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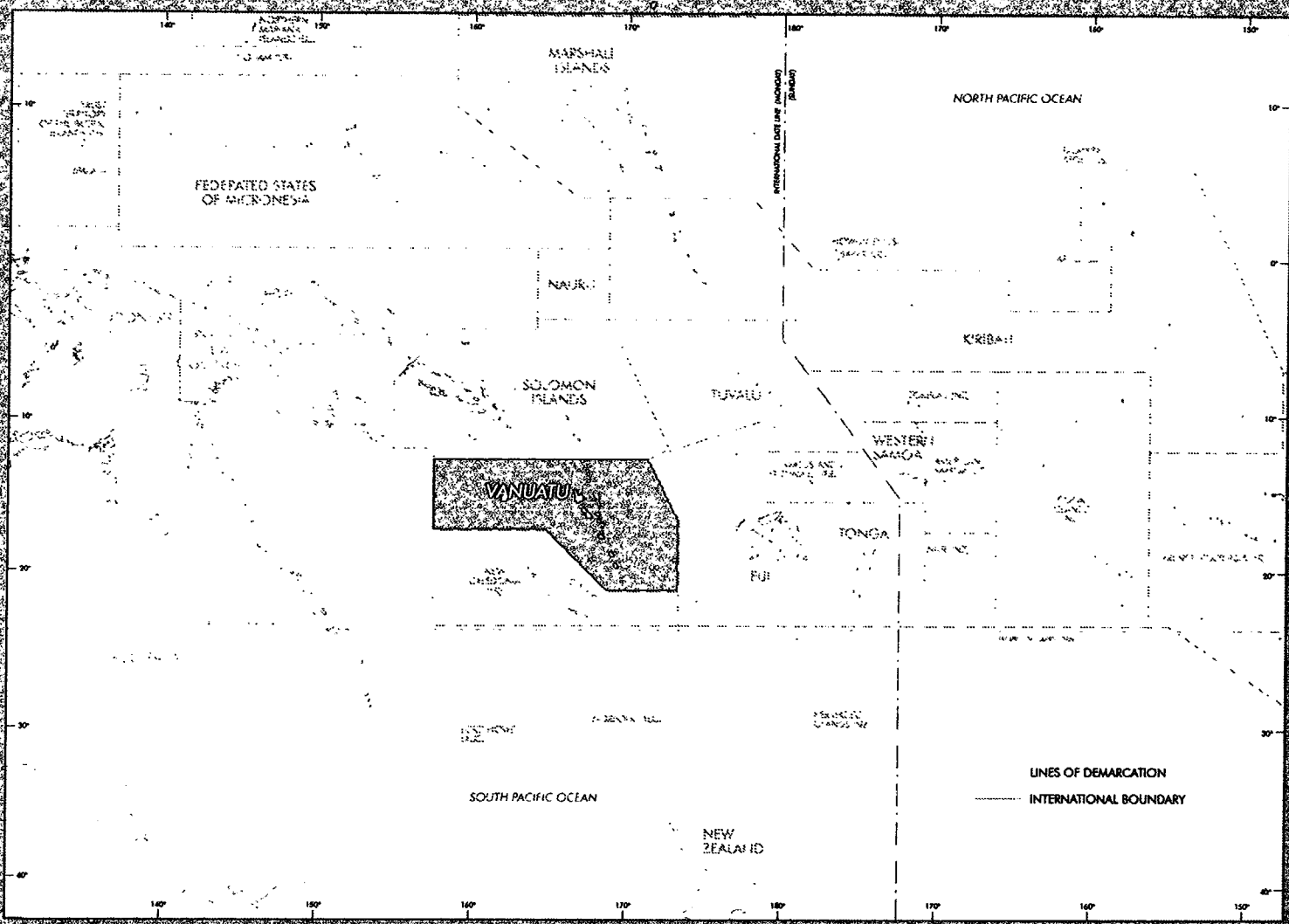
PREA

# Pacific Regional Energy Assessment

## Volume 12. Vanuatu: Issues and Options in the Energy Sector




The World Bank
in cooperation with
The UNDP/ESCAP Pacific Energy Development Programme
The Asian Development Bank
and

## CURRENCY EQUIVALENTS

1 US$ = VT 107 (February 1991)

## MEASUREMENTS

| | | | |
|---|---|---|---|
| Bbl. | Barrel | = | 159 liters; 42 US gallons |
| boe | Barrel of oil equivalent | = | 6 million Btu. |
| BTU (Btu) | British thermal unit | = | 0.252 kilocalories |
| GWh | gigawatt hour | = | million kilowatt hours |
| kJ | kilojoule | = | |
| km | kilometer | = | 1,000 meters |
| kW | kilowatt | = | 1,000 watts |
| kWh | kilowatt hour | = | 1,000 watt hours |
| $m^3$ | cubic meter | | |
| MW | megawatt | = | 1,000 kilowatts |
| TOE (toe) | tonne of oil equivalent | | |
| tonne | metric ton | | |
| Tpa (tpa) | tonnes per annum | | |

## ABBREVIATIONS

| | | |
|---|---|---|
| ADB | - | Asian Development Bank |
| ADO | - | Automotive Diesel Oil |
| CES | - | Compagnie d'Electricité de Santo |
| SPREP | - | South Pacific Regional Environment Program |
| LPG | - | Liquefied Petroleum Gas |
| NRSE | - | New and Renewable Sources of Energy |
| GDP | - | Gross Domestic Product |
| IDO | - | Industrial Diesel Oil |
| EEC | - | European Economic Community |
| GOV | - | Government of Vanuatu |
| UNELCO-Vanuatu | - | Union Electrique du Vanuatu |
| UNPEDP | - | United Nations Pacific Energy Development Programme |

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Pacific Islands Series
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# VANUATU

# ISSUES AND OPTIONS IN THE ENERGY SECTOR

August 31, 1992


## Abstract

A shortage of skilled manpower and financial resources makes it difficult for the Government to monitor and regulate the energy sector, as well as to formulate an energy development strategy. The report recommends that the Government use more effectively the contractual and regulatory tools that it already has, such as exercising its rights under its agreement with UNELCO, the private electricity supplier, and promoting more competition in petroleum supply. The Government should strengthen the expert energy staff needed for a meaningful dialogue with private energy suppliers. While UNELCO's system is well-run, there is a need to include cost reduction elements and incentives to pursue energy conservation campaigns in the supply contract. It may be possible to achieve reductions in the costs of import and storage by a relocation of storage facilities to a port area that is accessible to larger vessels with a full load. The Government should formulate, with require external assistance if necessary, exploration and development packages that will attract international companies to explore and develop Vanuatu's potential hydrocarbon and geothermal resources. The potential biomass energy supply is plentiful and could be used economically in the more remote areas of the country. Solar water heating and photovoltaic (PV) electricity generation for small individual uses could be attractive; if it is decided to use PV systems, the report recommends that an organization be created to provide fee-based maintenance services to the users.


Industry and Energy Operations Division
Country Department III
East Asia & Pacific Region

# VANUATU

## ISSUES AND OPTIONS IN THE ENERGY SECTOR

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### Annexes

## ENERGY CONVERSION FACTORS

| | | TOE Per Physical Unit /a |
|---|---|---|
| **Liquid Fuel** | (tonnes) /b | |
| | Avgas | 1.04 |
| | LPG | 1.08 |
| | Gasoline | 1.05 |
| | Kerosene/Turbo Fuel | 1.04 |
| | Diesel Oil (ADO) | 1.02 |
| **Electricity** | (MWh) /c | 0.25 |
| **Biomass Fuels** | (tonnes) | 0.33 - 0.35 |

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| | | | |
|---|---|---|---|
| /a | 1 TOE | = | 10 million kcal |
| | | = | 6.61 boe |
| | | = | 39.68 million Btu |
| /c | Avgas | = | 1413.6 liters/tonne |
| | LPG | = | 1729.1 " |
| | Gasoline (Motor Spirit) | = | 1356.8 " |
| | Kerosene/Avtur | = | 1229.1 " |
| | Diesel (ADO) | = | 1186.5 " |

/c Converted at thermal efficiency of 34% or 4 MWh per toe.

# VANUATU

## ISSUES AND OPTIONS IN THE ENERGY SECTOR

## SUMMARY

### Overview and Priorities

1. The development of Vanuatu's energy sector is constrained by a number of inherent features. These factors include:

(a) the fragmentation of the energy supply system and the energy consumption pattern as the natural result of the geography of a small decentralized island economy;

(b) the small size of the market for commercial energy, particularly electricity and petroleum products;

(c) the shortage of skilled manpower and expertise at all levels of Government which prevents the efficient monitoring of current energy supply and makes the formulation of a development strategy difficult;

(d) the severe financial constraints faced by the Government, both in terms of recurrent and development expenditures; and

(e) the dominant and largely unregulated position of outside energy suppliers, particularly in the electricity and petroleum subsectors.

2. The most apparent results of these constraints are: (i) the high cost of commercial energy, and (ii) a weak Government position in the promotion of national priorities when conducting a dialogue with major energy suppliers. While these drawbacks may cause the continuation of a perhaps suboptimal pattern of energy supply, there are no easy solutions to these problems, many of which are generic ones of an island economy. The best improvement possibilities lie in a twofold approach: first, the introduction of improvements within the existing institutional and supply framework, using the contractual and regulatory tools already at the Government's disposal. This would include the exercising of the full regulatory and shareholder rights already provided under the electricity supply franchise agreement with the private supplier, and the encouragement of more vigorous competition in petroleum product supply, perhaps through an increase in Government imports for domestic marketing, or through a resumption of an informal regulatory dialogue based on sound cost information. Secondly, the strengthening of the Government's expertise and stock of skilled human resources for the regulatory dialogue with private energy suppliers. This would mean a significant strengthening and full staffing of the Energy Unit in the Ministry with electricity and petroleum specialists, and the appointment of qualified persons that enjoy full Government support as Electricity Commissioner and Union Electrique de Vanuata (UNELCO) board member.

3. Beyond the immediate need to assert economic priorities within the existing structure, the long-term priorities call for the development of indigenous energy resources, if economically justified. The first steps in this respect will have to be the firming up of information on these resources, namely the study of (i) the potential for petroleum development in accessible offshore areas, (ii) the feasibility of the Sarakata and Teouma hydropower sites for electricity supply to the main urban centers, and (iii) the availability of geothermal steam for power generation. The hydro and geothermal generating possibilities depend to a large extent on the pace of power demand development in Port Vila and Luganville: fast growth in the tourism and small industrial sectors could advance the time when such investments are justified by the overall volume of demand. Current expectations, however, make it unlikely that new non-diesel generation sources will be needed before the year 2000. The potential for petroleum development, on the other hand, should be explored at the earliest possible time, as any hydrocarbon finds would enable the country to improve its trade balance.

Energy Consumption

4. About 70% of total national energy consumption is accounted for by biomass-based fuels, primarily fuelwood for cooking. Another 25% of total consumption consists of petroleum fuels, mainly used in the transport sector. While domestic consumers are responsible for almost half of energy consumption, other large shares of consumption are taken up by agricultural consumers for export crop drying, and by the transport sector.

5. Given the vigorous growth of diesel use in the transport sector, it is likely that further growth in the consumption of this product will exceed the expected economic growth rate significantly. Other petroleum products are likely to follow the GDP growth rate more closely. Electricity consumption in the dynamic Port Vila area can also be expected to register healthy growth of about 7% per year, while the Luganville demand center is less likely to show growth unless major new loads materialize. The use of biomass fuels in the domestic sector is expected to increase at the most in line with population growth, but its consumption in the agricultural sector is likely to decline with the decrease of copra and cocoa exports. On balance, therefore, an increased penetration of petroleum fuels and electricity is likely, while the share of biomass-based fuels will decline slowly.

Energy Supply

6. Petroleum Products. The three major supplying companies import and distribute small amounts of products, constrained by both demand levels and the shallow access to the ports. Larger product volumes could be imported at lower prices, but additional storage and deeper port access channels would have to be provided. The distribution to locations other than the main ports takes place in drums, which leads to high cost, high losses, and difficult transport arrangements.

7. Electricity. UNELCO, a privately owned utility, operates an efficient system of urban supply based on diesel generation. The system is well-run, but the small scale and the cost-plus nature of the franchise contract lead to high prices for consumers. Expansion plans for the future

call for an increase of the diesel generating capacity, while alternative sources of generation are evaluated. The supplier has formed a joint-venture company with the Government to develop attractive hydroelectric sites, when the demand will have reached levels that allow sufficient economies of scale. The Sarakata hydro site on Santo Island could be justifiable if developed to a minimum capacity of 1 MW, a size that the power demand in Luganville may reach by 1996. Other potential hydro sites on Efate and Malakula Islands need more study; while Malakula is more attractive than Efate, both do not appear attractive in comparison with other alternatives such as diesel, or local copra waste cogeneration, which should be studied in more detail.

8. New and Renewable Energy. The potential biomass energy supply is plentiful and could be used economically, together with solar energy, in the more remote locations of the country. Biomass gasifiers, if operated within a suitable institutional structure, could be competitive for local electricity generation on a small scale in selected circumstances. Biomass cogeneration at the large copra estates could be an alternative to local small diesel production of electricity. Finally, solar water heating and photovoltaic electricity generation for small individual uses could be attractive if compared to the high cost of delivering petroleum products to outer islands, and maintaining diesel sets.

Policy and Institutional Issues

9. The main issues arising in the development of the energy sector in Vanuatu are those concerned with the cost and pricing of energy, the institutional and regulatory framework, and the potential environmental impact:

(a) the power supply franchise agreement provides for a pricing formula that allows the passing on of most cost changes to consumers, but does not appear to have any incentives for cost minimization or efficiency increase.1/ Cost reduction elements and incentives to pursue energy conservation campaigns could be included in the supply contract;

(b) The wholesale margins of petroleum product suppliers have been increasing steadily over time as competition is limited in the small Vanuatu market. 2/ Competition could be encouraged if the Government would expand its current direct import to include some local marketing in parallel with the established distributors. Alternatively, a dialogue on the cost structure should be resumed with the oil companies;

(c) While, in principle, the Government has access to detailed information from the power utility, in practice the monitoring

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1/ By mid-1992, the Government had taken some steps to revise the tariff formula.

2/ By mid-1992, the Government had plans to exert some control over petroleum prices.

and regulation of the power utility is inadequate. The Government needs to exercise its rights and responsibilities under the existing franchise arrangements fully, such as by appointing an Electricity Commissioner and an UNELCO board member;

(d) Cost reductions in the import and storage of petroleum products can be achieved by a relocation of storage facilities to a port area that is accessible for larger vessels with a full load;

(e) Exploration for the possible hydrocarbons resources in offshore basins, and for the geothermal potential on Efate Island, will only go ahead if appropriate assistance is sought to develop attractive exploration and development packages to attract international companies; and

(f) Although no major environmental problems are evident at this time there is a lack of legal and regulatory provisions to deal with any problems from petroleum handling, lead and battery disposal, or diesel generating plant operation. If the hydro sites are developed, a careful environmental assessment will be necessary.

# I. ECONOMIC AND INSTITUTIONAL FRAMEWORK

## Energy and the Economy

1.1 The Republic of Vanuatu, known as the New Hebrides prior to independence in 1980, is an archipelago of some 80 islands, with a land area of about 12,000 square kilometers, and a population of about 143,000 (1989 census). More than half of the country's land area and population are concentrated in the three largest islands (Espiritu Santo, Malakula, and Efate). The only significant urban centers of the country are the capital Port Vila on Efate, and Luganville on Espiritu Santo, a total of about 26,000 people. The remainder of the local (ni-Vanuatu) population lives in scattered settlements on both major and minor islands of the archipelago with limited communication links to the urban centers.

