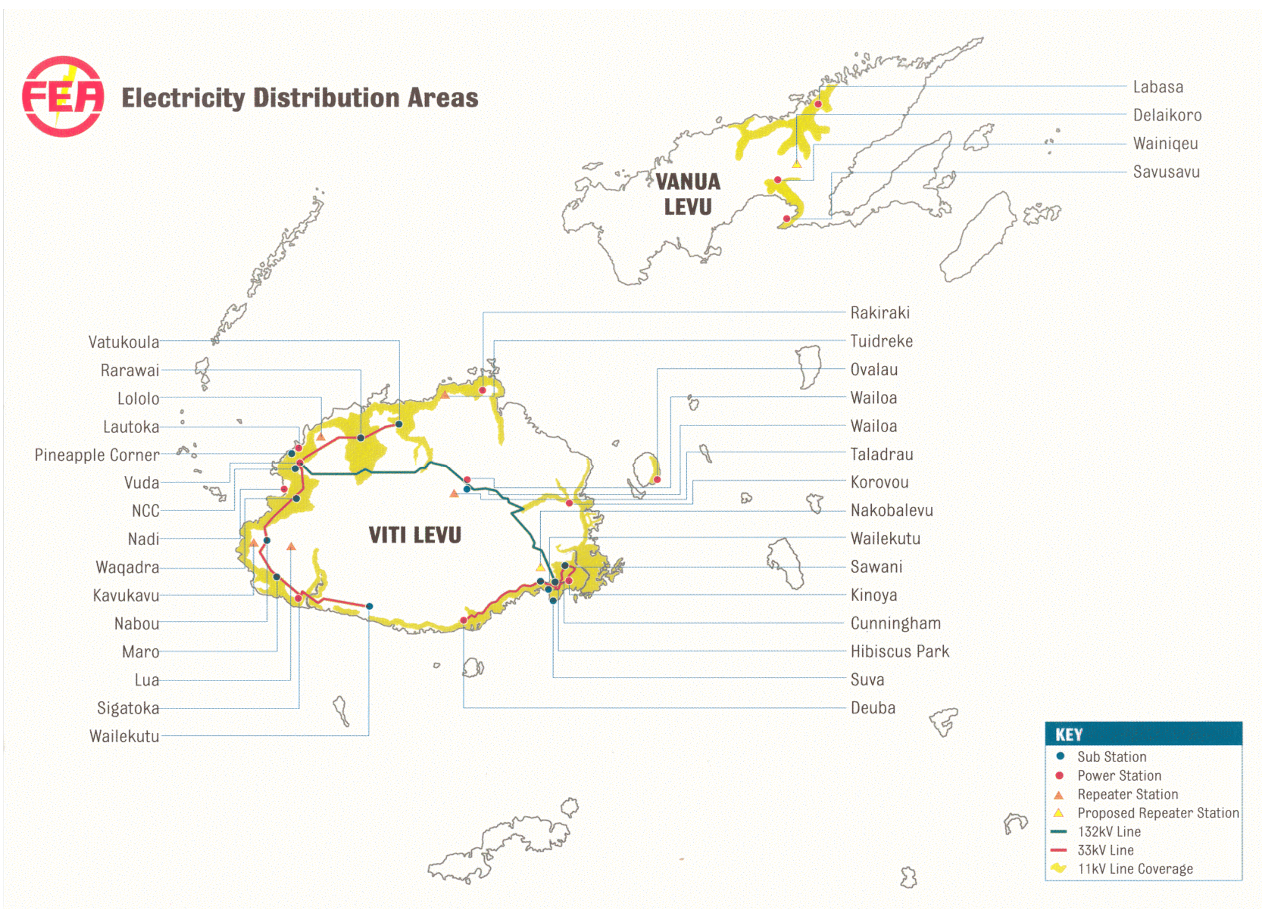
4.5 Fiji Electricity Authority

The Fiji Electricity Authority (FEA) is a wholly Government owned statutory authority responsible for generation, transmission and distribution of electricity. The FEA operates through a hydropower based Viti-Levu-Interconnected-System (VLIS) and the isolated Rakiraki diesel system in Viti Levu. In Vanua Levu there are two isolated systems: Labasa and Savusavu. In Ovalau there is the diesel system in Levuka. Presently, FEA includes a relatively small 10 kW PV array connected to the VLIS at the Navutu Depot in Lautoka. In addition to the major Wailoa (Monasavu Dam) 80 MW hydropower system there is a 0.8 MW hydropower plant in Waineqeu (Savusavu, Vanua Levu). FEA also purchases electricity, for the VLIS and Labasa grids, generated by Fiji Sugar Corporation (FSC) using bagasse.

<u>Summary of Existing and Planned Capacities for FEA</u>

Type of Generation		2010	2015	2020	2025
HYDRO					
1.	Wailoa Hydro (80MW)	400,000	400,000	400,000	400,000
2.	Wainique Hydro (0.8MW)	Variable	Variable	Variable	Variable
3.	Wainikasou Hydro (6.5MW)	18,000	18,000	18,000	18,000
4.	Nagado Hydro (3MW)	19,000	19,000	19,000	19,000
5.	Nadarivatu renewable hydro project (40MW, construction completion 2011)	0	101,000	101,000	101,000
6.	Wailoa Down Stream Hydro Power Station – 10MW by 2015	0	40,000	40,000	40,000
7.	Wainisavulevu Weir Raising (2013)		6,000	6,000	6,000
THERMAL					
1.	Diesel VLIS	103,000	104,000	110,000	125,000
2.	Diesel Others	Variable	Variable	Variable	Variable

Type of Generation		2010	2015	2020	2025
3.	HFO	260,000	300,000	340,000	370,000
4.	Others	No plans yet, this may change depending on resource availability			
WIND AND SOLAR					
1.	Wind Farm	1,000	1,000	1,000	1,000
2.	Solar Panel	8	15	25	35
INDEPENDENT POWER PRODUCERS					
1.	Biomass – Bagasse	32,000	52,000	60,000	60,000
2.	Biomass – Wood	24,000	86,400	120,000	140,000



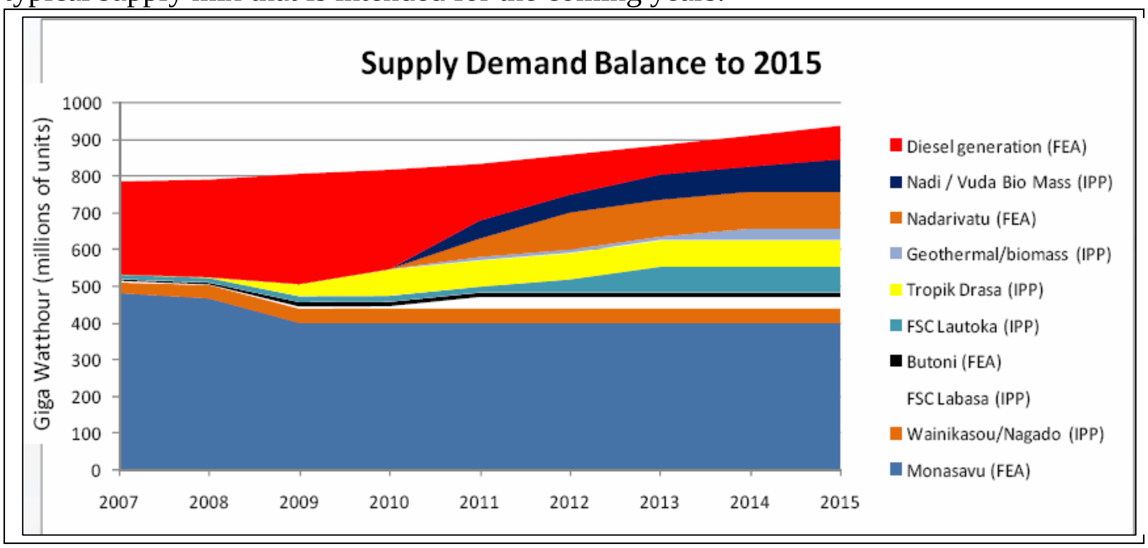
National Electricity Transmission and Distribution Grid (FEA).

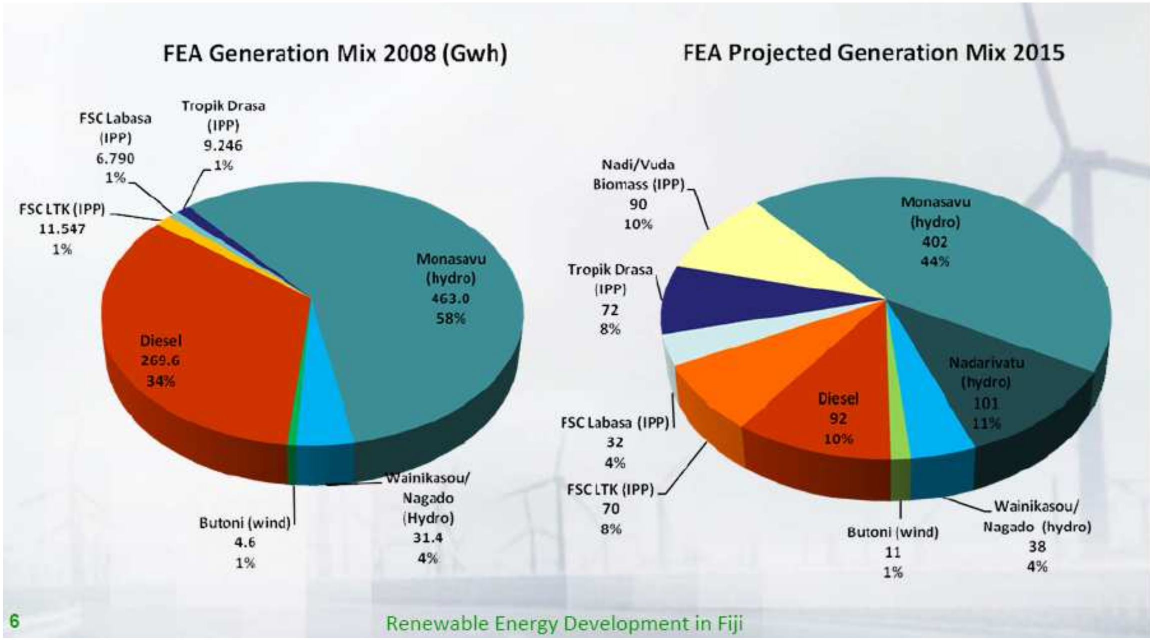
In 2008 an average mix 62.1 % of electricity requirements were met with hydropower with 33.8% of the balance coming from imported petroleum products with 0.6% Wind and 3.5% from Independent Power Producers.