1.2 The geographic fragmentation is paralleled in the economy which shows a sharp distinction between the modern sector, based on plantation agriculture, tourism, government services, and offshore finance, and the traditional sector (comprising a large majority of the population), consisting mainly of subsistence agriculture. The modern sector is almost exclusively urban-based, with the exception of some of the copra, coffee, cocoa, and livestock enterprises in rural areas. Measured GDP, dominated by services, has been growing by about 2.5% p.a. in real terms between 1985 and 1989 (about equivalent to the population growth rate), resulting in a per capita GDP of close to US$ 1,000 in 1989 (Annex 1.1). As expatriate income is well above average, the per capita income of the ni-Vanuatu population is likely to be significantly below this figure.

1.3 Vanuatu's trade balance is heavily negative at the level of about US$ 40 million (Annex 1.2). Although net inflows from services and private transfers diminish this negative balance, the current account deficit remains at about 20% of GDP, requiring a heavy dependence on foreign grants. Gross imports of petroleum products are equivalent to about 40% of domestically produced exports: however, as about 30% of imported petroleum products are re-exported as aviation fuel sales to international airlines, the net burden of product imports on the balance of payments is about 25% of exports.

1.4 Government projections for the Vanuatu economy call for relatively modest growth of about 2-2.5% p.a. during the next few years, perhaps increasing to about 5% thereafter. The growth of tourism and other services, which drives overall economic growth, will be affected by the softer Australian economy and the appreciation of the Vatu vis-a-vis the Australian dollar. Copra production and export, one of the traditional mainstays of the economy, is likely to stagnate or decline as world prices fall and the subsidies from the stabilization fund are phased out. Energy consumption growth is likely to be concentrated on tourism-oriented diesel use for power generation and marine transport, while the potential for alternative fuels such as copra production waste will be limited by the decline of the plantation industry.

1.5 The impact of energy sector constraints on economic development in Vanuatu is felt primarily through the high cost of energy. The causes of generally high energy price levels are twofold: first, the fragmented energy consumption pattern leads to complex distribution systems with a high potential for losses. Petroleum products, for example, have to be procured in small quantities, and are delivered to remote locations in drums: a system that encourages evaporation and loss of drums, and contributes to the high unit cost of fuel. Similarly, electricity has to be supplied to isolated demand centers by high-cost small diesel facilities rather than by more efficient larger generating capacity that could supply a bigger grid. Secondly, the supply of electricity and petroleum products is dominated by largely unregulated international companies. The three major suppliers of petroleum products avoid competition and operate with high margins, and the private holder of the monopoly franchise for electricity supply to the two urban centers operates under a long-term cost-plus contract. Although limited measures can be taken to enhance competition and increase supply efficiency, Vanuatu is likely to remain a high-cost energy supply location.

1.6 High energy prices influence Vanuatu's development in a number of ways: (i) an extension of electricity service or easier transport links to remote rural locations are prevented by the high cost of such investments; (ii) it is difficult to provide infrastructure to low-income urban or peri-urban areas without subsidies from a financially constrained exchequer; (iii) the modern sector of the economy faces the obstacle of high electricity and petroleum product prices in setting up new manufacturing or service facilities. While it is difficult to quantify the degree to which energy price considerations are affecting investment, it is evident that the tourism sector is already becoming less competitive vis-a-vis other Pacific destinations because of the escalation of other costs.

Institutional Structure

1.7 The Vanuatu energy sector is characterized by a weak Government capability to monitor the sector and largely unregulated activities of private energy suppliers. The cabinet portfolio for energy coordination, hitherto based in the Ministry of Trade, Commerce, Cooperatives, Industry and Energy, has been moved recently to the Prime Minister's Office.[1] Key senior staff dealing with energy matters, however (including the Ministry's "Energy Unit"), remain in the Ministry.[2] The responsibilities for elements of energy sector policy are split between the Ministry of Trade (responsible for administering the franchise of the private power supplier, UNELCO), the Department of Geology and Mines (responsible for the upstream evaluation of hydrocarbon and geothermal resources), the Department of Forestry, the Planning and Statistics

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1/ In September, 1991, it was reportedly moved to the Ministry of Energy again.

2/ By mid-1992, the Energy Unit had been moved to the Ministry of Natural Resources.

Office, the Business Licensing Office, and Local Government (responsible for local diesel generation).

1.8 The Energy Unit of the Ministry of Trade, theoretically responsible for energy sector coordination and analysis, is severely understaffed. Only two professional positions are currently filled, a staffing level which is inadequate to handle the regulatory responsibilities of the Government. Although grant funds become available from time to time to establish a temporary presence of resident advisers, it will be essential to strengthen the Unit on a permanent basis by increasing the number of professionals, some of them perhaps on a less than full-time basis, or for limited periods. Skills such as petroleum cost analysis, power sector regulation, and strategy planning would improve the Government's ability to conduct a meaningful regulatory dialogue with energy suppliers.

1.9 The bulk of electricity is supplied by Union Electrique de Vanuatu Limited (UNELCO-Vanuatu), a subsidiary of Lyonnaise des Eaux, a French-owned firm based in Paris. The remainder is provided by small isolated distribution grids based mostly on small diesel generation sets and operated by local governments. Remote individual consumers such as schools, hospitals, and resorts often provide their own power supply from diesel sets or solar installations. UNELCO and the Government have recently formed a jointly owned company, Hydro Power Development Limited, designed to prepare and construct future hydro generating facilities.

1.10 UNELCO was originally granted a monopoly concession by the Condominium Powers in 1939 to operate as a public power utility in Port Vila. This was subsequently renewed for a 14-year period in 1974. In November 1982, GOV authorized UNELCO to transfer the concession agreement and its associated "Cahier de Charges" to "UNELCO - Vanuatu" jointly owned by UNELCO and Socivan, one of UNELCO's subsidiaries. Similarly, on Santo Island, Compagnie d'Electricite de Santo (CES), which was 85% owned by UNELCO, was responsible for public power supply in Luganville until 1990.

1.11 In October 1986, GOV renewed the agreement with UNELCO and extended its concession up to 2011. As a part of this agreement UNELCO has also taken over CES. Thus UNELCO is currently solely responsible for public electricity supply in both Port Vila and Luganville. The terms of the original concession which exempted UNELCO from payment of taxes on capital equipment, spares, land and fuel had not been extended to UNELCO SANTO. UNELCO is therefore continuing to pay taxes on the automotive diesel oil (ADO) used for power generation in Luganville.

1.12 The franchise contract with UNELCO, the private power supplier in Port Vila and Luganville, provides for a Government counterpart in regulatory matters, namely the Electricity Commissioner. This position has not been filled, and the resulting simultaneous involvement of different counterparts on the Government side contributes to a lack of Government leverage vis-a-vis the supplier. Similarly, the nomination of a Government representative on UNELCO's board, an entitlement since the recent purchase of 10% of UNELCO equity by the Government, has taken a long time to materialize. In view of the Government's intention to increase its share to 30% in future, the appointment

of both the Electricity Commissioner and the Board Member are essential early steps to assert the regulatory responsibility. In contrast, the lack of electricity supply legislation is not a key obstacle as the system is small and simple. The best hope for an improvement in the efficiency of regulation lies in the full use of the instruments already at the Government's disposal, such as the appropriate consultation and reporting clauses in the franchise agreement, or the Government's shareholder rights in the supply company.

1.13 The import and distribution of petroleum products is handled by Shell, Mobil, and BP, with the exception of some direct imports for Government use. The market is small and competition between suppliers is limited. Boral Gas Co. operates a modest distribution system for LPG for urban household use. Petroleum product suppliers are not subject to regulation or legislation with the exception of normal business licensing procedures.

## II. ENERGY CONSUMPTION

### The Structure of Energy Consumption

2.1 Total energy consumption in Vanuatu is estimated at about 57 mtoe for 1989. This represents a decrease in the net domestic consumption as compared to the 1985 estimate of about 70 mtoe. The primary reason for the decline is the drop in copra production and the simultaneous improvement in the energy efficiency of copra drying3/. Of the total national consumption, approximately 70%, or about 40 mtoe, is comprised of biomass based fuels of which the primary component is fuelwood used by the domestic sector for cooking. The other major component of energy consumption is petroleum based fuels accounting for about 16 mtoe. Of this, about 13 mtoe, or approximately 80%, is utilized in the transport sector either in the form of gasoline, automotive diesel or lubricants. Approximately 6.7 mtoe of ADO is consumed by the utility sector to generate electricity. The net electricity available for consumption is equivalent to about 2 mtoe after accounting for conversion, transmission and distribution losses. A summary of the estimated 1989 Vanuatu energy balance and a graphical illustration of sectoral energy consumption is presented in Annex 2.1.

2.2 Domestic Sector: The domestic sector accounts for the largest component of energy consumption, equivalent to approximately 46% of the national total. Of the total annual domestic (household) sector consumption of about 26 mtoe, 95% is biomass based fuels, 3% is petroleum fuels in the form of kerosene and LPG, and only 2% is electricity. The electricity consumption is almost exclusively limited to expatriate and high income urban households in the Port Vila and Luganville service areas. A very small fraction of rural center electricity is produced but data on energy consumption and sectoral consumption for these rural centers are not presently available. The estimated total domestic sector energy consumption increased approximately 18% since 1983 which is equivalent to the increase in total population during this period.

2.3 Agricultural Sector: The agricultural sector accounts for the next largest component, equivalent to 26% of the total annual national energy consumption. The majority of the energy consumed by the agricultural sector is in the form of biomass fuels used for crop drying. An undetermined but small quantity of petroleum fuels is also consumed in the agricultural sector for process heat and electricity generation. The petroleum used for process heat is used to supplement crop drying in the copra and coffee processing operations of the large estates. Petroleum used for electricity generation is primarily for household consumption of estate managers and supervisory employees and, in some cases, to operate crop drying equipment. Petroleum is

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3/ It is estimated that 65 percent of the copra produced for export is now dried using "hot air" driers fueled with wood, husks and shells. In 1983, only 15 percent of the copra was dried with hot air driers. Hot air driers require approximately half the biomass fuel used by traditional smoke driers.

also used in the agricultural sector for freight transport and crop harvesting equipment.

2.4 Transport Sector: The transportation sector, which consumes petroleum fuels exclusively, accounts for about 12 mtoe or approximately 21% of total energy consumption. Of the total fuel consumption in the transport sector, ADO accounts for 60%, gasoline for 34%, aviation fuel for 4% and lubrication oils for 2%. Energy consumption in the transport sector is estimated to have increased by approximately 70% since 1983.

2.5 Commercial and Industrial Sector: The commercial sector is estimated to have consumed 2.3 mtoe in 1989, primarily in the form of petroleum products and electricity. Energy consumption in the industrial sector is estimated at 1.4 mtoe. The combined energy consumption of the commercial and industrial sector represent less than 7% of the total national energy consumption, an increase from the approximately 2% of total national energy consumption in 1983.

## The Consumption of Petroleum Products

2.6 Vanuatu imports all of its petroleum product requirements consisting of aviation gasoline (Av Gas), gasoline, kerosene, automotive diesel oil (ADO) and LPG for internal consumption and jet fuel for re-export to international airlines. Until 1986, industrial diesel oil (IDO) was also imported for re-export to a foreign-owned, Santo-based, fishing company (South Pacific Fishing Company) which has, since then, ceased its operations. As indicated in Table 2.1, between 1985 and 1990 the demand for aviation gasoline and ADO increased by almost 50% on account of increased power generation and transport sector activities. During the same period the demand for gasoline and LPG has remained static, possibly due to high prices of these commodities.

Table 2.1: PETROLEUM PRODUCT IMPORTS

| | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 |
|---|---|---|---|---|---|---|
| | (megaliters) | | | | | |
| AV Gas | 0.72 | 0.58 | 0.48 | 1.00 | 1.10 | 1.10 |
| Gasoline | 6.52 | 6.11 | 5.67 | 5.32 | 5.24 | 5.28 |
| Kerosene | 0.96 | 0.84 | 0.84 | 0.92 | 0.96 | 1.01 |
| ADO | 12.66 | 13.57 | 14.90 | 6.25 | 17.88 | 18.66 |
| LPG | 1.29 | 1.25 | 1.13 | 1.22 | 1.18 | 1.28 |
| Total Internal Demand | 22.15 | 22.35 | 23.02 | 24.71 | 26.37 | 27.33 |
| IDO | 5.60 | 3.19 | - | - | - | - |
| Jet Fuel | 5.00 | 3.16 | 4.09 | 4.83 | 5.56 | 5.01 |
| Total Re-export | 10.60 | 6.35 | 4.09 | 4.83 | 5.56 | 5.01 |
| Total Demand | 32.75 | 28.70 | 27.11 | 29.09 | 31.93 | 32.34 |

Source: Ministry of Trade, Commerce, Cooperatives, Industry and Energy, and Petroleum Marketing Companies.

2.7 The transport sector is by far the largest user of petroleum products accounting for over 68% of the total imports, with power generation accounting for about 23%, industrial and commercial usage for 5%, and household consumption for 4%. Of the ADO imports, about 56% is used in transport, 40% for power generation and 6% in mechanized agriculture and industrial steam-raising. LPG is used in restaurants and affluent households in the cities of Port Vila and Luganville. Table 2.2 indicates the approximate sectoral consumption on the basis of 1989 imports.

Table 2.2: SECTORAL CONSUMPTION OF PETROLEUM PRODUCTS (1989)

| | Transport | Generation | Households | Others /a | Total |
|---|---|---|---|---|---|
| | ('000 toe) | | | | |
| Av Gas | 0.80 | - | - | - | 0.80 |
| Gasoline | 4.09 | - | - | - | 4.09 |
| Kerosene | - | - | 0.79 | - | 0.79 |
| ADO | 8.72 | 6.11 | 0.72 | | 15.55 |
| LPG | - | - | 0.15 | 0.60 | 0.75 |
| Jet Fuel | 4.61 | - | - | - | 4.61 |
| Total | 18.22 | 6.11 | 0.94 | 1.32 | 26.59 |

/a Industry, hotels, and restaurants.

Source: Ministry of Trade, Commerce, Cooperatives, Industry and Energy.

2.8 The Government's development plans include the opening of a new international airport4/ and improvement of harbor facilities at Port Vila to promote tourist trade and to facilitate berthing of larger tankers (medium range vessels) so as to reduce the cost of petroleum imports; expansion of agro-based industries; and the promotion of exploration for hydrocarbon and geothermal resources. These developments will lead to increased demand for petroleum products (Table 2.3).

4/ By mid-1992, the airport was in operation.

Table 2.3: PETROLEUM PRODUCTS DEMAND PROJECTIONS

| | 1991 | 1995 | 2000 |
|---|---|---|---|
| | ('000 toe) | | |
| AV Gas. | 1.21 | 1.21 | 1.28 |
| Gasoline | 5.38 | 5.83 | 6.43 |
| Kerosene | 1.03 | 1.11 | 1.23 |
| ADO | 19.59 | 23.81 | 30.38 |
| LPG | 1.30 | 1.41 | 1.56 |
| Jet Fuel | 5.16 | 5.80 | 6.73 |
| Total | 33.58 | 39.17 | 47.61 |

Source: Mission Estimates.

2.9 These estimates are based on the assumptions that (a) the demand for ADO for the transport sector will grow at an average rate of 5% per annum over the next ten years, (b) the demand for gasoline, LPG, AV Gas and kerosene will follow the anticipated GDP growth rate of 2-2.25%, and (c) the demand for jet fuel will grow at an average rate of 3% per annum.

The Consumption of Electricity

2.10 Electricity is used primarily as a source of lighting and small appliances in the middle-income households and for lighting, cooking, air conditioning and small and large appliances in the high-income households. Household electricity consumption is limited to urban areas and consequently accounts for only a small part of the total consumption: Commercial consumers, particularly the hotels and tourist resorts, [and Government offices] are major electricity consumers in Vanuatu (Table 2.4). Given the present relatively high cost of electricity, there is only limited potential for the growth of electricity consumption in the household sector outside the main urban areas.

Table 2.4: PATTERN OF ELECTRICITY CONSUMPTION

| Category | Consumption in 1989/90 /a | |
|---|---|---|
| | MWh | % total |
| Low Voltage | | |
| Domestic | 1,050 | 4 |
| Other Small Users | 7,280 | 28 |
| Industry | 5,280 | 21 |
| Public Light | 260 | 1 |
| High Voltage | 11,950 | 46 |
| Total | 26,000 | 100 |

Source: UNELCO

/a Based on UNELCO data for Port Vila and Luganville which has been adjusted to include small rural-based supply systems.

2.11 Electricity sales in Port Vila, the biggest load center in Vanuatu, have increased from 14,727 GWh in 1982/83 to 22,220 MWh in 1989/90, i.e., an average annual growth rate of about 6%5/. However, the growth rate has been uneven in the past with negative growth being registered in 1985/86 and 1986/87, followed by over 20% growth in 1987/88 which, however, declined to 6.7% in 1988/89 but recovered to 12.1% in 1989/90 (Annex 2.2). The erratic growth of electricity consumption in the past is largely due to the impact of the high voltage consumers (mostly hotels and commercial establishments) who account for about half of the total consumption in Port Vila and whose offtake of electricity is governed by external factors, primarily tourism.

2.12 In the other major load center of Luganville, there has been virtually no significant growth in electricity consumption since 1982/83 and the total sales have stagnated in the range of 2,000 to 2,500 MWh. The annual variations reflect the actual offtake of the two largest consumers - a saw mill and an abattoir whose combined load (about 560 kW) almost equals the system maximum demand (about 600 kW).

2.13 In other areas, mostly rural in character, the consumption of electricity is insignificant compared with that of either Luganville or Port Vila. The population is very widely dispersed, the population of each village is mostly less than a hundred, and there are no sizable population centers. Therefore, establishment of island-wide power systems is not appropriate and

5/ The statistics available from UNELCO, which accounts for virtually the entire electricity consumption, are based on years beginning 1 October and ending 30 September.

small generating facilities are installed at separate demand centers. It is estimated that about 50 small diesel generators of 3.5 to 85 kW in capacity are already operated by a number of government agencies for use in government centers. PWD owns some rural power systems in Malakula and Tanna islands, which are operated part time only, for 3 to 12 hours daily (depending on availability of the fuel budget, and the consumer groups connected to the grid) to supply power to government offices and quarters, schools, hospitals, etc. Supply to local communities is limited. Though the operating cost varies considerably depending on the respective costs of diesel, operating load factor, etc., expenditure much exceeds the income based on the usual 25 Vatu/kWh tariff and there is little or no incentive to operate the system efficiently. Equipment is not well maintained and the operating efficiency is low.

2.14 There are also private generating facilities (diesel generators) for coconut processing plants, saw mills, institutions and individuals. Power is used for plant operation, domestic use by staff, churches, communities and others. Electric power is essential for their production processes, and therefore the condition of generating equipment of private operators is much better than that of government-owned equipment.

2.15 UNELCO's projections indicate that its system peak load in Port Vila will increase from about 5.6 MW in 1991 to about 10 MW by the year 2000, an average annual load growth of 7%. Its projections for Luganville also assume 7% load growth. UNELCO projects Luganville's peak load to increase from about 0.6 MW in 1991 to about 1.1 MW by 2000. While UNELCO's load projections for Port Vila appear to be realistic, there is less certainty about the projected Luganville demand growth unless the planned industrial estate takes off and the distribution system is extended to the nearby rural communities. Vanuatu's electricity consumption is forecast to increase from about 28 GWh in 1991 to 50 GWh in 2000 (Annex 2.3), primarily in Port Vila as there is little incentive for UNELCO to extend service to peri-urban communities.

## The Consumption of Biomass Fuels

2.16 Domestic Cooking: Total consumption of biomass fuels in 1989 is estimated at 40 mtoe. Of this total, fuelwood comprises 70% while agricultural residues, primarily coconut husks and shell, make up the remainder. Fuelwood continues to be the primary source of fuel for cooking in both the rural and urban low-income households of Vanuatu. There have been no accurate estimates or surveys of household energy consumption in Vanuatu. However, assuming an average annual domestic consumption of 500 kg/capita/annum results in approximately 73,000 tons of fuelwood consumption per annum or 25 mtoe/yr nationally. In addition, some small amounts of coconut husk and shells are used as cooking fuels primarily by rural households. In most cases, these "agricultural residues" account for less than 5% of the total biomass fuel consumption in the household sector.

2.17 Crop Drying: Energy is used extensively for crop drying especially on the large estates producing copra, cocoa and coffee. Copra exports in 1989 amounted to about 25,000 tons while that for cocoa was about 1,500 tons. Copra is dried in Vanuatu primarily by two methods. The traditional method has been by open-fire "smoke driers" which consumes approximately 2.5 tons of husk and shells per ton of dried copra. Until the early 1980s, the smoke-

drier method was the predominant means of copra drying in Vanuatu. This method leads to an inferior quality product which contributed to depressed prices for Vanuatu copra and a significant decline in copra production (Table 2.5). Since 1981, there has been an active government program in Vanuatu to convert the majority of copra drying to the more efficient method using "hot-air driers" which also results in a higher quality copra. The hot-air driers require between 1.0 and 1.25 tons of fuelwood or husk and shells per ton of dried copra. By 1989 it is estimated that approximately 65% of Vanuatu's copra production was dried by hot-air driers. Due to the better performance of hot-air driers with fuelwood, copra factory managers indicate that approximately half of their biomass fuel requirements were met with fuelwood while the other half was made up of waste husks and shells. As a result, about 3 mtoe of fuelwood is estimated to be used for copra drying especially by the larger estates in Vanuatu. The remaining fuel is provided by waste husks and shells which amount to approximately 11 mtoe.

2.18 Cocoa is the second most important agricultural export of Vanuatu. Cocoa exports have increased from 868 tones in 1981 to 1538 tons in 1989 (see Table 2.5). Cocoa plants are generally inter-cropped with coconut trees on large plantations. Cocoa in Vanuatu is dried using primarily solid fuel burners which force hot air over flat bed driers. It typically requires approximately one ton of biomass fuels to produce one ton of dried cocoa6/. Most cocoa driers are fueled with a combination of fuelwood as well as coconut husks and shells. No specific data exists on the exact use of these fuels in Vanuatu. Based on interviews conducted by the mission, it was estimated that approximately 20% of the total energy used for cocoa drying was obtained from fuelwood. Thus the total biomass energy used for cocoa drying was estimated at 0.52 mtoe of which 0.10 mtoe consisted of fuelwood.

Table 2.5: COPRA AND COCOA PRODUCTION - 1981 TO 1989 (TONS)

| Year | Copra | Cocoa |
|---|---|---|
| 1981 | 46,474 | 868 |
| 1982 | 34,256 | 528 |
| 1983 | 37,903 | 1,297 |
| 1984 | 47,759 | 782 |
| 1985 | 38,806 | 967 |
| 1986 | 41,798 | 1,281 |
| 1987 | 36,346 | 1,168 |
| 1988 | 29,559 | 756 |
| 1989 | 24,906 | 1,538 |

Source: Vanuatu Office of Statistics.

6/ "Cocoa - Wood & Woody Biomass Use in the Agro-Industries", Rural Development Series Handbook, RDSH No, 19, Department of Minerals and Energy, Papua New Guinea.

Consumption Outlook

2.19 Over the next 10 years, Vanuatu's consumption of commercial fuels (petroleum products and electricity) is likely to increase substantially, driven by the use of diesel (ADO) throughout the country, and electricity in Port Vila. The tourism and transport sectors are likely to be the driving forces behind the increase. On the other hand, the trend of declining biomass use in agriculture (particularly in the export crop production of copra and cocoa) will reduce the share of biomass in overall energy consumption, as domestic fuelwood use can be expected to increase only slowly: gradual penetration of other cooking fuels may hold the rate of increase of fuelwood use slightly below the population growth rate. On balance, Vanuatu will

## III. ENERGY SUPPLY

### Petroleum Procurement and Distribution

3.1 All petroleum products are imported and marketed by four international companies namely, Shell, BP, Mobil and Boral, who obtain the supplies from Australia and Singapore. The import and marketing of LPG is handled entirely by Boral which does not deal with any other petroleum product. The products are imported through the two major ports of Port Vila (Efate Island) and Luganville (Santo Island) with Port Vila receiving about 70% of the total. Port Vila cannot receive medium range vessels (MRVs)7/ due to harbor limitations8/ and Luganville, although possessing adequate harbor capability for receiving MRVs, lacks sufficient demand9/ for MRV-size cargo. Therefore both the ports receive the supplies through local coastal tankers10/ (LCTs) via Suva (Fiji) and Noumea involving payment of entrepot fees; together with the longer routing, this results in an increase of 3-6 Vt/liter in CIF costs.

3.2 The companies have adequate storage facilities (covering over 3 months' demand) in Port Vila and Luganville. The facilities for ground fuel storage in Port Vila are owned by Mobil and BP with Shell sharing Mobil's facilities. Those in Luganville are owned by Shell and shared with Mobil. LPG storage facilities and terminals at Port Vila and Luganville are owned and operated by Boral; LPG is bottled at the terminals. The storage facilities for aviation fuel in Port Vila and Luganville are owned by BP which shares its Port Vila facility with Shell. The Government has its own storage (for gasoline and ADO) at Port Vila, Luganville, Lakatoro (Malakula Island) and Isangel (Tanna Island). The marketing companies have no storage facilities in islands other than Efate and Santo.

3.3 Gasoline, diesel and kerosene are retailed in Port Vila and Luganville through the service stations owned by Shell, BP and Mobil and through other locally owned outlets. Other localities in Efate and Santo and the outer islands are supplied by local dealers who transport the products in 200 liter steel drums. The return shipment of empty drums is a major problem as the transporters do not find sufficient profit in such cargoes. Sale of aviation fuels in Port Vila, including re-export11/, is handled by BP and

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7/ Minimum 20,000 ton capacity.

8/ Although the harbor itself is 30 meters deep, its approach channel is shallow.

9/ Since the cessation, in 1986, of Santo-based South Pacific Shipping Company.

10/ Up to 2,000 ton capacity.

11/ On the basis of contracts negotiated with the airlines, no import duty is payable, a throughput fee of 0.2 Vt/liter is paid to the Government.

Shell and in Luganville by BP alone. Retailing of LPG is managed by Boral or by Speed-e-Gas, a subsidiary of Boral.

3.4 Large consumers such as UNELCO are supplied on the basis of negotiated bulk supply contracts. The petroleum products for the Government's own use (17% of the total imports) are procured on the basis of international competitive bidding.12/ This tendering process and subsequent contracting has steadily improved with the assistance of the Pacific Energy Development Program resulting in increased competition and reduced landed costs. An issue of high distribution margins remains however (para. 4.14).

Power Subsector

3.5 The public electric power supply in Vanuatu is entirely based on ADO and is operated at 50 Hz. It is dominated by UNELCO's two urban-based systems. At present UNELCO's power systems cover Port Vila on Efate Island, the capital and the biggest load center, and Luganville on Santo Island, the second largest urban center in the country. In other areas there are about 100 small and isolated diesel-based supply systems. UNELCO operates a diesel power station in Port Vila with a total installed generating capacity of 8,540 kW (Annex 3.1). Port Vila's system peak load in January 1991 was 5,640 kW. Its distribution system comprises about 70 km of 5.5 kV primary lines and about 130 km of 380/220 V secondary lines. By the end of December, 1990, UNELCO had about 3,000 consumers connected to its Port Vila system with a total connected load of 17,256 kVA. Of the 3,000 consumers, Domestic category accounted for about 33% of connections, other low voltage users for 52%, Industrial for 13%, and High Voltage consumers and Public Lights, 1%. During the period 1989/90, UNELCO generated 22,976 MWh and its sales to the ultimate consumers was 22,220 MWh. The system losses including station use accounted for about 6% of the total generation.

3.6 In Luganville, UNELCO has a diesel power station with a total installed generating capacity of 1,080 kW (Annex 3.2)13/ with an annual peak load of 630 kW in 1990. Its distribution system in Luganville comprises 17.8 km of 5.5 kV primary lines and 18.7 km of 380/220 V secondary lines. By the end of December 1990 there were 578 consumers connected to the utility - 274 Small Domestic (48%), 164 Other Low Voltage Users (28%), 133 Commercial (23%) and 7 High Voltage (1%). UNELCO has reported a total generation of 2,507 MWh during the period July 1989 through June 1990 and corresponding sales of 2,421 MWh. The system losses inclusive of the station use on the basis of these figures work out to only 3.43%. Such a low loss figure is attributed to, besides possible metering errors, the fact that the high voltage consumers, particularly the saw mill and the abattoir, account for the bulk of Luganville sales. In addition, as stated earlier, there are about 100 small diesel generators in isolated rural areas with unit ratings ranging from

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12/ Mobil holds the current contract awarded for a two year period expiring July 4, 1991. It is based on 50% spot and 50% posted price at Singapore.

13/ By mid-1992, the capacity had increased to 2,000 kW.

3 to 100 kVA. Their total capacity is, however, insignificant compared with that of UNELCO. The units are 15 to 30 years old and are in very poor condition with very low operational efficiency and reliability due to insufficient and infrequent maintenance. In addition, because of their isolated location, the ADO supplies provided to these generators, which are not always available when needed, carry a high transport premium.

Future Power System Expansion

3.7 The near-term system expansion program of UNELCO envisages retiring the old diesel units in Luganville which were installed in the 1960s and replacing them with a 1,000 kVA diesel unit by July 1991.14/ As a longer-term proposition UNELCO has also applied to GOV for the right to develop the Sarakata small hydropower project near Luganville (about 1 MW). Once the hydropower project is commissioned UNELCO proposes to keep the diesel plant as an emergency standby. GOV is, yet to respond to UNELCO's application. For meeting the projected increase in load in the medium term in Port Vila, UNELCO is planning to add a diesel unit with a rated capacity of 2,170 kW in 1992 at an estimated cost of $2 million. To meet the projected load growth on Efate in the 1990s, there are, besides the diesel, alternative generation options - hydropower in the medium-term, and geothermal in the longer-term. These, however, need to be studied further to establish their technical feasibility and economic viability.

3.8 The small hydropower potential in Vanuatu can be classified into two categories, namely (i) the relatively large-scale ones for supply to the urban power systems of Port Vila and Luganville, and (ii) the minor ones for rural supply in remote areas. Two hydropower projects, the Teouma river project on Efate for Port Vila, and the Sarakata river project on Santo for Luganville belong to the former category (Annex 3.3). The development scale envisaged in the past studies is 1,200 kW for the Teouma project and 600 to 6,400 kW depending on the prospective utilization of the available head and discharge for the Sarakata project.