FEA Total Electricity Production (GWh/year) for Period 1998-2008

Year	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
MWh	502,639	528,470	523,905	569,488	603,709	628,359	649,552	684,773	735,622	767,827	769,439

With the current plans the graph below illustrates the current planned Supply – Demand Balance that is being earmarked up till year 2015. In addition also further outlined is the typical supply mix that is intended for the coming years.





4.6 Petroleum and Liquid Petroleum Gas Supply in the Country

Three international oil companies (Mobil, BP and Total) import petroleum products into Fiji, distribute their products at wholesale and retail levels, and re-export to other PICs. Supply is by medium-range tankers from refineries in Australia, Singapore and New Zealand. Currently the Government of Fiji itself is supplied by Total through a five-year contract with the PWD.

The Ministry of Commerce regulates wholesale and retail prices of motor spirit (also called gasoline or petrol), kerosene and automotive diesel oil (ADO) and influences to some extent the technical specification of fuels. The prices of fuel is reviewed on a monthly basis. Prices vary in different geographical areas. Large consumers such as FEA negotiate bulk contracts.

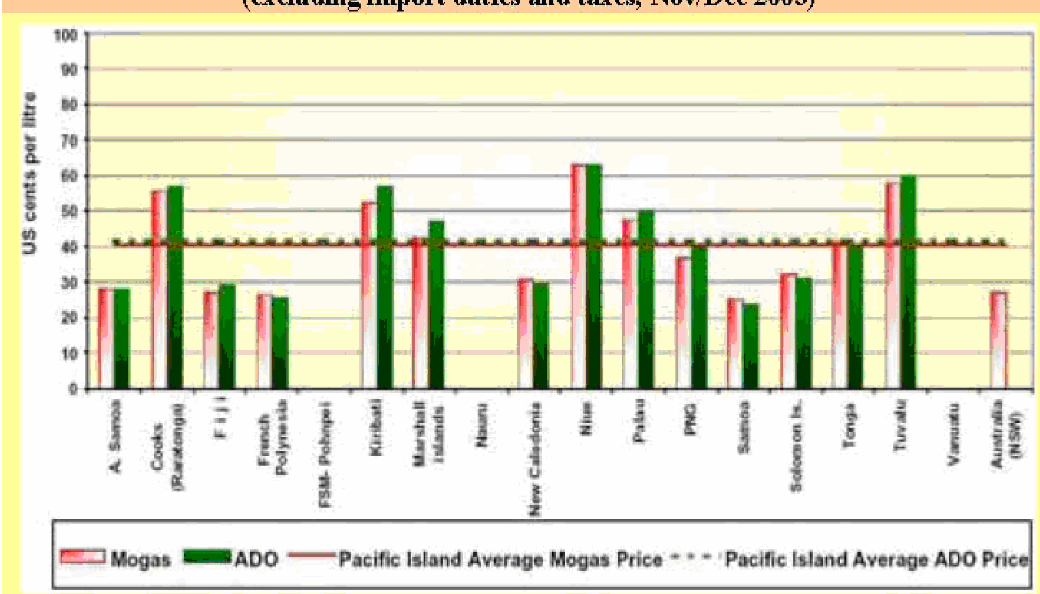
There are two retail distribution methods. The dealer-owned dealer-operated (DODO) system involves a private company selling fuel from its own premises, for example the Carpenter's Group which has a supply arrangement with Mobil. Under the second arrangement, company-owned dealer-operated (CODO), the oil company owns the assets and leases them to a private company which operates for typically 5-10 years. An example is the BP service station on Victoria Parade in downtown Suva.

Developments in recent years have seen Total acquiring Shell Fiji's Operations about 3 ago. This year (2009), talks are underway on the sale of BP's Fiji Operation to Pacific Petroleum Company, however the deal is yet to be closed.

In 1990, the GoF established a government-owned Fiji National Petroleum Company (FINAPECO), with the sole right to import petroleum fuels, which were expected to be distributed by the traditional oil companies. At the time, it was anticipated by the GoF that FINAPECO would later construct and operate a small refinery of about 25,000 barrels per day capacity. After a loss of some millions of dollars, FINAPECO closed without ever importing any fuel.

Liquid petroleum gas (LPG) is imported and marketed by two companies, Fiji Gas which has operated in the country for several decades and Bluegas, which began in 1989. LPG is not under government price control.

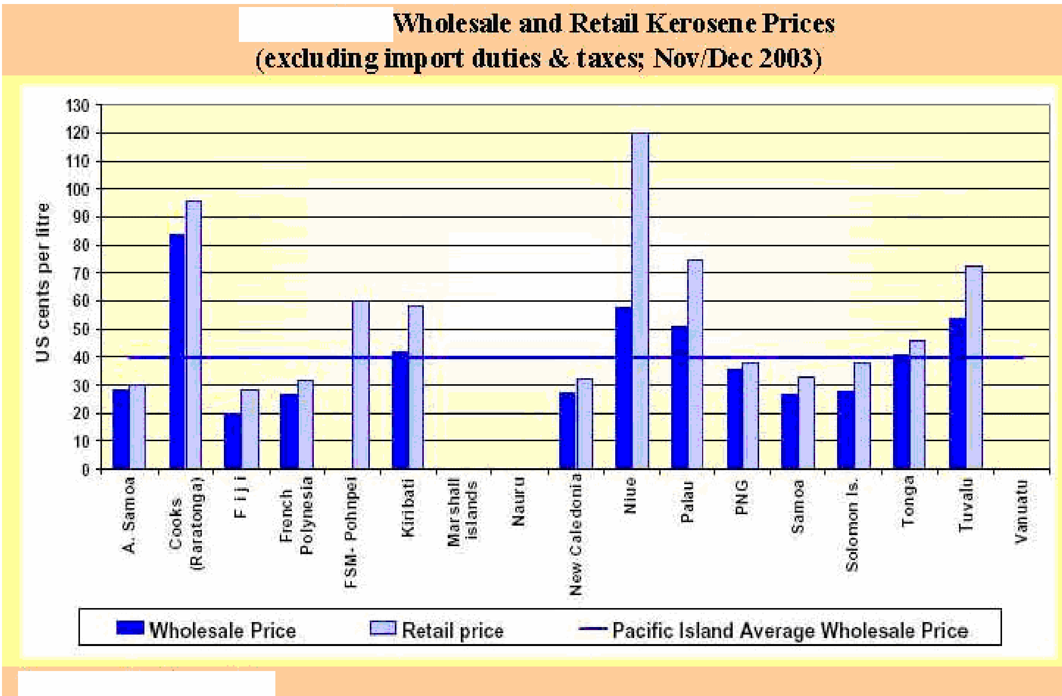
For some years, the Pacific Islands Forum Secretariat (PIFS) has provided comparative prices for petroleum products marketed in the PICs. For the most recent PIFS Fuel Price Monitor available at the time of writing, the wholesale prices of gasoline (also called petrol, motor spirit and mogas) and ADO, excluding all taxes and duties, are shown in Figure 3-2. Fiji prices were about 25% below the average for PICs. Although Fiji re-exports these products to Samoa, which has a much smaller market, the Samoan prices were lower than those in Fiji.[8]



PIC Wholesale Petrol and ADO Prices
(excluding import duties and taxes; Nov/Dec 2003)

Source: Pacific Fuel Price Monitor, Edition 7 version 2 (PIFS; 12 May 2004)

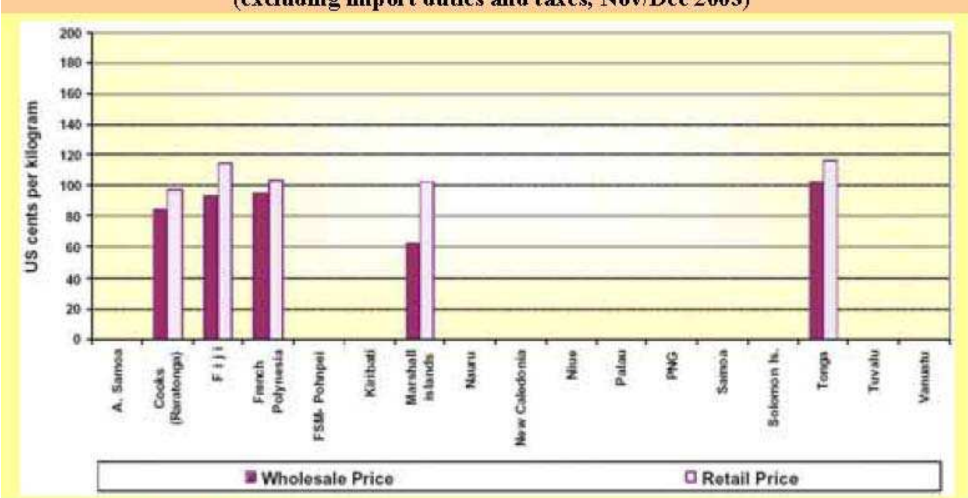
For kerosene (Figure 3-3) Fiji's prices are considerably lower than those of most PICs (and lower than Samoa's).



Samoa has had a consistent and aggressive approach to petroleum supply and pricing for nearly two decades. Unlike Fiji, Samoa owns its own petroleum storage facilities and tenders for the national fuel supply.

For LPG the figure below, based on a smaller number of PICs reporting prices, Fiji's wholesale price is below average for the region but the retail price is higher, suggesting a higher than average mark-up.

Figure 3-4 – PIC Wholesale and Retail LPG Prices (excluding import duties and taxes; Nov/Dec 2003)



Source: as for Figure 3-2

4.7 Other Institutions

There are numerous government bodies and other organisations with responsibilities which include some aspects of energy. The Ministry of Finance prepares the national strategic plan (which establishes the framework for energy) and the national budget (which provides or withholds funds for implementing the policies and projects). The Land Transport Authority (LTA) deals with motor vehicle regulation, licensing and inspections. LTA has a potential role in improving energy efficiency while reducing GHG emissions, which is a stated GoF objective. The Commerce Commission must consider any FEA tariff increase or change in its tariff structure.

For RE, an important institution is the Native Land Trust Board (NLTB), that administers all customary (native) land for the benefit of indigenous landowners, both current and future generations. Native land includes a "non-reserve" classification, which can be leased or licensed for up to 99 years for use by owners or others. There are nearly 32,000 outstanding NLTB leases, about 14,000 each for agricultural and residential purposes, and the rest for commercial, industrial, government and miscellaneous developments. Because about 90% of all land is native, and land lease issues have been contentious in recent years, the success of most large-scale (and many small-scale) RE systems in Fiji will be dependent on the policies of NLTB and attitudes of traditional landowners. The land transactions undertaken on behalf of the Government is carried out by the Department of Lands.

5.0 Renewable Energy Technologies: Technical Potential

Renewable energy resources and their potential application in Fiji are summarized in this Section.

5.1 Biomass Resource

The biomass resource supplies at least 50% of the energy consumed throughout Fiji. Rural households use firewood for cooking. There is also some trade in firewood in urban areas. Coconut residues are used for copra drying. The bulk of the bagasse available at the sugarmills is used to produce process heat and electricity for internal use. However, during sugar harvesting the mill in Labasa (Vanua Levu) supplies to FEA most of the

[8] Unlike the favorable situation with ocean thermal and wave resource, the tidal range in Fiji does not provide the resource required for tidal energy systems.

electricity distributed through the Labasa grid. Current installed capacity is 5 MW at the Lautoka sugar mill, 4 MW at the Ba mill, 3 MW at the Rakiraki mill, and 4 MW at Labasa. In 2008, about 3% of the electricity consumed in Fiji was produced using bagasse and other biomass.

5.1.1 Forestry

The forest sector on average accounts for 1.2% of GDP and 4.1% of export earnings. Fiji has a total forest cover of 1,054,419 ha, covering 58% of the total land area. This consists of 899,229ha of native forest, 116,488ha of plantation forest (52,419ha of hardwood plantations and 64,068ha of softwood plantations) and 38,742ha of mangrove forest. The native forest consists of 5,738ha of nature reserves, 16,109ha of forest reserves, and 1,300ha of recreational parks.

The performance of the sector in the past few years has been poor, it declined by 1.6% in 2007, 3.4% in 2008 and projected to continue to fall sharply in 2009 by 9.1% mainly due to woodchips exports, which, based on current orders, is projected to fall by 43.8%. However, a recovery of 4.3% and 0.9% is currently projected for 2010 and 2011 respectively, as Government puts in place measures to address the current institutional constraints.

Fiji is a producer and exporter of woodchips, sawn timber and plywood/veneer. Forestry exports have increased in the past few years with export earnings up by 27% in 2007 to $47.7m and 24.3% in 2008 to $59.3m. These increases were largely driven by earnings from export of woodchips which doubled in 2007 from $13.4m in 2006 to $27.1m in 2007 and later to $27.6m in 2008. A decline of export earnings by 15% is projected for 2009 due the depressed demand in the global economy. Nevertheless, a recovery in export earnings of 8% and 4% is projected for 2010 and 2011 respectively.

The National Forest Inventory, the formalization of the Fiji Forest Policy Statement and the National Forest Program provides the framework for the sustainable management of Fiji's forest resources. These tools represent a paradigm shift in the management focus away from timber production towards conservation and sustainable management. With emphasis on sustainable forest management, increased landowner aspirations, expansion in nature reserves, afforestation, climate change adaptation and globalization, there is more awareness on the social functions provided by forests to improve water source quality, improve agricultural land and reduce vulnerability to natural disasters especially flood mitigation.

Total wood production in Fiji is presently approaching 500,000m^3 annually with 100,000m^3 from native forests, 100,000m^3 from mahogany plantations, and 300,000 m^3 from pine plantations.

Fiji has a total of 41,000ha of mahogany stocking, which is one of the largest mature mahogany resources in the world. There is potential for large denuded forest grasslands to be converted into forest plantations of sandalwood (*Santalum yasi*) and teak (*Tectona grandis*) plantations. Reforestation could result in the employment of skilled and unskilled people who have been displaced from the sugar industry. The harvesting of the high value mahogany resource, technology, trade standards and forest certification are prominent in the National Forest Policy Statements. On the prospects of resource utilization and business development, there is potential for development of Wood Energy Industries, Furniture Manufacturing, Coco wood Industry and Carbon Trading.

5.1.2 **Baggase**

Sugar production has been on a decreasing trend over the years that started way back on 1997. However, it continued to be a major export commodity, accounting for around 21 percent of total exports in the period between 1998 – 2001. The industry had provided employment to about 40, 000 people from the farmers to the mill workers. With the decrease in production the Fiji Sugar Corporation has been facing annual losses ever since. Similarly the ability of the mill to provide electricity from baggase has also been affected.

5.1.3 **Coconut**

Coconut oil is also used as an alternative to diesel fuel to operate diesel generators at two FDoE pilot projects in rural locations: (i) 80 kVA generator supports 198 households in three villages in Vanuabalavu, Lau since May 2000; and, (ii) 45 kVA generator installed July 2001, for 60 households in Welagi, Taveuni. Preliminary indications are that the technology is viable but there are difficulties with the local management required for operations as well as in situ production of copra oil (fuel).With the recent intentions of the Government, bio diesel plants will now be installed in Copra producing communities. Apart from the production of bio diesel it is envisaged that the program will also incorporate value added activities boost income in the local communities.

With the increases in the price of fuel, the Government has considered a number of alternatives with respect to Biofuel. One of the most important of these raw materials is the utilization of Coconut oil for Bio-Diesel purposes. In addition the Government has also looked at the initiative as a means of rejuvenating the Copra Industry and also providing the much dynamism to the rural economy. As a result, the strategy currently pursued by the Government is the actual installation of Bio-Diesel Mills in rural communities. The Mills have the potential to produce about a million litres per year. The first mill is intended to be installed before the end of 2009.

Notwithstanding the above, the Government is also aggressively pursuing the development of the Biofuel industry through the involvement of the private sector. To this effect the Government has put in place specific fiscal incentives.

5.1.4 **Biogas**

FDoE has also installed several pilot projects using biogas produced through anaerobic digestion of rural and urban waste. The biogas is used for domestic cooking purposes and the digested material is used as fertilizer.

It was in the in the mid eighties that the FDoE began it investigations on the utilisation of biogas technology in the country. It was also around this time that the concept of Biogas Technology was formally introduced to the Government by an expatriate, Mr. Herbert Raedler that was working at the Ministry of Agriculture and Forestry at that time. Later, it became apparent that the technology had been around for some time dating back to the mid seventies where a Biogas fixed dome design was installed in a number of remote rural stations around the country. From its early beginnings, a couple of other designs have also been tested through the years that included the floating drum design, the tubular plastic bag type and the fiber glass digesters.

With the initial tests undertaken on Mr. Raedler's design (widely known as the Carmatec Design), the Department of Agriculture and the FDoE have installed more than twenty units between them for domestic and agricultural purposes(diary purposes) that dates back to about a decade ago. The results of the tests undertaken on the Carmatec Design have been rather mixed. The successful installations largely demonstrated the robustness of the design. However, the failures were largely attributed to the lack of knowledge on the part of the users or the recruited builders (human element).

With the success observed in terms of the robustness of the design, the technology was replicated in a number of rural areas around the country. To this effect, the Department in 2006 enlisted the services of a consulting firm – AGAMA Energy, South Africa to develop a more structured programme in the area of Biogas Technology that included capacity building and institutional structures for the promotion of biogas technology in the country.

The study also focused on the design, construction and management of Biogas plants. In addition it also focussed on putting in place a nation wide program in terms of the promotion of the technology in our rural areas. To this effect wide consultations and workshops were also part of the schedule that included other Government Departments, Non Governmental Organizations, local training institutions and the farming community.

With the completion of the study, a steering committee was formed with the objective of facilitating the implementation of the National Biogas Program. A total of 2, 500 is intended to be installed in the country for the next five years. The relevant ground work such as the marketing, awareness, training of builders and so forth is well underway. Outlined below are some of illustrations with regards to the work that is currently being undertaken and for information the focus is currently on institutions such as schools and training facilities.

5.2 Geothermal Resource

There is some evidence of geothermal resources (hot rocks) in two Vanua Levu sites. Preliminary assessments by the FDoE indicate that there is potential for steam generation in Labasa with an estimated sub-surface temperature at 500 m below ground of 125 ºC. Around Savusavu the estimate is 160 ºC. Deep drilling is necessary to verify the estimated resource data.