3.9 Based on the findings of the mission's site visit, the Sarakata project appears more likely to be economically attractive than the Teouma project in view of the larger available discharge, easier access, shorter waterway for the same head, and greater ease of installation of the waterway, factors which contribute to cheaper construction costs. Both projects are situated on limestone blocks and therefore need a thorough geological investigation before their costs can be realistically estimated.

3.10 The results of past prefeasibility studies indicate that the economic feasibility of the Teouma project is marginal and may only become viable at much higher oil prices. From similar studies, the Sarakata project appears to be far more promising, particularly if it is developed for a minimum 1,000 - 1,200 kW capacity. The latter would be justified only if the

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14/ By mid-1992, UNELCO had not replaced the old diesel units, but had added a 920 kW diesel unit.

demand in Luganville exceeds the 800 to 1000 kW level. In this context, it has been proposed to interconnect the Luganville system with nearby Malakula island. The interconnection with Malakula is not likely to be economically viable as the distance to Norsup, the largest load center, is 70 km from Luganville, including a 15 km submarine section, while its maximum demand is only about 100 kW.

3.11 Recently, the Japan International Cooperation Agency (JICA) has agreed to carry out a detailed feasibility study of the Sarakata project, scheduled to begin in 1991. GOV proposes to respond to UNELCO's application for development of the project after the results of the JICA study become available. If the JICA study indicates that the project is viable, GOV would consider its implementation, possibly by a joint development company (HPD). Implementation of this project should only start if it becomes clear that Luganville demand will resume growth beyond 1 MW maximum demand. Until then, the new diesel plant will provide adequate generating capacity.

3.12 The current demand for electricity in the individual rural centers, which are widely dispersed, is very small, rarely exceeding 20 kW. This makes even micro-scale hydro developments uneconomic in most cases. However, the Brenwe/Unmet hydropower project on Malakula Island, could be an exception (Annex 3.4). Further detailed studies should be carried out to establish its viability compared with other options such as small diesel or copra processing-based co-generation for meeting the combined demands of Norsup and Lakatoro towns, the most important regional centers after Luganville.

3.13 Preliminary investigations carried out by the Department of Geology and Mines indicate that there could be significant potential for electricity generation from geothermal energy on Efate Island. However, further investigations to establish the technical and economic viability of this potential resource need to be carried out before any investment decisions can be taken. An initiative of the Department of Geology and Mines to conduct exploration drilling for the final phase of the resource assessment on Efate is in progress. It is recommended that two exploration bore holes of depths between 1,000 to 1,500 feet be drilled, and that GOV seek either private financing or the assistance of multi-lateral institutions to finance the related exploration costs estimated at about US$4 million. Care should be exercised to ascertain first whether significant private interest in geothermal exploration and development can be mobilized, given the modest demand levels in Efate.

3.14 Wind-based generation might also prove to be a viable option in the longer term. At present, there is not much data on the potential for wind energy in Vanuatu. Stand-alone wind generators for isolated rural areas are unlikely to be cost effective. However, grid connected systems in the Port Vila and the Luganville areas, if viable wind regimes exist, could eventually provide opportunities for partial displacement of diesel-based generation. For the isolated rural centers, decentralized systems based on solar energy or agroindustrial cogeneration using biomass should be compared to the ADO-based electricity supply (paras. 3.17-3.23).

Biomass Potential

3.15 Fuelwood: The primary source of fuelwood in Vanuatu is from the natural forests. There are some estimated 900,000 ha or 75% of the nation's land area under natural vegetation.15/ Preliminary surveys of the natural forests indicate between 15-25 $m^3$/ha of useful timber but do not provide any estimate of total volume of wood per hectare. Assuming a net annual growth of 10 $m^3$/ha/yr in Vanuatu translates to approximately 9 million $m^3$/yr of wood. This is equivalent to approximately 6.3 million tons of wood/yr or over 80 times the current estimated annual consumption of fuelwood in Vanuatu. Assuming that only 10% of annual forestry growth is available for fuelwood, consumption still results in a total supply of approximately 214 mtoe/yr. Thus, there does not appear to be an immediate shortage of fuelwood in Vanuatu, especially in the rural areas. In the urban centers of Port Vila and Luganville, where 18% of Vanuatu's population is located, fuelwood is beginning to appear in the marketplace, possibly as an indication of the onset of diminishing freely available supply sources in the vicinity of these urban centers. Data on forest inventories and, in particular, urban fuelwood supply sources, is not available, making difficult any projections of future prospects for urban fuelwood supply.

3.16 Biomass Residues. While the bulk of biomass supply (more than 200 mtoe per year) comes from net growth of fuelwood, several sources of forestry and plantation residues add to the available biomass (Annex 3.5). Sawmill and logging residues amount to about 12 mtoe, priming and thinning yields from forestry plantations provide about 0.5 mtoe, and coconut residues and senile stemwood yield about 87 mtoe. The total potential supply of biomass for energy purposes, therefore, is more than 300 mtoe per year, compared to current annual consumption of about 40 mtoe. No general biomass supply constraint is evident.

Biomass Gasification

3.17 A successful small-scale biomass gasification projects is located at Onesua High School in north Efate. The system is a 15 kWe modified "BECE" power gasifier fueled by wood obtained from local Eucalyptus plantations. Labor for the system is provided by the students of the school. The system was installed in December 1986 under the EEC funded Lome II energy program. During the plant's first year of operation it was reported to have saved approximately US$7,000 in diesel fuel costs, equivalent to about 10% of the school's total annual operating budget. By the end of the second year the plant had logged over 5,000 hours of operation producing 57,000 kWh of electricity from 123.5 tons of dried fuel (or equivalent to 2.17 kg/kWh). This represented an average utilization factor of 29% and average load of 11.4 KW.

3.18 The economics of a typical potential biomass gasifier system for Vanuatu is presented in Annex 3.5. The analysis indicates that the 25 kWe biomass gasifier system, if manufactured locally in Vanuatu, could conceivably

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15/ Source: "Republic of Vanuatu - Second Development Plan:1987-1991"

be financially and economically competitive with a diesel electric generating system under the right circumstances. At present a 25 kWe diesel generator produces electricity at financial cost of approximately 75 Vt/kWh and an economic cost of 60 Vt/kwh. The imported gasifier system results in financial and economic costs of electricity of 89 Vt/kWh and 83 Vt/kWh respectively. If manufactured locally, the total capital cost of the gasifier could perhaps decline to the diesel level. If the diesel price rises above 130 Vt/l, even the higher cost imported biomass gasifier may become competitive.

3.19 Even with the relative success of the biomass gasifier project at Onesua, careful evaluation of the necessary organizational and institutional requirements to support successful gasifier projects like that at Onesua must be carried out prior to a commitment for wider scale dissemination.16/ Many biomass gasifier projects have been attempted in the Pacific and elsewhere and have failed because of a lack of the necessary considerable organizational and institutional support. The relative success of the Onesua project can be traced to a dedicated and well trained technician and above normal technical support for the project as it was carried out under a grant demonstration program.

Biomass Co-generation

3.20 The abundant availability in Vanuatu of potential biomass fuels, primarily wood and coconut husks, shells and stemwood, as well as the need for process heat for copra drying, could present the opportunity for biomass co-generation systems especially at large-scale copra estates located near a medium sized urban centers that are presently provided electricity through diesel generation. One such possibility exists on Malakula Island near Lakatoro. At present, Lakatoro is serviced by a 70 kVa diesel generator which operates approximately 12 to 14 hours a day. Energy supply in the area is severely limited by the small size of the Lakatoro diesel plant. In addition, small diesel generators are used to supply a local school, hospital and the staff of the nearby large copra estate. Potential demand for electricity in the Lakatoro area is estimated to be approximately 1 MWe. At present, diesel generation is the only alternative being considered. Opportunities for small hydro have been identified on Malakula but have not been adequately assessed to date to determine technical and economic viability. Given the availability of biomass fuels in the vicinity of the Lakatoro area and the need for process heat for copra and cocoa drying at the large estate, the possibility for a biomass co-generation system should be considered seriously. A proposal by the copra estate exists that offers to supply the community together with its own needs for drying, currently met by the use of residue from copra production. The supply price to be proposed by the estate should be compared to the cost of supply from expanded diesel generation and the proposed mini-hydro plant.

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16/ By mid-1992, the Government had plans to provide gasifiers to several schools.

Solar Energy

3.21 Solar energy represents the largest potential source of energy in Vanuatu. The annual average solar insolation in Vanuatu ranges from 2,000 to 2,300 hours at an average intensity factor of 6 $Kwh/m^2/d$. A 10% conversion efficiency of solar energy to electricity results in an equivalent of approximately 535 toe/ha/yr which is over 10 times more than the biomass energy equivalent produced by a managed plantation yielding 20 $m^3/ha/yr$.

3.22 The heat from direct solar energy is presently utilized to a certain extent in Vanuatu. The most predominant use of solar energy is for some copra and cocoa drying, primarily by small-holders. Another increasing use of direct solar energy in Vanuatu is for hot water heating primarily by high-income households both in the urban and rural areas. The alternative for hot-water heating in these homes is either electricity or LPG. At current costs for electricity and LPG, solar hot-water heaters are more cost effective and as a result have been widely adopted in the domestic sector. Opportunities for use of solar hot-water heating still exist in the commercial sector, especially for hotels and hospitals, where they can be used in conjunction with conventional water heating systems to reduce overall energy costs. The potential for photovoltaic electricity is not yet large, as comparative costs are high (Annex 3.5). However, at high delivered kerosene and diesel prices in remote areas, PV lanterns can become competitive above Vt 80/l diesel. PV systems also depend on the availability of spare parts such as controllers, batteries, etc., and their reliability may not be better than diesel supply or kerosene lighting if this is a problem.17/

3.23 It appears that biomass-based and solar energy supply could be competitive under certain circumstances in areas where petroleum product supply is difficult or expensive. Where gasifier options are considered, a careful evaluation of the sustainability in institutional terms is required. Biomass cogeneration or PV community supply systems should be tested for their attractiveness for private investors.

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17/ By mid-1992, the Government had received assistance from several organizations to speed the dissemination of PV lighting in rural areas, targeted at schools, clinics and other institutions.

# IV. POLICY ISSUES

## Environmental Issues

4.1 The limited extent of energy sector development to date has resulted in some improvements in the living environment while not producing significant detrimental environmental impacts. Nevertheless, the expansion of development activities and the fast growth of the country's population means that energy related environmental problems are a real future prospect, unless energy development is placed on a sound basis of environmental assessment and planning.

4.2 GOV has a policy for protection of the environment, and a certain amount of legislative power in this respect. Institutional provision has been made through a Department of Physical Planning and Environment which, among other things, has oversight of environmental assessment (mostly in the form of environmental impact assessment) of development activities. It is also the lead agency in the preparation of a national conservation strategy. Particular emphasis is given in GOV policy to protection of the marine environment, from which are taken the seafoods which constitute an important component of ni-Vanuatu diet.

4.3 One aspect of the social environment is of special importance in Vanuatu -customary ownership and use rights in areas subject to development projects. GOV efforts to make legal provision for an appropriate measure of benefits for landholding groups which make customary land and sea areas available for energy sector activities will be essential for the orderly development of the sector.

4.4 Petroleum Products and the Environment: The siting of Vila's petroleum storage is a matter of considerable local concern, not least because of the hazard which it poses for nearby residents. The storage facility predates recent squatter settlement and resolution of the problem lies in firm and effective town planning decisions. The prospect of marine pollution arising in the course of incidents involving tankers in Vanuatu waters, and with ship-to-shore transfers, is a matter which requires preemptive planning. Particular care is needed in the handling of imported petroleum products so as to minimize harm to the environment in the event of spillages. Some precautions are being taken by the companies concerned. This is not, however, backed by the legislation and environmental protection equipment needed to deal with spills. If GOV's marine protection objectives are to be met, such legislation should require oil companies to have oil spill contingency plans, equipment to deal with spills and staff trained to deal with such circumstances. The marine environment of proposed alternative sites for petroleum product storage is characterized by clear, unpolluted water, corals and seagrasses. These sites are well protected and any spills would not quickly disperse. A new storage facility should be subject to full environmental assessment.

4.5 Electricity Production: Diesel generating sets currently in operation in Vanuatu generate a measure of air, water and noise pollution. The resulting impacts are at present minimal. Even so, it is important that GOV firmly establish good environmental practice in and about diesel generating plant and so preempt the possibility of later problems. The general environmental circumstances of two priority hydro prospects were considered. Preliminary inspection suggests that since the catchment of the Sarakata (Santo) site carries forest cover which has been subjected to considerable disturbance through shifting cultivation, its natural values for conservation have probably been substantially reduced. The site at Teouma (Efate) is apparently much less disturbed. Both streams would experience reduced flows in streambeds between intake structures and the point at which water would re-enter the natural system downstream. In line with GOV policy these and other environmental changes would require environmental assessment before implementation is considered.

4.6 Biomass and the Environment: Fuelwood is extensively used by both rural and urban households. This is mostly obtained by collecting wood from secondary forest, particularly old food garden areas. Some areas are now experiencing shortages. To ensure continued availability of fuelwood supplies in future, it would be advisable to encourage smallholder woodlots. Environmental consequences of not doing this could be depletion of biodiversity in pockets of remaining natural vegetation and increased soil erosion and landslips on steep land from which vegetation is removed. This could adversely affect other sectors such as agriculture and fisheries. Industrial scale biomass energy development schemes should be undertaken in close consultation with agriculture, forestry and environment agencies, and fully assessed in environmental terms.18/

4.7 Conclusions: There is limited provision for dealing with the environmental aspects of energy development in Vanuatu. These have not been seriously addressed in the various reports on proposed energy projects, nor does GOV yet have adequate capability in environmental assessment, or the administration of any new legislation.19/ Through the South Pacific Regional Environment Programme, there are growing opportunities to obtain the type of assistance required. The measures needed for addressing environmental matters in energy sector development include:

(a) Enact environmental assessment and planning legislation;

(b) Prepare a national oil spill contingency plan backed by legislation, trained personnel and pollution control equipment;

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18/ Guidance is provided by PEDP Reports REG 84-10: **Guidelines for Large Scale Fuelwood Plantations in the Pacific Islands** and REG 89-2: **Guidelines for Environmental Assessment of Energy Projects in Small Island Countries.**

19/ By mid-1992, the Government had taken some measures to reduce the lead content of motor spirit.

(c) Strengthen the capacity of Energy Unit staff to contribute to national development objectives by providing training which would fit them to better understand the environmental and social dimensions of their work;

(d) Address and act on the possible public health hazards associated with the energy sector, currently concerning disposal of lead and alkaline batteries;

(e) Utilize opportunities available through the South Pacific Regional Environment Programme for advice, training and other assistance regarding environmental aspects of the energy sector;

(f) Customary land tenure and rights to be sensitively considered and rights-holders given maximum opportunities for participation in assessments and monitoring;

(g) "Development benefit packages" for those groups and individuals who have valid customary rights in the area of a project;

(h) More far reaching analysis of the implications of energy pricing on natural resource use and the environment; and

(i) Provision for management of hydropower catchments with a view to maintenance of water quantity and quality and protection of biodiversity.