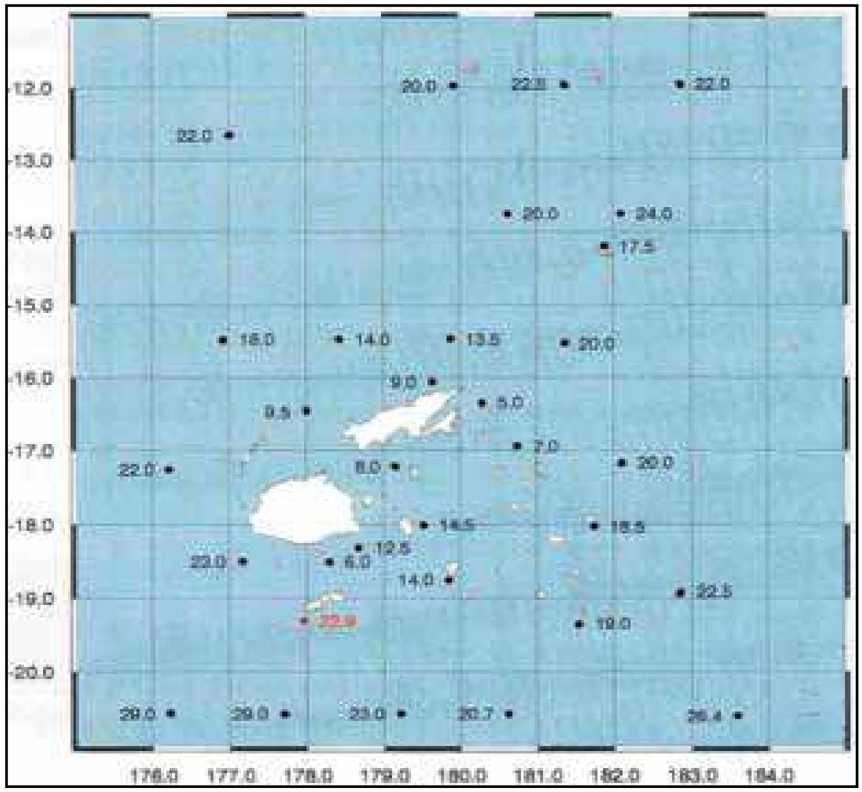
Early this year with collaboration with Japanese Government, surveys are currently being carried out in Viti Levu with the intention of finding sufficient potential for power development. The outcome of the studies will be available later in the year.

5.3 Ocean Energy Resources

The ocean off Fiji has the appropriate thermal resource to fuel an ocean-thermal-energy-conversion (OTEC) plant. A Japanese consortium determined that off the Viti Levu Coral Coast, the temperature difference between the surface ocean water and the deep ocean waters, at depths of at least 800 m, was on the average 22 ºC. They conceptualized a multiple purpose land-based 1 MW OTEC for Somosomo Bay (March 1991).

Information about the wave power resource is available in a report entitled *Ocean Wave Energy in the South Pacific: the resource and its utilisation* (Barstow and Falnes, November 1996, SOPAC Report 234).

It is reported that wave conditions vary considerably amongst the group of islands that make up the Fiji archipelago. The long-term Waverider buoy location to the southwest of Kadavu is far enough from the coast to be representative of offshore wave conditions. The long-term average wave power at this location is 23 kW/m. The satellite data shows that further offshore wave power reaches about 29 kW/m on average. On the northern facing reefs and shores of Viti Levu and Vanua Levu, the resource is significantly less and is estimated from satellite data to be around 9 kW/m on average. In among the islands of the Lau Group and the Koro Sea to the east of Viti Levu, wave conditions vary considerably depending on directional exposure. However, high power coastlines can also be found here with levels similar to the southern coast of Kadavu.



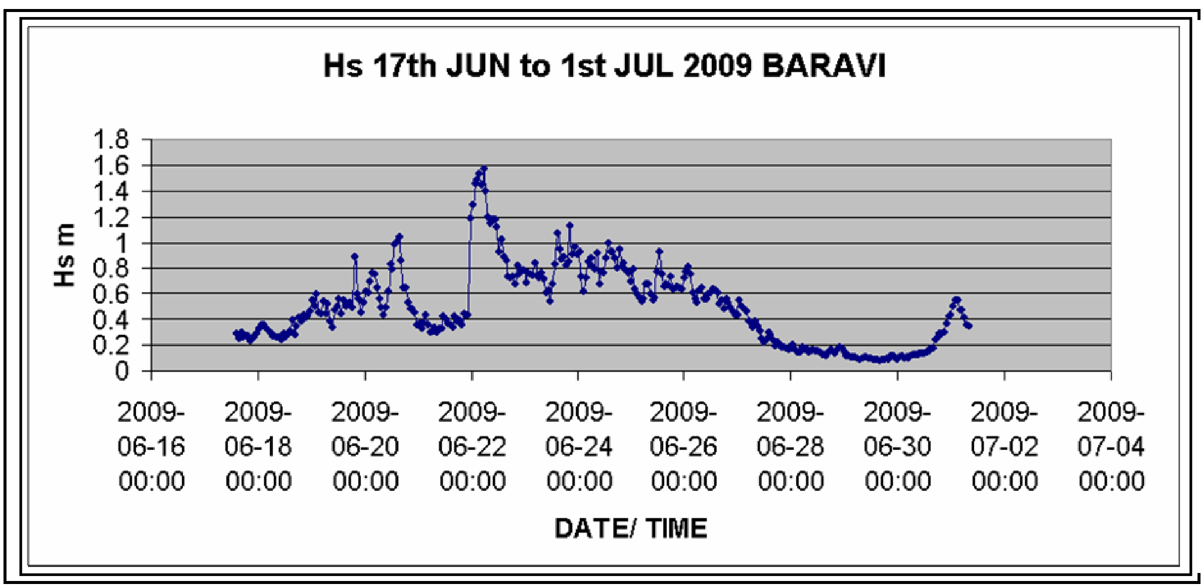
Sea wave Energy Measurements for Fiji

However, the technology for both the wave and ocean thermal resources is not ready for deployment in developing countries like Fiji[8]. The approach should be to wait until industrialized countries develop technology to a stage that is comparable to the developmental and implementation stage of wind-turbine generators and solar electric panels (PV).

Currently a project has been initiated by DoE in conjunction with University of the South Pacific (USP). A Directional Wave Recorder (DWR) has been given to the later for research and development for a period of one year. After much consideration and negotiation the DWR has been deployed near Baravi Village in Sigatoka to measure the pressure variations caused by the waves. These data will later converted into actual wave data. Further to this the DWR will also calculate the direction from which the waves are coming by measuring the current oscillations caused by wave motions. The figure below illustrates the DWR that has been deployed at Baravi.

DWR that has been deployed at Baravi

The DWR has been monitoring the wave pattern for past few months and figure 5.0 illustrates the analysis of the data obtained.



Significant wave heights for Baravi wave monitoring project. On average the significant height for June was 0.504948 m (Hs multiplied by 0.995 to get meters). However the maximum significant height is 1.573304 m. There were 331 bursts of 1024 samples taken. The first burst was discarded. Each burst lasted 1024 seconds (1Hz sampling) or 17 minutes. There are 337,920 useful values of wave height measured over 15 days

5.4 **Hydraulic Resource**

In past years, hydraulic resources have supplied a significant component of the electricity available through the national electrical distribution grid operated by FEA. Unlike in the part, land issues now have significant bearing to the implementation of such projects in Fiji.

FDoE has an ongoing program monitoring potential micro-hydro sites in rivers and creeks. The aim is to identify sites to produce electricity for communities not served by the FEA grid. At least two to three-year long records of flow rate, water level and rainfall are required for feasibility analysis and to develop a preliminary design of micro-hydro power plants. FDoE has installed recording instruments in as many as eight locations around the country. Topographic measurements are performed for sites deemed feasible. The FDoE has published potential / preliminary or instantaneous data collected from around 200 sites around the country. The report provides a brief with regards to basic parameters at the surveyed sites including potential available load.

As shown in the table below the total micro-hydro installed capacity is about 960 kW (84% at Wainikeu or Wainiqeu a system operated by FEA). It is estimated that the four additional sites were FDoE is planning to install monitoring equipment might represent a combined 500 kW potential.

Micro-Hydro Projects in Fiji.

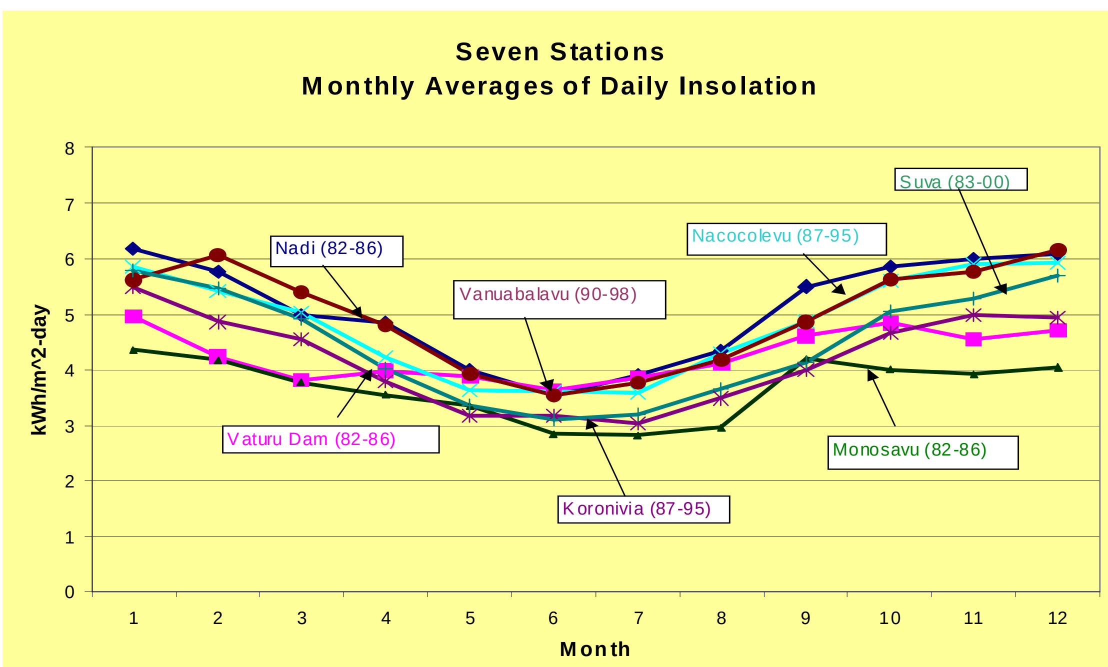
Project / System	Location (Island)	Installation Year/ Cost (F$)	Capacity (kW)	H, Net Head (m)	Q, Flow Rate (m^3/s) 90% Exceedance
Wainikeu	Vanua Levu	1992/$4000K	800	122	*0.964*
Nasoqo	Viti Levu	1984/$40K	4	30	*0.020*
Bukuya	Viti Levu	1989/$900K	100	161	*0.091*
Vatukarasa	Viti Levu	1993/$150K	3	10	*0.044*
Koro	Kadavu	1994/$80K	20	40	*0.074*
Muana, Cakaudrove	Vanua Levu	1999/$500K	30	140	*0.032*

5.5 Solar Resource

The Fiji Meteorological Service has six pyronometers stations in Viti Levu (Nadi, Vaturu, Monasavu, Nacocolevu, Koronivia, Laucala Bay); one in the Lau Group (Vanuabalavu); and, two in Vanua Levu (Dreketi, Seaqaqa). There is also ongoing data recording at the Nabouwalu Hybrid Power Station (since 1996) with an annual daily average insolation of 4.5 kWh/m^2-day. These ten pyronometer stations are listed in the table below.