Energy Pricing Issues

4.8 Power Tariffs and Utility Finance: UNELCO's tariffs, which are now uniformly applicable in both Port Vila and Luganville are based on the relevant provisions of the Concession Agreement. The tariffs applicable for the fourth quarter of 1990 are summarized in Table 4.1.

Table 4.1: UNELCO'S TARIFFS FOR FOURTH QUARTER OF 1990
BASIC PRICE P = VATU 29.60

| Low Voltage - Domestic | Rate | Charges |
|---|---|---|
| Standing charge per kVA | nil | nil |
| 1st rate : 0 to 60 kWH | 0.65 P | 19.24 Vt/kWh |
| 2nd rate : 61 to 120 kWh | 1.00 P | 29.60 Vt/kWh |
| 3rd rate : 121 kWh & above | 1.70 P | 50.32 Vt/kWh |
| **Low Voltage - Other Uses** | | |
| Standing charge per kVA | 19 P | 562.40 Vt/kVA |
| kWh price | 1.00 P | 29.60 Vt/kWh |
| **Low Voltage - Businesses** | | |
| Standing charge per kVA | 20 P | 592 Vt/kVA |
| kWh price | 0.90 P | 26.64 Vt/kWh |
| **Low Voltage - Public Lighting** | | |
| Standing charge per kVA | nil | nil |
| kWh price | 0.80 P | 23.68 Vt/kWh |
| **High Voltage** | | |
| Standing charge per kVA | 25 P | 740 Vt/kVA |
| kWh price | 0.67 P | 19.832 Vt/kWh |

Note: The above charges are based on an average power factor of 0.80%. Should the power factor drop below 0.80%, the base price of electricity is increased by one per cent per hundredth of the average power factor below 0.80%. There is, however, no corresponding decrease in the base price if the consumer maintains higher-than-the stipulated power factor.

Source: UNELCO

4.9 All consumers are required to contribute to UNELCO's service connection costs. Such consumer contribution for the low voltage consumers is 70% of the costs if the length involved is 300 meters or less and 90% if it exceeds 300 meters. High voltage consumers are, however, required to pay 90% of the costs of system extension, 50% before the start of the works and the balance before the supply is effected.

4.10 UNELCO's tariffs are adjusted every quarter based on a complex formula as provided under the concession.20/ Essentially the adjustments allow for variations in the following:

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20/ By mid-1992, the Government had started a study aimed at revising the tariff calculation mechanism.

(a) average overall wholesale price index published by the INSEE (French National Institute of Statistics and Economic Studies);

(b) average price of diesel oil ex-wharf Port Vila as per the last two delivery invoices received by UNELCO in the first three months of the six-month period preceding the adjustment period;

(c) amount of fees and excise taxes payable by UNELCO;

(d) number of kWh sold in the first twelve months of the fifteen-month period preceding the adjustment; and

(e) average daily wage earned by an unmarried laborer during the first three months of the six-month period preceding the adjustment.

4.11 Given the small market and the generally high costs prevailing in the other sectors of the economy in Vanuatu, electricity prices can be expected to be higher than elsewhere. On the other hand, UNELCO's technical operations are being conducted efficiently and economically, and the system energy loss and staffing levels are well within the industry standards. Nevertheless, UNELCO's tariffs are generally perceived to be higher than they need be even after allowing for a reasonable return on investments. Also, there appears to be no rationale for adopting French indexes for adjusting the power tariffs in Vanuatu. Since no detailed cost data are publicly available, it is not possible to quantify the actual costs and estimate appropriate tariff levels. In this connection it should, however, be noted that UNELCO is self-supporting and is able to generate adequate revenues internally or from commercial borrowing to finance all its system improvement and expansion projects. As the pricing formula is essentially a cost-plus one, there are no strong incentives for UNELCO to reduce costs, such as by minimizing their fuel price, or cutting labor cost.

4.12 In the context of attempting to reduce UNELCO's generation costs, the possibility of switch-over from ADO to Heavy diesel oil as fuel for generation from the larger-size units (1,000 kW and more) has been reviewed. However, such a fuel conversion is not expected to be cost-effective since the additional costs of handling and storage of another petroleum product (currently heavy diesel oil is not being imported by Vanuatu) and the equipment conversion costs will far outweigh the possible savings in the fuel costs, particularly in view of the limited quantities involved.

4.13 Petroleum Product Prices: The Government abolished price control in May 1989.21/ Since then the marketing companies and retailers have been free to set the prices. The cost structure of gasoline, ADO, kerosene and LPG as on Sept. 1986 and Sept. 1990 (before the recent Gulf War crisis) is given in Table 4.2.

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21/ By mid-1992, the Government had formulated plans to exert some controls on petroleum prices.

Table 4.2: PETROLEUM PRODUCTS COST STRUCTURE

| | Gasoline | | ADO | | Kerosene | | LPG | |
|---|---|---|---|---|---|---|---|---|
| | Sept 86 | Sept 90 | Sept 86 | Sept 90 | Sept 86 | Sept 90 | Sept 86 | Sept 90 |
| | Vt/liter | | | | | | Vt/Kg | |
| CIF | 22.60 | 25.90 | 18.2 | 26.02 | 18.95 | 26.57 | Na | 52.36 |
| Duty | 12.00 | 32.00 | 7.00 | 12.00 | 2.00 | 8.00 | 17.00 | 17.00 |
| Service Tax | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 |
| Wholesale Price | 47.13 | 80.50 | 41.42 | 61.50 | 36.30 | 65.50 | Na | Na |
| Retail Price /a | 55.13 | 87.70 | 47.42 | 67.00 | 41.30 | 70.40 | 122.00 | 164.00 |

/a In major towns only.

Source: Ministry of Trade, Commerce, Cooperatives, Industry and Energy.

4.14 While the CIF prices, during the period Sept. 1986-Sept. 1990, for gasoline, ADO and kerosene increased by 15%, 42% and 40% respectively, the wholesale prices increased by 60%, 48% and 80%. During the same period, wholesale margins (wholesale price less import duty, service tax and CIF price) for gasoline, ADO and kerosene increased by 135%, 66% and 150% respectively. It is likely that this can be attributed to the limited competition due to the small and remote market.

4.15 Two other factors are also contributing to high prices:

(a) The approach channel to Port Vila harbor (receiving about 70% of the total petroleum product imports) is not deep enough to allow medium range vessels (20,000 tons capacity) to carry the freight directly from the supply ports. Even the local coastal tankers (2000 ton capacity) can negotiate the approach channel only with a maximum of 900 tons of cargo. The products are therefore brought in only partially (40%) loaded local coastal tankers from Suva and Noumea involving additional expenditure in the form of entrepot fees and additional mileage, increasing the freight cost by 3-6 Vt/liter.

(b) Steel drums are used for the transportation of products from wholesalers' depots in Port Vila and Luganville to retailers on outer islands. This mode of transportation involves about 15% loss of product and about 20% loss of empty drums, resulting in an increase of about Vt 20/liter in the cost of the product.

4.16 A combination of several measures involving (i) improvements in infrastructure, (ii) increased competition, and (iii) enhanced monitoring of operations is required to control the escalation of petroleum product costs. Port Vila storage facilities should be made available to medium range vessels (MRVs). Since about two thirds of the country's product imports are received at Port Vila, an additional freight cost of about Vt 80-100 million per year is being incurred. The Government has two options of making the storage accessible to MRVs: (i) construction of a pipeline from the nearby deep harbor to the storage tanks along with an enhancement of the safety measures commensurate with the proximity of the town, or (ii) relocation of the storage tanks to a site that is accessible for MRVs. An early decision will result in considerable savings in recurrent costs. Similarly, distribution costs could be decreased by the use of the "fabridrum", a synthetic rubber bag, an alternative which is being evaluated by PEDP in cooperation with Mobil Oil Fiji. The Government should conduct such trials with technical assistance; if satisfactory, the use of the fabridrum may reduce the losses substantially.

4.17 As the domestic market for petroleum products is small, it is unlikely that any more international oil companies will be attracted to operate there. To introduce further competition - with a view to reducing the retail price - the Government should explore the possibility of marketing part of the domestic needs (particularly kerosene) at competitive prices but without subsidies. The required quantities to be imported can be packaged into the usual tender for the import of products for the Government's own use. Preliminary estimates indicate that the cost of additional storage and related facilities may be recoverable in 6-8 years. However, adequate maintenance and management of such additional storage facilities will be necessary, a difficult task in view of the skill shortages of the Government. An alternative may be a resumption of the regulatory dialogue with the oil companies, albeit on a more informal basis than before. For long-term planning and cost control, the Government needs to acquire the capability of evaluating and monitoring the costs of procurement, freight, storage, and distribution of products. Initially, a cost analyst should be appointed in the Energy Unit. This will enable the Government to have a productive dialogue with the importers, wholesalers, and distributors in matters of cost control and desirable profit margins.

Institutional and Strategy Issues

4.18 Power Sector Regulation: There is no effective Government regulation, a normal feature in any country. There are neither electricity legislation nor safety standards and codes governing the power subsector though UNELCO voluntarily follows French standards. GOV also lacks adequate staff with the required expertise and experience to effectively regulate the public power supply and safety.22/ The Government mechanism to monitor the power subsector is thus virtually non-existent. Nevertheless, the Government, presumably with a view to having a greater say in matters relating to UNELCO's

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22/ By mid-1992, the Energy Unit had started a long-term program to acquire more detailed information from UNELCO.

operations, has recently acquired 10 per cent equity in UNELCO, financed through commercial borrowings, and even proposes to increase its stake in the utility to 30 per cent. Further, GOV has also recently established Hydro Power Development Limited, a joint venture with UNELCO, for developing the indigenous hydropower potential.

4.19 In the light of the above, the first priority of GOV should be to acquire the urgently needed expert advice and assistance so that it can effectively use its stake in UNELCO for steering UNELCO's future operations more in the national interests than has been possible in the past. This is particularly important since the franchise of UNELCO will come up for renewal only in the year 2011. On the whole, the Government's best strategy appears to be a gradual increase in the exercising of its regulatory role within the framework of the franchise agreement vis-a-vis UNELCO. Towards this end the appointment of an Electricity Commissioner as the agreed representative of the regulating government is considered an essential and urgent step. The Electricity Commissioner can also assist the government in the implementation of the various technical assistance projects recommended in Section V. In the above circumstances it is not considered necessary or practical for GOV to introduce special electricity supply legislation at this stage. Such legislation could be deferred until UNELCO's concession agreement comes up for renewal in 2011. However, institutional weaknesses of GOV in the power subsector need to be addressed immediately so that it can effectively monitor the operations in the power subsector role and safeguard the interests of the public within the existing framework.

4.20 Power Supply Standards: As stated earlier, Vanuatu does not have any design standards or safety standards and codes. In their absence, UNELCO is adopting the French standards developed by Electricite de France. Adoption of these standards and the technical competence of UNELCO have enabled it to meet the industry standards and provide reliable power supply in its franchise areas. As such the absence of national design standards by itself is not a matter of concern. However, the absence of safety standards and codes needs to be rectified from considerations of public safety. Since the Government lacks the necessary resources - financial and manpower - it is recommended that GOV should seek and obtain foreign technical assistance for developing the relevant standards and codes and for ensuring their compliance.

4.21 Electricity Conservation: Considering the current complete dependence on imported fuel - automotive diesel oil - for power generation, there is a compelling need to promote energy conservation and demand management in this vital subsector. Opportunities for energy conservation through use of compact high efficiency fluorescent lamps, better insulation of air-conditioned homes and higher efficiency appliances, need to be actively promoted through information campaigns and through appropriate incentives such as import duty exemptions on energy efficient appliances and equipment. Given the tariff structure (i.e., a cost-plus tariff formula), which for high-energy users includes a substantial charge based on connected load, there is hardly any incentive for UNELCO to promote these conservation measures. The consumers also do not have any incentive to invest in power factor correction equipment, one of the most effective means of reducing their demand, since UNELCO's tariff structure is based on connected load and does not reward

consumer initiative for improving their power factor above the stipulated 80 per cent level. This leaves only the Government to take the required initiative and devise appropriate incentives. However, GOV lacks the requisite organization and expertise though a UN volunteer has been in Vanuatu for two years. Hence it is recommended that GOV should also seek foreign technical assistance to develop appropriate measures for demand management and energy conservation and implement them in a cost-effective manner.23/

4.22 Rural Electricity Supply: The diesel units in the isolated rural areas are very old and inefficient. Significant improvements in their generation efficiency and reliability as well as reductions in consumption of the imported ADO, which has to be transported to isolated areas at considerable cost, need to be effected. These could be achieved by improving the quality and frequency of maintenance provided for these units. In cases where they are to be replaced, a careful evaluation should be undertaken before action is taken on installing new diesel units to determine if alternative energy sources such as photovoltaic lighting or biomass gasification systems (similar to that at the Onesua High School in north Efate) would be more cost effective. In this context, a careful evaluation of the necessary technical and organizational support for these renewable energy systems must also be undertaken prior to the implementation of these alternatives since without such support these options can not be sustained for any length of time.

4.23 Promotion of Hydrocarbon Exploration. According to the study conducted under the auspices of the South Pacific Geophysics Program (completed in 1988), four sedimentary basins in the waters of Vanuatu (North Aoba, South Aoba, Malakula, and East Santo) could be potential hydrocarbon targets. Since North and South Aoba lie in waters too deep for present day drilling and development capabilities, Malakula and East Santo appear to be the most promising sites for further exploration. Faults, folds and reefal structures in these basins could be potential hydrocarbon reservoirs. As part of the preparation to promote exploration in Vanuatu, the Government intends to produce a promotional handbook in 1991 and draft petroleum legislation will shortly be put before Parliament. However, additional supporting data, through detailed seismic studies, would still be required to tempt the international oil industry to undertake petroleum exploration in these basins. The Government should therefore seek technical assistance to conduct these studies as soon as possible and present the results in a promotional seminar.

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23/ By mid-1992, the Government had undertaken some energy audits, and had plans to request assistance from the Forum Secretariat for audits of all Government offices.

## V. INVESTMENT AND TECHNICAL ASSISTANCE PRIORITIES

### Power Subsector

5.1 It is unlikely that there will be a need for any significant GOV investment in the power subsector in the medium-term. Even if the technical and economical viability of the Sarakata mini-hydropower project is established by the JICA study, in view of GOV's financial resource constraints it is recommended that the project be implemented by UNELCO or by VHD with UNELCO's resources. There are, however, several areas where the government needs considerable foreign technical assistance. A list of the technical assistance projects which are urgently needed is given below:

(a) Institutional Support: GOV requires immediate institutional support in the power subsector to enable it to effectively monitor and regulate UNELCO's operations. Towards this end GOV needs the services of an experienced power utility expert to work as Electricity Commissioner backed by a small functional secretariat. If no full-time qualified person can be found, a part-time solution could be envisaged. The cost of providing these services for an initial period of three years is estimated at about US$500,000;

(b) Development of Renewable Energy Resources: Technical assistance is required to study the technical and economic feasibility of (i) diesel replacement programs in the rural areas, where alternatives are economically and institutionally attractive; (ii) the 120 kW Brenwe/Unmet hydropower project and other power supply options in the Norsup/Lakatoro area; and (iii) wind energy-based electricity generation as supplementary power for the Port Vila grid. The cost of this technical assistance is estimated at about $500,000;

(c) Safety Standards and Codes: The proposed technical assistance essentially envisages the provision of the services of an expert in electrical safety standards and codes for a 3-month period to develop the standards and codes for Vanuatu. The implementation of the standards and the codes can be handled by the Electrical Commissioner. The cost of the proposed technical assistance is estimated at about $75,000; and

(d) Energy Conservation: The proposed technical assistance envisages the provision of the services of an expert in energy conservation for a period of one month to draw up the relevant measures to be adopted by the government. The implementation of these measures can be handled by the Electrical Commissioner. The cost of the proposed technical assistance is estimated at about $25,000.