In addition, there is a two-year record available for Vunatovau from the Southern Pacific Monitoring Project (1995-1996). The annual average insolation for this location is 4.8 kWh/m^2-day. The complete corrected solar radiation records are available from FDoE and have been used solar-home-systems design training[10].

The figure below represents the long-term monthly averages of daily insolation at seven stations ranging from site with highest to the site with the lowest insolation in Fiji. Highest values are found at Nadi Airport station with long-term annual average of daily insolation at 5.1 kWh/m^2. At Vanua Balavu, in the Lau Group, the long-term average is also relatively high at 5 kWh/m^2. Around Bua Province (Vanua Levu) the value is ~ 4.5 kWh/m^2. Lowest value is found in Monasavu Dam (808 m elevation) with long-term annual average of daily insolation at 3.7 kWh/m^2.



[10] Records and training material are included in CD supplied to PIREP international consultants.

Monthly Average of Daily Insolation for Seven Stations Ranging from Highest (Nadi Airport) to Lowest (Monasavu Dam).

Name	Island	Years	Latitude (S)	Longitude (E)	Elevation	Fiji Met. Service i.d.
Nadi Airport	Viti Levu	1972-2001	17:45	177:27	16 m	V 7774403
Vaturu Dam	Viti Levu (East of Nadi)	1982-1987	"	177:40	546 m	V 7776503
Monasavu Dam	Viti Levu	1980-1987	"	178:03	808 m	V 7870803
Nacocolevu Research Station	Viti Levu (Rewa)	1987-1995	18:06	177:32	11 m	V 8715203
Koronivia Research Station	Viti Levu (by Nausori)	1987-1995	18:03	178:32	15 m	V 8805303
Laucala Bay	Viti Levu (Suva)	1983-2001	18:09	178:27	6 m	V 8814303
Vanuabalavu	Lau Group	1990-1998	17:14	*178:57 West*	30 m	W 6770003
Dreketi	Vanua Levu (Near Bua Province)	1987-1995	16:35	178:51	8 m	V 6858103
Seaqaqa Agricultural Station	Vanua Levu (close to Labasa)	1987-1999	16:28	179:10	91 m	V 6941203
Nabouwalu Hybrid P.S.	Vanua Levu	1996-1999	17:00	178:42	66 m	Hybrid Power Station

Table 29.-Fiji Pyranometer Stations.

To utilize the solar radiation received in Fiji, Solar Photovoltaic (PV) has been used to charge batteries and provide household solar lighting during night. Around 1987, over 100 SHS were installed in cane settlements in Viti Levu. They were maintained by DoE with a monthly fee of F$4.50. Due to undersizing of systems causing customer dissatisfaction

However, a similar SHS project was installed in Vanua Levu. And currently there are about 1200 SHS installed in Vanua Levu and nearby Islands. The system consists of a 100 W solar panel, lights (1 x 1W, 1 x 7W and 3 x 11W), one 12 V power point, powered by 100 Amp hour. The Figure above illustrates a SHS in Vanua Levu.

5.6 Wind Resource

It is speculated that appropriate wind resources are to be found in Fiji because of the prevalent offshore winds and the island topography. FDoE and FEA have pursued evaluation of wind resources in several locations.

There are wind data records available from the FDoE and the Fiji Meteorological Service (FMS). FDoE has data for eight sites:

- Gamu (10 m above ground level, AGL)
- Kavukavu (40 m)
- Korotogo (10 m)
- Nabouwalu (18 m)
- Tamuka (48 m)

- Vunatovau (10 m; 21 m)
- Vunisea (30 m)
- Yaqara (20 m)
- Waibogi (10 m)

The FMS has 10-m anemometers at the following sites:

- Nabouwalu Government Station (1978-2002)
- Nadi Airport (1993-2002)
- Nausori Airport (1988-2002)
- Rotuma Government Station (1998-2002)
- Suva at University of the South Pacific (1998-2002)
- Vunisea Government Station (1978-2002)

The FMS anemometers tend to be installed in sheltered locations and not for the purpose of evaluating the wind resource. For example, the annual speed average estimated from the FDoE anemometer installed in Vunisea is about 4.8 m/s while the value from the Government Station anemometer is closer to 3.7 m/s.

5.6.1 FDoE Anemometer Stations

FDoE has an ongoing anemometry program with stations at the locations given in the table below. Data availability is also summarized. The Latitude and Longitude values listed, with the exception of Vunatovau, are approximate readings from maps. Coordinates for Vunatovau were determined using a GPS system.

Unfortunately, there is no documentation at FDoE indicating how were wind vanes set. There is only documentation about the setting of wind vanes in Vunatovau. These were set to true north at 0° (zero degrees). Other sites might have been set to magnetic (compass) north ignoring deviation from true north, or not set at all. Therefore, it must be emphasized that, with the exception of Vunatovau, wind direction data has undetermined offsets.

Site	Descriptor	Height (m)	Latitude (South)	Longitude (East)
South Coast Viti Levu				
Gamu	Pacific Harbour 2 km inland and 120 m ASL	10	18° 15’	178° 02’
Korotogo	By Sigatoka 1 km inland and 40 m ASL	10	18° 10’	177° 32.5’
Vunatovau	3 km north of Sigatoka 6 km inland and 183 m ASL	10 and 21	18° 06.8’	177° 29’
Waibogi	Between Vunatovau and Coast 80 m ASL	10	18° 09’	177° 30’
West Coast Viti Levu				
Kavukavu	Momi Bay & Likuri Harbour 3 km inland and 300 m ASL	40	17° 58’	177° 18’
North Coast Viti Levu				
Tamuka	In Rakiraki 163 m ASL	48	NA	NA
Yaqara (new 8/02)	Tuidreke St. in Rakiraki 258 m ASL	20	17° 27’	177° 59’
Kadavu				
Vunisea		30	19° 03’	178° 10’

Table :-Locations of Fiji DoE Anemometer Stations.

Site	Height (m)	Period	Speed	Direction
South Viti Levu			**Average**	**Avrg**
Gamu	10	2/95 to 11/95 (10-months)	5.5 m/s	*"97 °"*
Korotogo	10	9/94 to 7/95 (11-months) 1/96 to 9/97 (17 of 21 months)	5.3 m/s 5.5 m/s	*"114 °"*
Vunatovau	10 21	12/94 to 3/97 (28-months)	5.4 m/s 5.7 m/s	129° True 126° True
Waibogi	10	1/95 to 1/96	4.9 m/s	
West Viti Levu				
Kavukavu	40	8/00 to 9/00 5/01 8/01 to 9/01 10/01 to 11/01 4/02 to 6/02	5.1 m/s 0.8 m/s 5.1 m/s 4.7 m/s 4.7 m/s	*"191 °"*
North Viti Levu				
Tamuka	48	7/99 to 10/99 12/99 to 2/00 7/00 to 10/00 12/00 to 2/01 9/01 to 11/01 11/02 to 1/03	6.3 m/s 4.8 m/s 6.0 m/s 4.8 m/s 6.6 m/s 7.0 m/s	*"136 °"*
Yaqara (installed 8/02)	20	10/24/02 to 1/22/03	6.8 m/s	*"98 °"*
Kadavu				
Vunisea	30	5/00 to 9/00 (4-months)	4.8 m/s	*"134 °"*

Table: -Wind Data Records Available from FDoE Anemometry Program.
[N.B. Only Vunatovau Wind Vane confirmed to be set to True North.]

Recent and current wind monitoring station records

Location	Height (a.g.l)	Measurement Period	Average Speed (m/s)	Prevailing Direction
Benau, Savusavu	30	12/04 to 3/08	4.8	150 °
Wainiyaku (Taveuni)	30	12/06 to current	7.2	160 °
Nacamaki (Koro Islands)	30	7/06 to current	7.9	50 °
Vadravadra (Gau Island)	30	12/02 to 4/05	5.5	75 °

Location	Height (a.g.l)	Measurement Period	Average Speed (m/s)	Prevailing Direction
VanuaBalavu (Lau Group)	30	10/08 to current	6.7	240 º
Nabouwalu	30	12/08 to current	5.5	150 º

Apart form long-term wind monitoring station, wind surveys are also been carried out. Following the wind surveys and upon analysis of the data of the survey, long-term wind monitoring is done. The table below shows some of the recent wind surveys carried out by FDoE.