### Petroleum Subsector

5.2 The oil and gas subsector presents several attractive opportunities for development and technical assistance to the Government:

(a) Hydrocarbons Exploration: Detailed seismic studies and their analysis and presentation are needed to complement the ongoing preparation of petroleum legislation and a promotional handbook;

(b) Petroleum Product Transport Cost Reduction: The decision to either relocate existing storage facilities to the deeper harbor area, or construct a pipeline from the deeper harbor to the present storage location, will have to be based on a detailed cost comparison and environmental evaluation. Some public sector investment may be necessary to provide an incentive for the suppliers to switch to larger tankers. In parallel, trials with fabric containers for local distribution should be conducted; and

(c) Energy Unit Staffing: The Energy Unit of the Ministry of Trade needs to be equipped with a petroleum cost analyst who could be financed through technical assistance. As this position does not necessarily have to be full-time after an initial period, a Pacific Regional solution can be envisaged.

New and Renewable Sources of Energy (NRSE)

5.3 Fuelwood: There is little reliable and accurate information on the supply and consumption of fuelwood in Vanuatu. There is no Government institution that is directly responsible for assuring the continued supply of fuelwood. The Forestry Department is only now beginning to assess the forest resource base. However, very little of this effort is directed at determining the rate of growth of fuelwood supply and regeneration. It is therefore recommended that technical assistance be provided to Vanuatu to:

(a) Conduct a comprehensive fuelwood resource assessment that is incorporated within the ongoing Department of Forestry work;

(b) Conduct a detailed survey of urban and rural household energy consumption patterns with the emphasis on determining more accurately the levels of consumption of fuelwood and other sources of energy as well as the economic and social parameters that govern household energy decisions; and

(c) Create, within the Energy Unit, the capacity to develop and formulate a "household and fuelwood energy strategy" which accounts for Vanuatu's growing urban population, increasing demand on fuelwood and decreasing forestry resource base.

5.4 Other Renewable Energy Options: To date, only minor efforts have been undertaken to accelerate the economic development of these resources. It is recommended that technical assistance to assess and develop these renewable energy options be provided specifically to:

(a) Identify opportunities for the use of biomass waste resources and small-scale biomass gasification systems to displace imported petroleum fuels especially in rural agro-industries such as copra processing and for small-scale rural electrification; and

(b) Investigate the feasibility of solar PV lanterns and small village solar electrification schemes to displace the present consumption of kerosene and diesel for these purposes.

5.5 A majority of the recommended NRSE technical assistance initiatives should be undertaken within a carefully coordinated program. At present, the Energy Unit lacks the manpower to undertake any of these efforts. As such, priority should be given to recruiting an experienced international NRSE expert capable of both carrying out a comprehensive evaluation program while training the Energy Unit's staff. In addition, financial assistance to carry out the components of the NRSE evaluation should be secured. It is estimated that US$3 million over a three year period is required to assist Vanuatu in developing its NRSE resources and potential.

VANUATU

ENERGY ASSESSMENT

GROSS DOMESTIC PRODUCT (GDP) By Kind of Economic Activity, 1985-1989
(in Million Vatu)

| SECTOR | At Current Prices | | | | | At Constant 1983 Prices | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1985 | 1986 | 1987 | 1988 | 1989 | 1985 | 1986 | 1987 | 1988 | 1989 |
| AGRICULTURE, FISHING AND FORESTRY | 3693 | 2958 | 2881 | 2933 | 3149 | 2771 | 2539 | 2383 | 2148 | 2350 |
| Copra | 1473 | 948 | 799 | 896 | 789 | 741 | 778 | 675 | 552 | 508 |
| Cattle | 262 | 317 | 346 | 430 | 455 | 241 | 248 | 276 | 286 | 298 |
| Cocoa | 137 | 142 | 142 | 93 | 176 | 78 | 103 | 94 | 61 | 123 |
| Coffee | 10 | 16 | 8 | 2 | 4 | 7 | 8 | 7 | 2 | 3 |
| Poultry/Dairy | 44 | 77 | 81 | 117 | 118 | 39 | 67 | 67 | 87 | 79 |
| Other Commercial Agriculture | 535 | 239 | 29 | 48 | 58 | 504 | 190 | 22 | 34 | 40 |
| Subsistence Agriculture | 1071 | 1098 | 1157 | 1211 | 1268 | 1044 | 78 | 147 | 80 | 192 |
| Forestry & Logging | 162 | 122 | 319 | 135 | 279 | 118 | 78 | 147 | 80 | 192 |
| INDUSTRY | 1018 | 1117 | 1498 | 1767 | 2079 | 940 | 1025 | 1282 | 1473 | 1625 |
| Manufacturing | 481 | 471 | 613 | 702 | 880 | 466 | 467 | 588 | 684 | 774 |
| Electricity | 202 | 200 | 189 | 206 | 254 | 192 | 190 | 180 | 191 | 214 |
| Construction | 335 | 445 | 696 | 859 | 945 | 282 | 368 | 514 | 598 | 638 |
| SERVICES | 7823 | 8104 | 9025 | 10306 | 11139 | 6534 | 7179 | 7125 | 7229 | 7368 |
| Wholesale and Retail Trade | 3492 | 3348 | 3874 | 4309 | 4444 | 2779 | 3014 | 3090 | 3032 | 3011 |
| Hotels and Restaurants | 554 | 454 | 519 | 658 | 810 | 484 | 364 | 362 | 428 | 471 |
| Transport, Storage and Communication | 873 | 909 | 1085 | 1216 | 1375 | 770 | 741 | 735 | 776 | 847 |
| Finance and Insurance | 1027 | 1434 | 949 | 1458 | 1576 | 967 | 1285 | 757 | 1064 | 1062 |
| Real Estate and Other Services | 749 | 793 | 890 | 987 | 1190 | 454 | 708 | 727 | 705 | 784 |
| Government Services | 1710 | 1893 | 1909 | 2144 | 2037 | 1629 | 1721 | 1614 | 1564 | 1390 |
| Less: Inputed Banking Charges | 583 | 727 | 201 | 466 | 293 | 548 | 654 | 160 | 340 | 198 |
| GROSS DOMESTIC PRODUCT At Producers' Prices | 12534 | 12179 | 13404 | 15006 | 16367 | 10245 | 10743 | 10790 | 10850 | 11343 |

VANUATU

ENERGY ASSESSMENT

## I. IMPORTS BY STANDARD INTERNATIONAL TRADE CLASSIFICATION (SIIC)

(MILLION VATU C.I.F.)

| PERIOD | Food and Live Animals | Beverages and Tobacco | Crude Materials Excluding Fuels | Mineral Fuels | Animal Vegetable Oil, Fats | Chemicals | Basic Manu-factures | Machines, Transport Equipment | Misc. Manuf. Goods | Goods Not Specified | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1985 | 1210 | 295 | 68 | 651 | 38 | 395 | 1083 | 1387 | 972 | 286 | 6385 |
| 1986 | 1089 | 252 | 67 | 573 | 37 | 364 | 1062 | 1503 | 820 | 138 | 5905 |
| 1987 | 1022 | 204 | 226 | 634 | 25 | 450 | 1624 | 1918 | 983 | 364 | 7450 |
| 1988 | 1263 | 368 | 88 | 584 | 31 | 421 | 1430 | 1797 | 651 | 233 | 7066 |
| 1989 | 1213 | 331 | 65 | 640 | 33 | 540 | 1437 | 2452 | 934 | 237 | 7882 |

## II. PRINCIPAL EXPORTS AND RE-EXPORTS

(MILLION VATU F.O.B.)

| | DOMESTIC EXPORTS | | | | | | | | | | | RE-EXPORTS | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PERIOD | Copra | Cocoa | Beef & Veal Chilled or Frozen | Beef & Veal Processed | Timber: Sawn/Log | Cowhides | Shells | Kava | Coffee | Others | TOTAL | Fish and Others | Petroleum Products | TOTAL | TOTAL EXPORTS & RE-EXPORTS |
| 1985 | 1392 | 133 | 185 | 1 | 136 | 23 | 24 | 7 | 21 | 48 | 1970 | 1017 | 265 | 1282 | 3252 |
| 1986 | 461 | 196 | 148 | 3 | 63 | 17 | 26 | 5 | 7 | 46 | 970 | 768 | 103 | 871 | 1841 |
| 1987 | 719 | 207 | 250 | 2 | 208 | 28 | 27 | 6 | 9 | 46 | 1502 | 254 | 186 | 440 | 1942 |
| 1988 | 953 | 117 | 243 | - | 106 | 34 | 35 | 5 | 4 | 61 | 1558 | 346 | 162 | 508 | 2066 |
| 1989 | 750 | 174 | 262 | - | 204 | 36 | 59 | 9 | - | 118 | 1612 | 723 | 228 | 951 | 2563 |

VANUATU

ENERGY ASSESSMENT

TABLE 3: VANUATU: ENERGY BALANCE ESTIMATES, 1990
('000 toe)

| | Fuelwood | Agric. Residues | Total Biomass | Petroleum | Electricity | Total Energy | Shares |
|---|---|---|---|---|---|---|---|
| Gross Supply | | | | | | 0.00 | |
| Production | 27.76 | 14.20 | 41.96 | | - | 41.96 | |
| Imports | | | | 26.59 | - | 26.59 | |
| Exports | | | | | - | 0.00 | |
| Bunkers | | | | -4.61 | - | -4.61 | |
| Total Supply | 27.76 | 14.20 | 41.96 | 21.98 | 0.00 | 63.94 | |
| Conversion | | | | | | | |
| Power Generation | | | | -6.11 | 6.11 | 0.00 | |
| Conversion Losses | | | | | 4.27 | 4.27 | |
| Trans/Dist. Losses | | | | | 0.40 | 0.40 | |
| Discarded/Un-used | | | 0.00 | | 0.00 | 0.00 | |
| Net Supplies | 27.76 | 14.20 | 41.96 | 15.87 | 1.44 | 59.27 | |
| Sectoral Consumption | | | | | | | |
| Domestic | 24.82 | | 24.82 | 0.94 | 0.36 | 26.12 | 45.5% |
| Commercial | n.a. | n.a. | | 0.79 | 0.97 | 1.76 | 3.1% |
| Industrial | | | | 0.53 | 0.65 | 1.18 | 2.1% |
| Transport | | | | 13.61 | | 13.61 | 23.7% |
| Agricultural | 2.94 | 11.72 | 14.66 | | | 14.66 | 25.6% |
| Others | | | | | 0.02 | 0.02 | 0.0% |
| Total Consumption | 27.76 | 11.72 | 39.48 | 15.87 | 2.01 | 57.36 | 100.0% |
| % of Total Consumption | 48.40% | 20.43% | 68.83% | 27.67% | 3.50% | | |

Table 2: VANUATU - 1990 Petroleum Supply/Demand Ballance

FIG 2.1: Sectoral Energy Consumption
Vanuatu - 1989

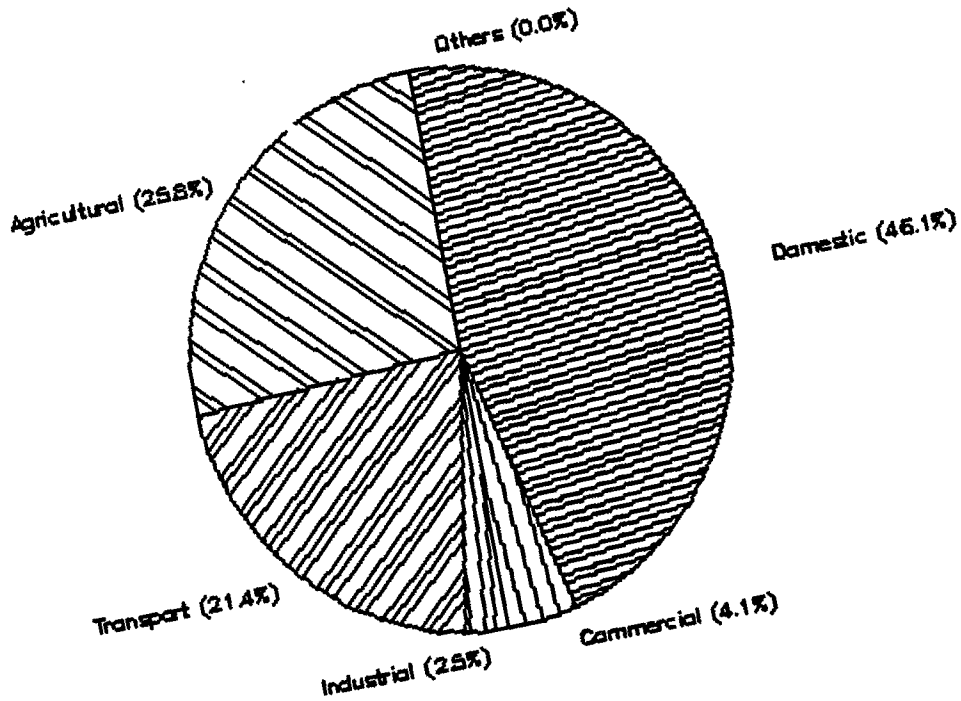
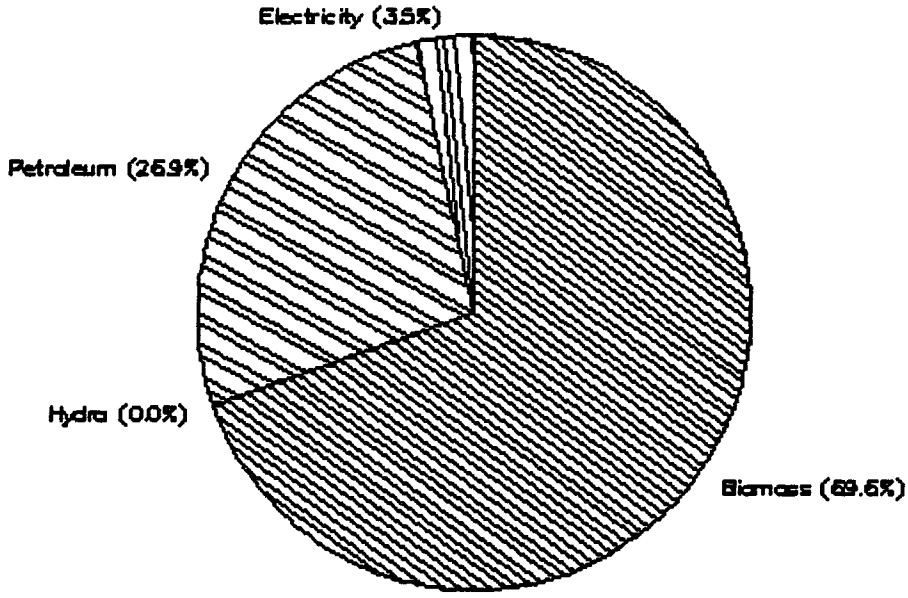


FIG 2.2: National Fuel Consumption

Vanuatu - 1989



VANUATU

ENERGY ASSESSMENT

UNELCO'S ENERGY GENERATION AND SALES
(MWh)

Port Vila

| Year /1 | Generation | Sales | % Change | Losses MWh | Losses % of Gen. |
|---|---|---|---|---|---|
| 1982/83 | 15,311 | 14,727 | | 584 | 3.81 |
| 1983/84 | 16,379 | 15,626 | 6.1 | 753 | 4.60 |
| 1984/85 | 17,418 | 16,970 | 8.6 | 448 | 2.57 |
| 1985/86 | 17,504 | 16,797 | -1.0 | 707 | 4.04 |
| 1986/87 | 16,074 | 15,383 | -8.4 | 691 | 4.30 |
| 1987/88 | 19,327 | 18,566 | 20.7 | 761 | 3.94 |
| 1988/89 | 20,605 | 19,817 | 6.7 | 788 | 3.82 |
| 1989/90 | 22,976 | 22,220 | 12.1 | 756 | 3.29 |

Average Annual Growth rate - 6.05%

Luganville

| Year | Generation | Sales | Losses MWh | Losses % of Gen. |
|---|---|---|---|---|
| 1982/83 | 2,258 | 2,137 /2 | 121 | 5.36 |
| 1983/84 | 2,272 | 2,180 /2 | 92 | 4.05 |
| 1984/85 | 2,262 | 2,121 /2 | 141 | 6.23 |
| 1985/86 | 2,190 | 2,058 /2 | 132 | 6.02 |
| 1986/87 | 2,141 | 2,068 /2 | 73 | 3.40 |
| 1987/88 | 2,185 | 2,069 /2 | 116 | 5.31 |
| 1988/89 | 2,273 | 2,141 /2 | 132 | 5.80 |
| 1989/90 | 2,575 | 2,445 /2 | 130 | 5.05 |

Average Annual Growth rate - 1.94%

/1 01 October to 30 September

/2 There has been virtually no load growth during the period from 1982/83 to 1988/89 in Luganville. The small variations in the sales are essentially due to the actual offtakes of the two largest consumers viz., a saw mill with a connected load of 400 kVA and Santos Abbatoir with a connected load of 300 kVA.

Source: UNELCO

ANNEX 2.3

VANUATU

ENERGY ASSESSMENT STUDY

ELECTRICITY DEMAND FORECAST FOR VANUATU

| Year | Energy Sales - MWh | | | |
|---|---|---|---|---|
| | Port Vila | Luganville | Others | Total |
| 1991 | 25,000 | 2,500 | 500 | 28,000 |
| 1992 | 26,750 | 2,550 | 510 | 29,810 |
| 1993 | 28,620 | 2,730 | 520 | 31,870 |
| 1994 | 30,630 | 2,780 | 530 | 33,940 |
| 1995 | 32,770 | 2,840 | 540 | 36,140 |
| 1996 | 35,060 | 2,895 | 550 | 38,505 |
| 1997 | 37,500 | 2,950 | 560 | 41,010 |
| 1998 | 40,140 | 3,010 | 570 | 43,720 |
| 1999 | 42,950 | 3,070 | 585 | 46,605 |
| 2000 | 45,960 | 3,130 | 600 | 49,690 |

Source: Mission estimates

Note: In this forecast it is assumed that Port Vila demand would increase at annual growth rate of 7% and that in the other areas at 2%.

ANNEX 3.1

VANUATU

ENERGY ASSESSMENT

POWER GENERATION IN PORT VILA

**Installed Generating Capacity**

| Unit No. | Capacity - kW | Year Installed | Hours Operated 1/ |
|---|---|---|---|
| 1 | 250 | 1962 | 86,659 |
| 2 | 620 | 1970 | 60,458 |
| 3 | 620 | 1971 | 64,966 |
| 4 | 1,040 | 1974 | 54,183 |
| 5 | 1,040 | 1974 | 60,138 |
| 6 | 1,040 | 1975 | 52,164 |
| 7 | 1,040 | 1984 | 29,203 |
| 8 | 2,170 | 1989 | 3,063 |
| TOTAL | 7,820 | | |

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1/ As of 30 September, 1990

**Operational Data**

| Month | Gen. MWh | Stn. Use MWh | Sales MWh | Fuel Oil k.liters | Lube Oil k.liters | Pk.Load kW | Load Factor per cent |
|---|---|---|---|---|---|---|---|
| 1989 | | | | | | | |
| June | 1,682 | 49 | 1,556 | 376 | 3.97 | 3,847 | 60.7 |
| July | 1,700 | 50 | 1,579 | 380 | 2.68 | 3,904 | 58.5 |
| Aug. | 1,697 | 53 | 1,635 | 376 | 2.03 | 3,621 | 63.0 |
| Sept. | 1,746 | 50 | 1,608 | 389 | 2.70 | 4,017 | 60.4 |
| Oct. | 1,870 | 51 | 1,826 | 417 | 2.15 | 4,300 | 58.5 |
| Nov. | 1,893 | 56 | 1,869 | 424 | 2.07 | 4,639 | 55.1 |
| Dec. | 2,037 | 54 | 1,716 | 425 | 2.79 | 4,413 | 62.0 |
| 1990 | | | | | | | |
| Jan. | 2,170 | 62 | 2,118 | 483 | 2.92 | 4,992 | 58.4 |
| Feb. | 1,936 | 56 | 1,899 | 431 | 2.81 | 4,992 | 60.2 |
| March | 2,173 | 60 | 1,959 | 487 | 3.57 | 4,752 | 61.5 |
| April | 1,934 | 53 | 1,857 | 432 | 2.28 | 4,469 | 60.1 |
| May | 1,987 | 56 | 1,846 | 446 | 2.71 | 4,469 | 60.0 |
| TOTAL | 22,825 | 650 | 21,468 | 5,066 | 32.68 | 4,992 | 58.0 |
| | ====== | === | ====== | ===== | ===== | ===== | ==== |

Station Use as per cent of generation - 2.85%
Losses as per cent of generation - 3.1%
Total system losses as per cent of generation - 5.95%
Specific fuel consumption - 4.5 kWh/liter
Source: UNELCO

ANNEX 3.2

VANUATU

ENERGY ASSESSMENT

POWER GENERATION IN LUGANVILLE

**Installed Generating Capacity**

| Unit No. | Capacity - kW | Year Installed |
|---|---|---|
| 1 | 250 | 1960s |
| 2 | 250 | 1960s |
| 3 | 250 | 1960s |
| 4 | 250 | 1960s |
| 5 | 80 | 1960s |
| 6 | 920 | 1992 |
| TOTAL | 2,000 | |

**Operational Data**

| Month | Generation (MWh) | Sales (MWh) |
|---|---|---|
| **1989** | | |
| July | 196 | 189 |
| August | 200 | 193 |
| September | 179 | 173 |
| October | 215 | 208 |
| November | 207 | 200 |
| December | 184 | 178 |
| **1990** | | |
| January | 210 | 203 |
| February | 220 | 212 |
| March | 222 | 214 |
| April | 225 | 217 |
| May | 212 | 205 |
| June | 237 | 229 |
| TOTAL | 2,507 | 2,421 |

Losses as per cent of generation: 3.43 %

Source: UNELCO

# VANUATU

## ENERGY ASSESSMENT

### Small Hydropower Projects for Major Power Systems

1. Various studies have been performed in the past to identify the hydropower potential in the country, and the two hydropower projects of the Teouma river project for Port Vila and the Sarakata river project for Luganville have been selected as the most favorable projects. ENEX of New Zealand issued a prefeasibility report for these two projects in July, 1987 and Hangzhou Regional Center for Small hydro Power of China presented a feasibility report for the Teouma river project in December, 1989. These past studies were based on 3 years of data from 1982 to 1984 taken by the ORSTOM center of Noumea, New Caledonia. At present the Department of Geology, Mines and Rural Water Supply is conducting hydrological observations for these two projects. By installing self-recording instruments, they are collecting rainfall data of their respective basins and discharge measurements and stage recordings are performed near the proposed intake sites. A data base for hydrological data has been formulated.

2. The two projects were conceived as run-of-river developments, consisting of diversion and intake structures, sand settling ponds, waterways, regulating ponds, steel penstocks, powerhouses with generating equipment, spillways, transmission lines, etc. In Vanuatu, the monthly rainfall in a year is relatively well distributed; the minimum monthly rainfall is more than the half of the annual average, and relatively heavy rainfall occurs during the hot and wet summer time when there is a high airconditioning load, and is small in the winter season when the electricity demand is less. This fact favors run-of-river hydro development.

The Teouma River Project is located about 10 km east of the capital Port vila and is planned to generate 1,200 kW power by utilizing about a 40 m head of the river. The catchment area at the proposed intake site is 38.5 km and the annual mean flow is 2.42 $m^3$/sec. Due to the porous nature of the catchment geology, the annual flow duration characteristics are relatively flat and the firm flow is high. The site geology consists mainly of Pumice Breccia and Limestone. Due to the existence of soft rock, the river is incised deeply forming very steep and rugged terrain in the area. The river flow is not steep and over 2 km of waterway with some high-cost tunnel section lined with concrete is required in rugged terrain to obtain about 40 m head. A 6 km access road is to be constructed for approaching the site and 13 km of 20 kV line is required for sending the generated power to Port Vila. The peak and minimum demand of the Port Vila system in 1990 was 5,318 kW and 2,400 kW respectively, therefore all the

generated energy can be consumed in the system. Careful geological investigations by core drilling, permeability tests, material tests, etc. will be required to confirm the geological conditions of the site. The site is a recreation spot of Port Vila residents and the effect of constructing a hydropower project should be carefully studied.

The Sarakata River Project is located about 10 km north-west of Luganville on Espiritu Santo island and can generate up to about 6,400 kW of electric power by fully developing the available head and discharge. However, the 1990 peak demand of the Luganville system was only 630 kW and the full output development cannot be justified at the present stage. Therefore, a staged development plan has been prepared and the first-stage development now being considered is to develop 1,000 kW by utilizing about 40 m head. The catchment area at the proposed intake site is 97 $km^2$ and the annual mean flow is 8.78 $m^3$/sec. The site is predominantly limestone terrain with raised limestone, which is overlaid by laterite. By utilizing a 16 m high waterfall and rapids just upstream and downstream of the waterfall, about 40 m head can be obtained by leading water for about 700 m. The site topography is relatively gentle and low-cost surface installation of waterway is possible by laying PVC pipes by digging a trench into the lateritic soil. A motorable road which requires some reinforcement leads near to the river bank and only accesses going down to the intake and powerhouse sites will be required. For sending the generated power to Luganville, a 20 kV transmission line of about 13 km in length will be required. The permeability of the limestone bed rock should be confirmed by geological investigations.

3. Based on available information from past studies and the results of the mission's site visit, the Sarakata project looks more attractive from the viewpoints of large available discharge, easier access, shorter and far cheaper waterway for similar head, ease of installation of the waterway, etc., while the length of the transmission line is almost the same. These factors result in a cheaper unit construction cost of the Sarakata project. According to the results of past prefeasibility and feasibility studies, the economic feasibility of the Teouma project is marginal, and may only become feasible at much higher oil prices. There seems to be little doubt about economic viability of the Sarakata project if the demand in Luganville reaches 800 to 1,000 kW.

4. The Government of Vanuatu approached the Japanese government for technical and financial assistance for the 1,200 kW development (4 x 300 kW) Sarakata project, and the basic design study of the project will be commenced in April, 1991. Since the peak demand of the Luganville power system in 1990 was only 630 kW and the average growth after 1983 (peak demand of 490 kW) was 3.66%. This demand level will be too small to economically justify the execution of the construction works and if no special measures are taken, the project will be justified only after the year 2000. A significant demand

growth could only be realized by the connection of village loads adjacent to Luganville to the system, by establishment of industries and by extensions of the power system to other load centers in the island. An interconnection with Malekula island is not likely to be economically justified as the distance to Norsup, the largest load center in the island with 200 to 300 kW probable future peak demand, is 70 km from Luganville including a 15 km submarine section. Although GOV has already received an application from UNELCO for developing this project, the government is now awaiting the results of the basic design to be conducted under Japanese aid.

# VANUATU

## ENERGY ASSESSMENT

### Mini Hydropower Projects for Rural Electrification

1. For electric power supply to rural demands by mini- to micro-hydropower projects, a Prefeasibility Study on Micro Hydropower Development for Rural Electrification was presented with German funding dated January, 1989. The rural demand of Vanuatu is very widely dispersed and the demand of rural centers rarely exceeds 20 kW, which makes economic development of micro-hydro projects difficult due to the negative effect of the economies of scale. Amongst these, the Brenwe/Unmet project of 215 kW capacity for power supply to the combined demand of village demands in the adjacent area and Norsup and Lakatoro towns in Malakula island is considered to be one of the better projects. As for the Woundaous/Navota and Kere/Fimele projects on Espiritu Santo island near Luganville, priority for power supply should be given to supply from Luganville by extending the high tension system. If the Sarakata hydropower project is executed, the additional cost for increasing plant output will certainly be much smaller than the construction cost of a new mini-hydro plant.

2. The location of the Brenwe/Unmet project is on the west coast of Malakula island and is about 15 km west of Norsup on the east coast. The catchment area at the proposed intake site is 22.8 $km^2$ and enough discharge is available to generate power to meet the demand in the supply area by utilizing the available head of 80 m. The project envisages to supply not only the five villages adjacent to the project but also Norsup and Lakatoro on the east coast. The area with these two towns is the most important center in Vanuatu next to Luganville and PWD is operating diesel power stations in these two towns. At Norsup, there is also a coconut processing plant which is operating its own diesel generators. Though accurate estimation of future power demand of such a center is very difficult, the combined peak demand is roughly estimated at 250 kW. A high tension transmission line of 5.5 or 11 kV will be required to deliver the generated power to the loads.

3. By commissioning a hydropower project, the power supply situation of the demand center will be much improved. The power supply area will be much enlarged from the Present PWD's limited supply. Instead of part-time supply by diesel generators, 24 hour supply will become available, and reliability of the power supply will be improved.

4. Though detailed data are not available, the electric energy generation cost by diesel generator is roughly estimated to amount to at least 50 to 70 Vatu/kWh and the economic viability of a hydropower project should be evaluated by comparison with this cost. The construction cost of this hydropower project will fall in the range of $5,000 to 10,000 per kW installation though this varies depending on various other conditions.

5. For promoting the mini-hydro development plans, skilled staff in charge of the particular project will be essential. The staff for operation and maintenance of mini-hydro power plant will not be readily available in the rural community of Vanuatu, and training of available electricians, mechanics or other potential staff should be conducted during construction and the commissioning tests, if minihydro projects are implemented.

# VANUATU

## ENERGY ASSESSMENT

### Biomass and Solar Options

1. Sawmill/Logging Residues: Total logs cut in Vanuatu in 1989 were estimated at 36,600 $m^3$ (Table 1). This comprised 15,100 $m^3$ of export logs and timber and 21,540 $m^3$ for domestic timber consumption. While the total log cuts have remained relatively constant over the past six years, the data clearly indicate a trend toward an increasing percentage of log consumption for domestic use (see Table 1). The Second Development Plan indicates that the Ministry of Agriculture intended to establish a ban on the export of logs by 1990. However, the 1989 data indicates that of the total volume of logs cut for export, only 17%, or approximately 2,600 $m^3$ of logs, were processed to timber products for export. Total sawn timber production in 1989 is estimated at 11,000 $m^3$. The resulting sawmill residues from this production are estimated to be approximately equal to 13,300 $m^3$ and the logging residues are approximately equivalent to 24,100 $m^3$. The logging residues from export logs are estimated at 12,500 $m^3$. Thus the estimated total logging and sawmill residues in Vanuatu in 1989 are equal to approximately 50,000 $m^3$ or equivalent to 11.90 mtoe1/ in terms of potential energy value.