Recent wind surveys carried out by DoE

Location	Co-ordinates	Height (a.s.l)	Average Speed (m/s)
Tabiang (Rabi)	16 º32 05 S 179 º58 49 E	60	3
Duavata Junior School (Cakaudrove)	16 º13 08 S 179 º51 03 E	54	8
Yanuca Island			2.6
Kadavu Provisional High School	18 º59 20 S 178 º26 15 E	30	0.9
Vunivaivai (Kadavu)	18 º72 32 S 178 º 33 01 E	35	1.2

a.s.l = above sea level

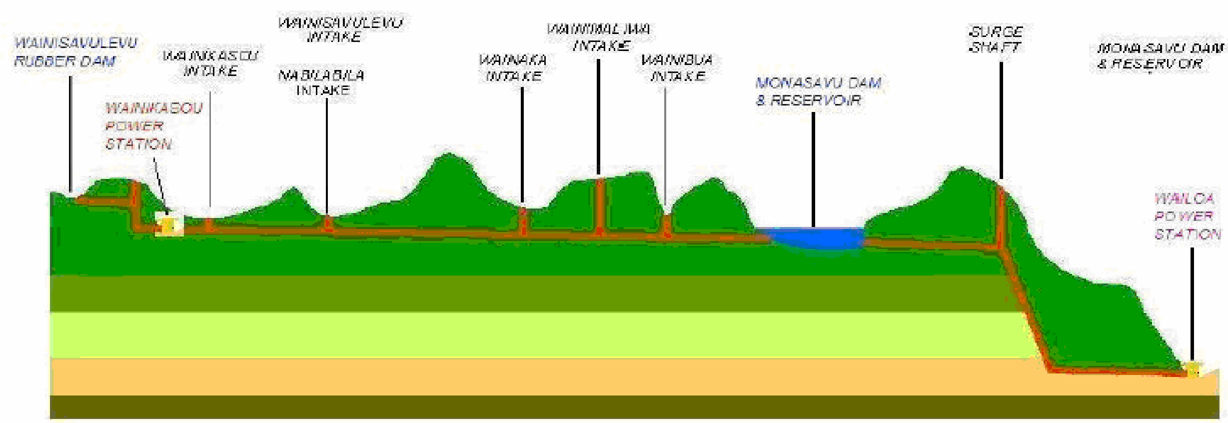
Prasad (1999) in a study on wind power in Fiji determined that the average wind power flux over the windiest areas is between 42 and 140 W/m^2 (wind speed between 4 and 6 m/s). Taking into account the scenario for Fiji, power in the wind can be utilized to provide mechanical power (for water pumping) and for electricity generation. There is good potential for use of small scale wind turbines, using battery storage to provide power to remote communities and for remote telecommunication installations.

6.0 Renewable Energy Projects (Indigenously Developed RE Projects): Status

A number of rural electrification projects that have been implemented in Fiji are **discussed / summarized** below;

6.1 Monasavu Hydro Power Project

This is an existing hydro dam and a power station located as Wailoa in the centre of Viti Levu with an installed capacity of 80 MW and capable of generating 400 Million units of electricity per year on average. A longitudinal section through the Monasavu Hydro Electric Scheme.



LONGITUDINAL SECTION THROUGH MONASAVU HYDRO ELECTRIC SCHEME

PROJECT DETAILS	WAILOA POWER STATION	WAINIKASOU POWER STATION
YEAR COMMISSIONED	1983	2004
POWER STATION CAPACITY	80 MW	6.4 MW
ANNUAL ELECTRICITY PRODUCTION	400 GWh	19 GWh
WATER YEARLY FLOW TO POWER STATION	290,000,000 m^3	70,000,000 m^3
TOTAL LENGTH OF TUNNELS & SHAFT	17,200 m	1,564 m
RESERVOIR CAPACITY	133,000,000 m^3	37,000 m^3
GROSS HEAD	623 m	116.8 m
TAILRACE TUNNEL TO MONASAVU		11000 m

The project was commissioned in 1983.

6.2 Wainikasou Hydro Project

The Wainikasou hydro station is a run off river system that was developed and commissioned by Sustainable Energy Ltd a joint venture company between FEA and Pacific Hydro Ltd of Australia. It has an installed capacity of 6.4 MW and an estimated annual energy generatior of about 20 GWh. The instake weir was raised by 1.5 meters to increase storage capacity a Rubber Dam and a collapsible using Obermyyer Gates during excessive overflows.

The Wainikasou hydro state has 2 x 3.2 MW Fancis turbines was in commissioned in June 2004 and the water discharged from the station is diverted to the Monasavu Dam after which is re-used in the Wailoa Hydro Station. With the current design, a 1 unit (kWh) of electricity generated at Wainikasou, produces a total of 4 kWh at the Wailoa Power Station. Outlined below is an illustration of the Wainikasou Hydro station with its rubber dam

6.3 Nagado Hydro Station

The project is another storage system that was commissioned in May 2006 by Sustainable Energy Ltd with an installed capacity of 2.8 MW and produces about 18 GWh. The station is located at the Nagado Water Treatment Plant (main Nadi and Lautoka region water source). The hydro station utilizes with water from the Vaturu Dam for power generation before it goes into the water treatment plant. The Pipeline diameter was increased to cater for increased demand no break pressure tanks along the pipeline has to be installed for the new pipeline so that pressure is maintained for hydro power operation.

6.4 Nabouwalu Wind/PV Hybrid Power System

An integrated PV and wind-turbine-generators with the diesel generators was installed in Bua providing electricity to the Nabouwalu Government Station. This complementary use of renewable and fossil-fuel resources referred to as hybrid power system (HPS), had worked well for a number of years. The Design was undertaken by a private not-for-profit institute located in Hawaii. The Ministry of Foreign Affairs of the Government of Japan donated the renewable energy equipment. The system was installed in 1998 and operated for about 4 years.

The hybrid wind-solar-diesel power system in Nabouwalu in Vanua Levu, Fiji, was a successful example of the use of wind power and solar energy to generate electricity, however it is currently not in operation due to lack of maintenance. The 720 kWh/day hybrid power plant for the provincial center at Nabouwalu in Vanua Levu, Fiji was designed by Pacific International Center for High Technology Research (PICHTR) to integrate renewable indigenous resources with the existing diesel-generator electricity distribution mini grid. The Ministry of Foreign Affairs of Japan (MOFA) covered equipment capital cost.

Figure *Nabouwalu hybrid system*

6.5 **Butoni Wind Farm**

The Fiji Electricity Authority (FEA) in 2005 entered into a $FJ26 million wind farm power contract with a French company Vergnet. The total project cost was $FJ 30M and was commissioned in October 26, 2007. Vergnet a supplier of water and wind energy systems supplied the wind turbines which were assembled and installed by FEA at Butoni, in Sigatoka. This is the first grid connected wind farm in Fiji. FEA installed 37 Vergnet turbines (figure 2.0) along the Butoni ridge line to create a 10 MW wind farm. The turbines are 55 meters high, have two blades and generate electricity between wind speeds of 4 and 20 m/s. Each turbine has a rated power capacity of 275 kW.

The wind farm in total has a capacity of 10 MW, based on wind data for the area; it is anticipated to produce 11.5 GWh of electric energy annually to the FEA grid (Wind Prospect, 2005). This new addition from Butoni is to increase the total generation capacity comprising of hydro, wind, and diesel close to 166 MW on Viti Levu, Fiji. The current maximum power demand in Viti Levu is close to 110 MW.

The initial performance of the project has produced somewhat mixed results. This has been brought about by a number of technical issues surrounding the project and also extreme weather patterns that resulted in the lower of turbines. However, it is hoped the system would improve and with the contribution from wind energy we will be able to continually minimize the amount of diesel fuel that is utilized for power generation in the country.

Butoni wind farm during its construction stage in 2007

6.6 Biomass Utilization

Woodstoves

In the mid 1980's, a series of high efficiency wood stoves were developed with the intention of improving cooking conditions for women and to reduce their work loads for gathering fuel wood. The stoves were designed for easy construction in rural areas at a cost affordable by rural households. Several hundred were built and used in a number of communities. However, acceptance was limited and the project did not result in the widespread change from cooking on open fires to enclosed wood cook stoves that was hoped for. Nonetheless, the project did result in widespread acceptance of the concept for rural schools and the construction and use of institutional stoves using the designs of the 1980s continues today.

Steam Cogeneration Plant

In 1979 a small, and very robust, wood/coconut waste-fuelled steam power system was installed at the plantation of Adrian Tarte in southern Taveuni to provide heat for copra drying and electricity. After 25 years, it is still operating, though it has been modified over the years. Two steam engines operate on an alternating basis, switched every two weeks. The steam system saves 27 litres of diesel fuel per hour (relative to a diesel genset), equivalent at Taveuni fuel prices to annual fuel savings of up to $263,000. The cost of running the steam engine is about $20,000 per year.

In 1987 a similar system was commissioned at the nearby village of Navakawau (PEDP, 1988). Using 500 kg of wood and coconut husk/shell over eight hours, the boiler provided heat for copra drying and steam for the 10 kW steam engine that supplied electricity to 47 homes for 4-8 hours daily. The system was a DoE project supported by a US$42,000 grant from the US Agency for International Development (USAID). With considerable support from DoE and Tarte (DoE, 2000), including the provision of thousands of seedlings to improve fuel supply, the system operated on and off for about

10 years but the community was not seriously committed to the project. In 1987, the US Ambassador promised funding for an additional 16 systems but the military *coups* of the same year ended US support for the project (Johnston et al, 2004).

Coconut Biofuel

Coconut oil has been used as an alternative to diesel fuel to operate diesel generators at DoE pilot projects in two rural locations:

i) an 80 kVA generator installed in May 2000 provides electricity for 198 households in three villages in Vanuabalavu, Lau; and

ii) ii) a 45 kVA generator installed in July 2001 electrifies 60 households in Welagi in Taveuni.

Preliminary indications are that the technology is viable but there are difficulties with the local management required for operations as well as on site production of copra oil (as oil).

Ethanol

There were several feasibility studies around 1980 to develop ethanol to blend with petrol (15-20% ethanol / 80-85% petrol) as a transport fuel. The FSC and British Petroleum proposed a 10-15 ML per year plant using molasses from the sugar mills as feedstock but viability was at best marginal. The GoF also seriously considered a similar sized ethanol facility based on Brazilian technology in Bua, Vanua Levu using sweet sorghum as a feedstock. It too was economically and financially marginal and plans were abandoned.

Gasifiers

Trials of a sawdust fuelled gasifier for power production were carried out by FEA in the 1980s. The trials were not successful and there has apparently been no further trial of gasification technologies in Fiji.

Pyrolysis

Although there is no practical experience in Fiji with pyrolysis, it is an option reportedly being considered for use as a diesel fuel. Telesource, the company managing FEA's diesel systems, considers biomass pyrolysis to produce liquid fuels to be a real possibility due to an increase in research and development efforts in recent years and Fiji's suitability for a pilot project (Johnston et al, 2004):

- A large agricultural and forestry sector (sugar and timber), with two 'mine-mouth' operations generates considerable biomass residue (FSC. and Tropik Wood) that is largely unused;
- Some FEA diesel gensets are obsolete and can be used and cannibalised

for trials with pyrolysis oils; and

- Telesource's sales agreement with FEA allows power that is generated from fuels other than diesel to be fed into the grid and generate revenues.

6.7 Micro Hydro Installations

Small hydro systems have been used at mostly rural religious missions and plantations for more than 100 years. Since 1980, five village scale hydro installations have been commissioned mainly for home lighting and entertainment. To be economically viable, microhydro power must be very close to the load and this has greatly limited the number of sites that can be developed.

The main problems at existing installations have been technical in nature, primarily electrical, with problems of site access and limited technical skills available in the rural villages causing long power outages and high costs for repairs when breakdowns occur. For many of the installations, this has resulted in periods without power being longer than periods with power. Another issue has been secure access to land for the construction and operation of small hydro projects.

6.8 Solar Photovoltaic Installations

The first rural electrification project in Fiji using solar photovoltaics and a RESCO-type structure was carried out by the DoE in 1983. The project was developed after then Prime Minister, Ratu Sir Kamisese Mara, directed DoE to arrange a pilot project of 100 solar home systems (SHS) in outer islands. USAID agreed to finance three separate "small grant" projects developed through Peace Corps volunteers in rural villages (Johnston et al, 2004).

The three sites selected were Namara (Kadavu), Totoya Island and Vatulele (Koro), each village receiving between thirty and forty systems for a total of 100 installations. Each community established a cooperative structure to manage the systems. Each coop was required to send at least two people for training by the DoE and to agree to collect fees from users sufficient to pay the local technicians and to purchase replacement batteries on a three-year cycle. The fee structure decided upon by the cooperatives varied but was about US$ 3-4 per month. Additionally an installation fee of F$25 was charged for each user wanting a system. System ownership remained with the cooperative, not the users. The DoE agreed to provide periodic training to local technicians, to assist in obtaining replacement parts as needed, and to provide technical advice when required. No further subsidies were promised or provided. Installations were to be carried out by the trained local technician with support from the Peace Corps volunteers and DoE technicians.

The technical systems installed were purchased by competitive tender. A local dealer, South Pacific Solar, won the tender and provided the components from the USA. These included a 42 watt panel, an electronic charge controller, with the capability of charging "D" size rechargeable Ni-Cd batteries, and a gelled electrolyte battery of 45 Ah capacity. Two 13 watt tube-type fluorescent lights were included. A portable light and four rechargeable Ni-Cd "D" cell batteries were also provided each household. The component cost of each system was approximately US$ 550.

The Totoya systems were never installed, although components were shipped to the island, because the Peace Corps team left early without developing the project. The equipment was not recovered since the Totoya people promised to continue with the installations. However, there was no further progress and the difficulty and expense of access prevented direct intervention by DoE in the project.

The Koro project was completed and operated as designed during the term of the Peace Corps volunteers but upon their departure, about a year after installations were completed, the co-op spent the accumulated funds, stopped collecting fees and the systems fell into disrepair and were abandoned.

Only in Namara was there a continuing attempt to maintain the installed systems and retain a community structure for their maintenance. By 1993, approximately half of the installed systems were still operational, having gone through several battery replacement cycles, although not all continued to operate at design capacity. However, the co-op had not survived and maintenance was being handled by individual users rather than through a RESCO structure.

Since these were pilot projects intended to determine the problems and successful approaches to PV based rural electrification, they provided much useful information for later projects. They were not considered successful rural electrification projects, however.

In 1986-1987, over 100 SHS were installed in scattered homes in cane farming settlements of Viti Levu. Using a design similar to the 1983 installations, the systems were maintained by a DoE technician with a fee of F$4.50 per month charged for the services provided. The systems were undersized and did not perform up to the expectations of users.

In the late 1980s solar electrification was trialed at approximately ten community centres. There was sufficient capacity for video operation and provision of services for meetings and community activities. These were primarily technical and social trials to determine the social acceptance of the installations and the performance of the equipment under field conditions. Results were mixed, neither very positive nor were they considered a failure. Rehabilitation and upgrading of these installations is currently being considered.

In 2001 FDoE had speculated that a cost effective alternative might be provided by stand-alone PV-based SHSs for locations with appropriate solar resource. It began with a an installation of 250 systems that was provided through funding from the Ministry of Foreign Affairs of the Government of Japan and coordinated through the Pacific Centre for High Research and Technology in Hawaii. A further funding of around 100 systems was provided thereafter. However over the years through the Government Rural Electrification program a total of 1200 systems in Vanua Levu has now been installed in Vanua Levu.

A private company has been trained and contracted to maintain the system. The equipment installed includes prepayment meters. The meters require the punching / entering of codes into the meter for a timed period of use. The cards are purchased at the local Post Offices.

The private company performs monthly inspection visits. Users pay a monthly fee of $F14 that covers all life cycle costs (e.g., maintenance, repair and replacement) excluding equipment purchase. Funds collected are kept in an escrow account managed by FDoE. The record indicates that the majority of rural citizens presently using kerosene or benzene lamps and dry cell batteries, are willing and able to pay for SHSs operated by a responsive service provider.

6.9 Solar Thermal

Solar water heaters have been manufactured in Fiji since the 1970s and thousands of locally made and imported systems have been installed in homes and hotels. The most common of the local designs uses a separate collector and a copper storage tank in a highly efficient and very reliable thermosiphon design that has had wide acceptance over the years. The systems are well made, efficient, cost effective and have a long life but are relatively difficult to install and are not attractive. Australian designs typified by Solar Edwards and Solahart have been recently more successful in the urban Fiji market place. Their success is mainly due to their ease of installation and relatively attractive appearance.

7.0 Promotion of Renewable Energy

Over the years the Government has noted the alarming increase with regards to the cost of fuel imports into the country as outlined in part 3.0 above. In its efforts to manage this particular situation it has also included a number of incentives to encourage the development of renewable energy in the country. These incentives has been in the form of policies (also including fiscal policies) and financing packages (subsidies and loans).

Firstly the fiscal incentives have been part of the Government Budget over the years. Generally the incentives have included the drastic reduction or removal in the custom duty levied on renewable energy equipment. However, the Government has maintained the Value Added Tax (VAT) component on all these equipment or items.

Other Fiscal Incentives that have been put in place includes;

a. Accelerated Depreciation

- 100% write off will be available in the year the expenditure was incurred on water storage facilities and renewable energy plant and machines.

b. Bio-Fuel Production

- 10 year tax holiday is available to a taxpayer undertaking a new activity in processing agricultural commodities into bio-fuels as approved by the Commissioner from 1 January 2009 to 31 December 2014. To qualify, the taxpayer must have:-
  - Minimum level of investment of $1,000,000; and
  - Employ 20 local employees or more for every income year.

- Duty free importation of plant, machinery and equipment for initial establishment of the factory.
-
- Duty free importation of chemical required for bio-fuel production.

c. Manufacturers :
Renewable Energy Projects and Power Cogeneration

- 5 year tax holiday is available to a taxpayer undertaking a new activity in renewable energy projects and power cogeneration as approved by the Commissioner.
- Duty free importation of renewable energy goods is also available.

Tax Free Region Incentives

This incentive is available to a newly incorporated entity engaged in a new trade, business or manufacture established in the following areas:-

- Vanua Levu – includes Taveuni, Rabi, Kioa and other islands generally included for government's administrative purposes as being in the Northern Division.

- The incentives are applicable to existing businesses in Vanua Levu provided that there is an increased sale by 25% or more and 5 new persons are employed from 2005.
- The package entails the following:-
  - 300% Tax Deduction on Capital Expenditure until 31 December 2010
  - 100% Tax Exemption Export Incentive until 31 December 2010.
- Vanua Levu also includes Taveuni, Rabi, Kioa and other islands generally included for government's administrative purpose as being in the Northern Division.

Secondly, apart from the above fiscal incentives the Government had earlier approved a charter for the establishment of RESCOs and draft legislation has been prepared to develop a public – private partnership for rural electrification. The mechanism recommended that the Government through the FDoE purchase the solar home systems and lease them at a subsidized rate to private companies who will install and maintain them in return for a user fees adequate to cover all operational and maintenance cost.

In addition recently Cabinet had approved Public Private Partnerships for various sectors of the economy including energy. Even though at this stage the various mechanisms / framework to access the facility is yet to be finalized.

In addition, with the current Rural Electrification Policy the FDoE is now rigorously promoting the utilization of Renewable Energy Technologies. Even with its Diesel Generating Systems the specifications have been made to be attuned to the utilization of Bio Diesel. For the 400 odd existing Diesel generating Systems that are in operation the field the FDoE is looking at conversion of the system to use of Bio Diesel and also the incorporation of Gasification Technologies.

Apart from the above, currently the FDoE is working in collaboration with the World Bank on the promotion of Renewable Energy in Country. The project is aimed at providing the necessary financing to those that wish to adopt renewable energy. As part of the project a local bank has been engaged (to lend) in this regard. With the project the World Bank has put up fifty percent (50%) as collateral for the financing of Renewable Energy Technologies.

8.0 Renewable Energy Markets and Industries

With the absence or difficulty in attaining the critical mass with respect to the manufacture or production of Renewable Energy Technologies in Fiji, generally the Renewable Energy Technologies sold in the country are imported from other countries. This more often affects the costs of the investment on renewable energy projects in the country.

However, notwithstanding the above there are number of locally produced items that include batteries that are used for our Solar Home Systems and other minor components.

8.1 Potential Private Sector Energy Service Providers

One of the main activities of the UNDP GEF project that was conducted in the country in early 2000 was to identify all potential Renewable Energy Service Companies and to select one to operate Nabouwalu Hybrid and other rural sector systems using renewable energy resources like the solar-home-systems that were being installed in Vanua Levu. These entities were supposed to indicate their commitment by participating in technical and business training offered by FDoE.

Only four relatively small companies were able to participate and these only had appropriate background to operate systems like those in Vanua Levu. The larger companies like Shell and BP were no longer able to participate because they were trying to survive the situation in Fiji concentrating in their main core business (selling fossil fuels). Of the four participating companies two demonstrated, through the training activities as well as their ongoing business, that they were qualified for installation and maintenance of SHSs but not yet for systems like the one installed in Nabouwalu. The other two were lacking the technical personnel and were mostly concentrating in sales of different types of equipment to the rural sector. Their familiarity with the rural sector is an asset but unfortunately there are not presently ready to provide renewable energy services.

In summary, at that time there were two private entities operating in Fiji that were qualified to supply, install and operate SHS equipment. With the current World Bank initiative on promoting renewable energy in Fiji, a total of around six additional companies are now doing a lot of work in Fiji on renewable energy. This includes not only the supply of these equipment and materials but also the actual installation and also the maintenance and repair of the technology.

9.0 Research and Development Work on Renewable Energy

It has only been recently that a lot more collaboration is being undertaken in the area of renewable energy between local educational institutes and the FDoE. The main educational institutes in Fiji are the University of the South Pacific and the Fiji Institute of Technology which now has been incorporated as part of the Fiji National University that was formally established this year – 2009.

Notwithstanding the above this year two important Seminars were conducted by the University of the South Pacific where local and overseas academic professionals had participated in. It is also interesting to note that the two institutions are now offering energy (including renewable energy) as part of the courses and curriculum.

10.0 Barriers to Development and Commercialization of RE Technologies

The barriers to implementation of renewable energy technologies in Fiji can be grouped under three categories: (i) Commercial viability; (ii) financial Feasibility; and, (iii) Appropriate service fee or tariff. These barriers are discussed herein considering the technology identified by FDoE as having wide applicability in the rural sector, i.e., solar-home-systems. We are primarily considering the rural sector although certainly our discussion also applies to urban areas.

10.1Commercial Viability

From the private sector perspective several issues must be resolved before, for example, energy services with SHSs are commercially viable. By commercial viability it is meant that a service is provided for a fee that covers all life-cycle costs associated with providing that service and that the fee is collectable. Presently, with the exception of the Viti Levu customers of FEA, no user of electrical services in Fiji pays a fee that covers costs. This assertion includes all sectors throughout the nation.

Providing citizens a subsidy for a particular service is an option exercised by every government in the world but the difficulty in Fiji is that subsidies are not transparent. Clearly, if costs are higher than fee someone is covering (subsidizing) the difference. This is an obvious and simple-minded statement, however, attempting to identify and precisely quantify electricity service subsidies in rural settings proved to be an illusive challenge.

The Fijian private companies presently involved in direct sales and installation of PV lighting and other renewable energy equipment rely on clients that can afford cash purchases. A typical transaction calls for 50% at the time order is placed with 40% upon installation and the 10% balance one week after installation to allow client a chance to use equipment. Self-installed equipment is paid in full upon purchase.

The following issues were identified through the implementation of the experimental service model with SHSs in Vanua Levu as well as experiences selling and maintaining renewable energy equipment in Fiji. They are listed in no particular order.

- The tariff charged to users must cover all costs: capital amortization, operations, maintenance, repairs and replacement through the life of the project as well as a reasonable profit. If subsidies are available they should only be capital cost subsidies.

- The contract between service providers and users must incorporate:

  - Installation deposit equivalent to at least 3 months of service refundable after system is returned;
  - Pre-Payment of the monthly service fee that covers borrowed capital amortization, maintenance, repair and replacements and a reasonable profit;
  - Removal of the system for non-payment of fees;
  - Reinstallation fine equivalent to twelve months of fee;
  - Tampering fine equivalent to twelve months of fee.

- Systems must include electronic pre-payment meters.

- Service provider must have legal safeguards that allow for the removal of equipment from delinquent users[22]. (Note that this is also required to obtain financing from banking institutions.)

- Need to have a critical mass of systems (customers) for viable service provision venture. For example, the number of SHSs under one service provider should be in the thousands instead of hundreds.

- Competition is welcomed but Government must insure that only qualified outfits provide service. Likewise, equipment sellers must be certified or have some sort of seal of approval from FDoE. This is to avoid negative reputation that results when renewable energy equipment is used improperly.

- Must consider the technical aspects regarding appropriate brands of lights and battery useable life.

- Financing must be in local currency.

- Consider Government Finance Guarantee to obtain more favorable loan terms.

From the private sector perspective, the issues listed above must be resolved or addressed before energy services with SHSs became commercially viable.

[22] The legal aspects of right-of-way entry should be explored. Note that in Fiji, for example, lack of periodic payment for appliances purchased on credit result in removal by bailiffs that work for law firms. However, this procedure adds to financing costs (fee) and is used for purchases close to urban centers.

10.2 Financial Feasibility

Presently, in Fiji there is only appropriate private sector human infrastructure for the provision of electricity service to the rural sector with SHSs. This infrastructure could handle the introduction of about 1000 to 1500 fee-for-service SHSs per year.

The FDoE socioeconomic survey indicates that the baseline affordable monthly tariff is about $F20 to $F 25. The survey also reveals that there are about 12,000 un-electrified households in Fiji that could use SHSs. Three hundred (300) SHSs could be purchased annually assuming that 50% of the average annual rural electrification budget[23] is used for equipment purchases. This optimum budget allocation results in 40-years required to purchase 12,000 systems.

The determination of the all-inclusive cost of providing service with SHSs, using actual maintenance records, leads to the following financing extreme scenarios to meet the $F20 to $F 25 baseline tariff:

Scenario-1) for <u>tariff = cost</u>: this unsubsidized scenario requires a concessionary loan with terms of no more than 2% annual interest and at least 20 years and would allow for installation of about 1200 SHS per year;

At the other extreme we have,

Scenario-2) for <u>tariff = cost – 90% Capital Purchase</u>: this scenario, with capital subsidy, uses a realistic commercial loan from Fiji Bank at 9% interest for 8 years, but only allows for the installation of about 300 systems per year

Clearly there are many financing scenarios between these two extremes.

10.3 Concessionary Loans and Grants Financing

Herein the experience to date trying to identify funding for thousands of solar home systems is discussed from the perspective of financial feasibility. Early on it was learned that the US Agency for International Development (AID) does not operate in the South Pacific because of the relative smallness of potential projects compared to management requirements. Likewise the World Bank (WB) generally assumes that South Pacific Islands are in the Asian Development Bank (ADB) area. Presently, WB only has a country program for Papua New Guinea. Notwithstanding the above there are also other problems / reasons which are certainly beyond the scope of this project.

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[23] This is using Policy (1993) guideline of 90% capital cost covered by Fijian Government and 10% by consumer.

10.4Service for Fees

In addition to the lack of financing, it is the lack of appropriate and enforceable tariffs that impedes the widespread use of renewable energy technologies in Fiji. The private organizations identified as potential RESCOs, for example, must compete with subsidized service provided through government.

One of the revelations of the socioeconomic survey was that when diesel-scheme service is made available for a fee, residents that already had their own genset sign-up for the service immediately and express highest levels of satisfaction. This clearly indicates that the fee is below actual recurring costs. These individuals expressed that service could be improved by having better equipment maintenance and some mentioned that fee could be higher in exchange for more reliable service. However, households without experience operating private gensets complained about both unreliable service and high fee. It is universal human nature to try to get as much as possible from the government and for free.

Operations and detailed record keeping of SHSs schemes in Vanua Levu have shown that villagers are willing and able to pay for a service that provides an alternative to the wide spread use of benzene lights and dry cell batteries. Users value the SHS service over what they had before. For example, users that were caught tampering agreed to pay a fine equivalent to twelve times the monthly service fee. This is a clear indication of satisfaction with service and the superiority of the PV lights compared to benzene lights. There is an acceptance of SHSs and a willingness to pay. This is in great part due to the fact that a qualified private company services the Vanua Levu SHSs.

The socioeconomic survey revealed that there are about 12,000 un-electrified households in Fiji that could use solar-home–systems and that at least 4,500 of these expend more than $F 20 monthly in benzene/kerosene lights and dry cell batteries for radios.

11.0 Capacity Development Needs as a Barrier Removal

The primary barrier to RE systems implementation is the absence of adequate financing from international development agencies. In Fiji human resources are such that inappropriate-capacity-development cannot be categorized as a barrier.

Presently, RE technologies with wide applicability in Fiji are:

- hydro and wind farms for FEA;
- PV arrays for FEA and telephone companies;
- microhydro and solar home systems for rural electrification (FDoE).

We concluded that although continuing education is required to ensure appropriate human resources, these are adequate to support implementation of the RE technologies listed above.

The University of the South Pacific (USP) includes Renewable Energy, engineering and resource assessment courses in their School of Pure & Applied Sciences. The Fiji Institute of Technology (FIT) that has been recently incorporated as "Fiji National University" provides an adequate supply of electrical technicians trained to Australian standards. Their electrical generation course incorporates design techniques for PV systems. Recently, the two institutions have also placed much emphasis in training people on Renewable Energy. This is attributed not only with the rise in renewable energy technologies implemented locally but also as a result of the global trend and that a significant number of graduates do opt for better conditions in Australia and New Zealand.

The Center for Appropriate Technology Development (CATD) trains villagers to assist in the installation and basic maintenance of PV lighting equipment. The two firms identified as potential RESCOs employ FIT graduates and use CATD trainees for installation of PV lighting systems.

References

1. Fiji Department of Energy, 2006, Fiji National Energy Policy.
2. Fiji National Planning, 2009, Roadmap for Democracy and Sustainable Socio-Economic Development 2009 – 2014
3. Fiji Department of Energy, 2009, Fiji's Hydro Potential, Vol 2.
4. FEA, 2009, Annual Report 2008
5. FEA, 2008, Annual Report 2007
6. Johnston, et al, October 2004, Pacific Islands Regional Assessment – 2004 – Fiji National Report,Pacific Islands Renewable Energy Project (A climate change partnership GEF, UNDP, SPREP and the Pacific Islands)
7. Snowy Mountain Engineer Consultants, October 2009, Fiji National Energy Security Report (Draft Report)
8.