Table 1: PRODUCTION OF FOREST PRODUCTS - 1984 TO 1989/a ($m^3$)

| Year | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 |
|---|---|---|---|---|---|---|
| Exports | 27,184 | 22,146 | 6,637 | 23,716 | 5,001 | 15,085 |
| Domestic | 9,293 | 10,795 | 12,962 | 15,521 | 17,899 | 21,540 |
| Total | 36,477 | 32,941 | 19,599 | 39,237 | 22,900 | 36,625 |

Source: Vanuatu Office of Statistics.

2. Forestry Plantations: The Forestry Department continues to maintain two forest plantation programs: the Local Supply Plantation (LSP) program; and the Industrial Forestry Plantation (IFP) program. The LSP program is intended to help supply future local demand for sawn wood and timber. The LSP program was started in 1975 and by 1985 approximately 34 sites had been established covering 1,064 ha. The IFP program is intended to provide for future exports of lumber and to support an expanded wood processing industry. By 1986, the IFP program had established 8 sites which represented 1,128 ha. The primary objectives of the LSP and IFP programs were to provide an assured future supply source of timber for local and export needs. However, to date these

1/ Assumes 0.7 ton wood/$m^3$ wood and 0.34 toe = 1.0 ton of wood at 30% mcwb.

supply sources have not been brought into production as the expected increases in domestic and export volume have not materialized. These plantations represent a potential source of fuelwood derived from their pruning and thinning as standing timber, if the expected demand for timber does not materialize. Assuming an availability of $1m^3$/ha/yr from pruning and thinning results in a woodfuel equivalent of approximately 0.52 mtoe/yr.

3. Coconut Residues: It was estimated that Vanuatu produced approximately 312 million coconuts in 1989[2]. From this production, Vanuatu exported 24,906 tons of copra and consumed the equivalent of 17,801 tons of copra (mostly in the form of fresh coconut). Approximately 2.98 kg of husk and shell (at 30% mcwb) are produced per 1.0 kg of dried copra. As a result, total husk and shell residues from coconut production is estimated at 127.3 $x10^3$ tons or equivalent to 43.3 mtoe. Approximately 29.2 $x10^3$ tons of husks and shells are consumed for copra and cocoa drying leaving about 98.1 $x10^3$ tons/yr of husk and shells unused. This is equivalent to 33.35 mtoe/yr.

4. Coconut Stemwood: In addition to the coconut husks and shells, there is a significant energy potential from senile coconut trees. The last agricultural census carried out in 1983/84 estimated 91,291 ha of coconut plantations of which about 21% are large plantations and the remaining 79% are smallholders[3]. Coconut trees have a productive life of approximately 50 years. At present however, it is estimated that over 25% of the coconut groves in Vanuatu are over 50 years and another 25% are expected to enter this category in the next 15 years. Copra production has declined significantly in Vanuatu over the past three years due to damage from major cyclones also resulting in a large number of unproductive trees, and also due to a drop in copra prices.

5. Coconut trees number between 100 and 150 per hectare. Given the relative high age profile of coconut groves in Vanuatu, it is reasonable to expect a replacement of approximately 4%/yr or 2,400 ha/yr of plantations which is consistent with the reported 1,600 ha planted by just the smallholders. Taking the conservative estimate of 100 trees/ha results in the approximate replacement of 240,000 trees/yr or equivalent to approximately 53.3 mtoe[4]. The senile coconut stemwood is not used widely as a domestic fuelwood substitute because it is difficult to chop into the appropriate sizes for cooking needs. However, the stemwood could be used as a supplementary fuel for copra drying or as an input to a coconut husk and shell direct combustion co-generation plant at major plantations. The constraints to utilizing coconut stemwood in these applications are due primarily to (a) the difficulty of cutting or chipping the stemwood; (b) the high silica content of

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2/ Vanuatu Statistical Bulletin -15/10/90: "Copra and Cocoa - 1981 to 1989".

3/ "Report on the Smallholder Agricultural Survey - 1989", Statistics Office, NPSO, Port Vila, April 1990.

4/ Assumes the coconut tree stem equals 1.06 tones/tree at 56% mcwb and the energy value of the oven dry stemwood is 20 MJ/kg.

the wood which results in excessive wear of processing machinery; and (c) the lower energy content per unit of volume of coconut stemwood as compared to fuelwood. The total potential biomass supply per year, therefore, is likely to amount to more than 300 mtoe (Table 2).

Table 2: SUMMARY OF POTENTIAL BIOMASS ENERGY SUPPLY

| Source | mtoe |
|---|---|
| Forests | 214.20 |
| Sawmill/Logging Residues | 11.90 |
| Forestry Plantations | 0.52 |
| Coconut Husk/Shells | 33.35 |
| Coconut Stemwood | 53.30 |
| TOTAL | 312.97 |

6. Solar Lighting: Solar photovoltaic (PV) lanterns that can replace kerosene lanterns are presently available in the US, Europe and Asia. These "PV lanterns" use photovoltaic cells to charge a 12 or 24 volt storage battery during daylight hours which is then capable of supplying up to six hours of light. The PV lanterns are designed with a high-intensity, low energy (5-11 watt) fluorescent light which provides over ten times as much light (when measured in lumens) than the conventional kerosene wick lantern. The conventional kerosene lantern, widely used in the un-electrified areas of Vanuatu, is estimated to have a conversion efficiency of only one percent.5/ As a result, the cost of lighting with kerosene wick lanterns is relatively expensive and inefficient. Kerosene pressure-type lamps are also available, giving higher-quality light.

7. At present, the cost of PV lanterns is extremely high, approximately US$190 per lantern. One of the major reasons for the high costs is the relatively low demand for such devices in most developed countries. Mass production of these lanterns in a country like India, where there are presently an estimated 100 million kerosene lanterns in use, could significantly reduce the costs of the PV lanterns to one-third of their present costs or about US$65 per lantern.

8. A comparison of the costs of lighting with kerosene lanterns versus PV lanterns is presented below. At the current cost of 70 Vt/l of kerosene, average daily lighting costs due to kerosene consumption are estimated to be approximately 17 Vt/d. Alternately, the costs of the PV lantern is estimated to be nearly 20 Vt/d. This does not account for the fact that the PV lantern

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5/ Source: World Bank, Industry and Energy Department Working Paper, Energy Series No. 6.

provides a brighter light. If, however, the mass production of PV lanterns are realized as is being presently investigated in India, the daily price of PV lighting could fall to about 8 Vt/d.

9. Solar Electricity: Solar PV electricity, especially in isolated rural areas, where small diesel generators (less than 10 kWe) are used, can be considered for housing and community lighting, television, radio and some refrigeration. The exact economics of such a case is dependent on the costs of the PV systems and the price of diesel. A simple analysis of a solar PV community electricity system versus a 2.5 Kwe diesel system is presented below. The results indicate that a solar PV system could be only slightly more expensive than the diesel system at diesel prices of 100 Vt/l. At this price the cost of electricity is estimated at 96 Vt/kwh from the diesel system versus 103 Vt/kWh from the solar PV system. This does not account for the fact that the PV system has a greater reliability. It can be seen that at approximately 110 Vt/l for diesel the solar system becomes competitive. Given the remote locations of most rural areas in Vanuatu, the financial and economic prices of diesel can be beyond the rate of 110 Vt/l. Thus, The potential to use solar PV systems in these areas should be carefully evaluated.

VANUATU

ENERGY ASSESSMENT

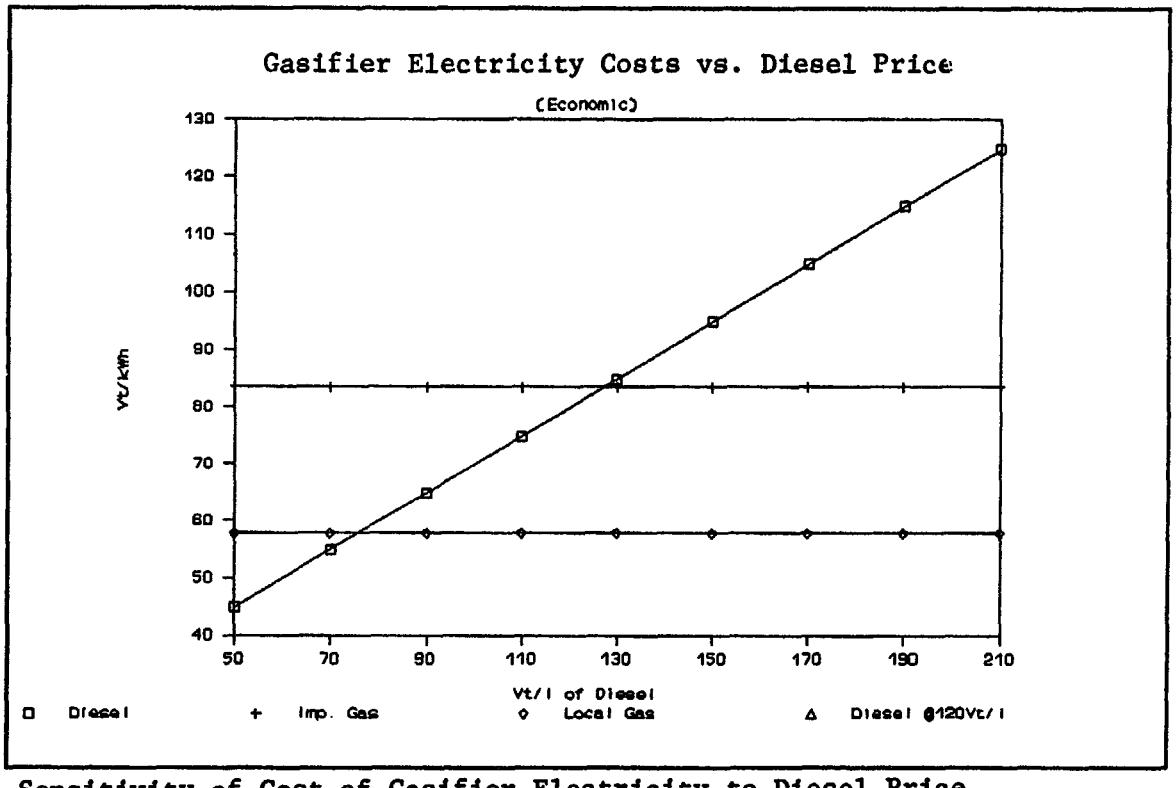
VANUATU: BIOMASS GASIFIER ANALYSIS

| Basic Parameters | Financial | Economic |
|---|---|---|
| Discount Rate (%) | 10.00% | 10.00% |
| Diesel Fuel Costs (Vt/l) | 100.00 | 80.00 |
| Wood Fuel Costs (Vt/kg) | 10.00 | 15.00 |
| Lube Oil Costs (Vt/l) | 150.00 | 190.00 |
| Skilled Labor Costs (Vt/hr) | 250.00 | 200.00 |
| Unskilled Labor Costs (Vt/hr) | 100.00 | 75.00 |
| Diesel Energy Content (MJ/l) | 36.00 | 36.00 |
| Wood Energy Content (MJ/kg) | 16.00 | 16.00 |
| Unit Energy Costs - Diesel (Vt/MJ) | 2.78 | 2.22 |
| Unit Energy Costs - Wood (Vt/MJ) | 0.63 | 0.94 |
| Base O&M Costs (% of Cap Costs) | 5.00% | 5.00% |
| Annual Operating Days/yr | 350 | 350 |
| Import Duties (%) | | 30.00% |
| Standard Conversion Factor | | 0.9 |
| Daily Operating Hours | 8 | |
| Average Plant Load Factor | 0.6 | |

| | Diesel | | Imported Gasifier | | Local Gasifier | |
|---|---|---|---|---|---|---|
| | Financial | Economic | Financial | Economic | Financial | Economic |
| Net Plant Capacity (kWe) | 25 | 25 | 25 | 25 | 25 | 25 |
| Plant Life (yr) | 15 | 15 | 15 | 15 | 15 | 15 |
| Capital Costs | | | | | | |
| Engine/Generator (Vt) | 2,000,000 | 1,400,000 | 2,818,800 | 1,973,160 | 2,400,000 | 1,680,000 |
| Gasifier (Vt) | 0 | 0 | 5,637,600 | 5,637,600 | 2,000,000 | 1,800,000 |
| Shipping & Handling (Vt) | 300,000 | 270,000 | 1,502,200 | 1,351,980 | 500,000 | 450,000 |
| Installation Costs (Vt) | 690,000 | 501,000 | 2,987,580 | 2,688,822 | 1,470,000 | 1,179,000 |
| Buildings (Vt) | 700,000 | 700,000 | 1,000,000 | 1,000,000 | 1,000,000 | 1,000,000 |
| Total Ins. Cap. Costs (Vt) | 3,690,000 | 2,871,000 | 13,946,180 | 12,651,562 | 7,370,000 | 6,109,000 |
| Operating Parameters | | | | | | |
| Annual Operating Hours | 2,800 | 2,800 | 2,800 | 2,800 | 2,800 | 2,800 |
| Net Plant Efficiency (%) | 20% | 20% | 18% | 20% | 18% | 20% |
| Net Plant Heat Rate (MJ/kWh) | 18 | 18 | 20 | 18 | 20 | 18 |
| Annual Power Output (kWh/yr) | 42,000 | 42,000 | 42,000 | 42,000 | 42,000 | 42,000 |
| Daily Sk. Labor (hr/d) | 2 | 2 | 4 | 4 | 4 | 4 |
| Daily Un-sk. Labor (hr/d) | 8 | 8 | 16 | 16 | 16 | 16 |
| Engine Oil (l/hr) | 0.0233 | 0.0233 | 0.0233 | 0.0233 | 0.0233 | 0.0233 |
| O&M Costs (% of Cap Costs) | 3.33% | 3.33% | 3.33% | 3.33% | 3.33% | 3.33% |

VANUATU

ENERGY ASSESSMENT




Sensitivity of Cost of Gasifier Electricity to Diesel Price

**VANUATU**

**ENERGY ASSESSMENT**

Ann. Int. Rate = 10.00%
Ex. Rate (Vt/$)= 108
Ann O&M = 5.00%

**PV LIGHTING COSTS**

| Components | Present Capital Costs | Daily Amortized Costs | Potential Capital Costs | Daily Amortized Costs | Expected Life in Years |
|---|---|---|---|---|---|
| Lamp (Vt) | 3240.00 | 2.29 | 1500 | 1.06 | 5 |
| ($) | 30.00 | 0.02 | 13.89 | 0.01 | |
| Battery (Vt) | 14040.00 | 9.94 | 6240.00 | 4.42 | 5 |
| ($) | 130.00 | 0.09 | 57.78 | 0.04 | |
| PV Module(Vt) | 9180.00 | 4.04 | 3120.00 | 1.37 | 10 |
| ($) | 85.00 | 0.04 | 28.89 | 0.01 | |
| Ann. O&M (Vt) | 1323.00 | 3.62 | 543.00 | 1.49 | |
| ($) | 12.25 | 0.03 | 5.03 | 0.01 | |
| Daily Energy (Vt) | | 17.61 | | 7.28 | |
| Costs ($) | | 0.16 | | 0.07 | |
| Total Daily (Vt) | | 19.91 | | 8.34 | |
| Costs ($) | | 0.18 | | 0.08 | |

## VANUATU

## ENERGY ASSESSMENT

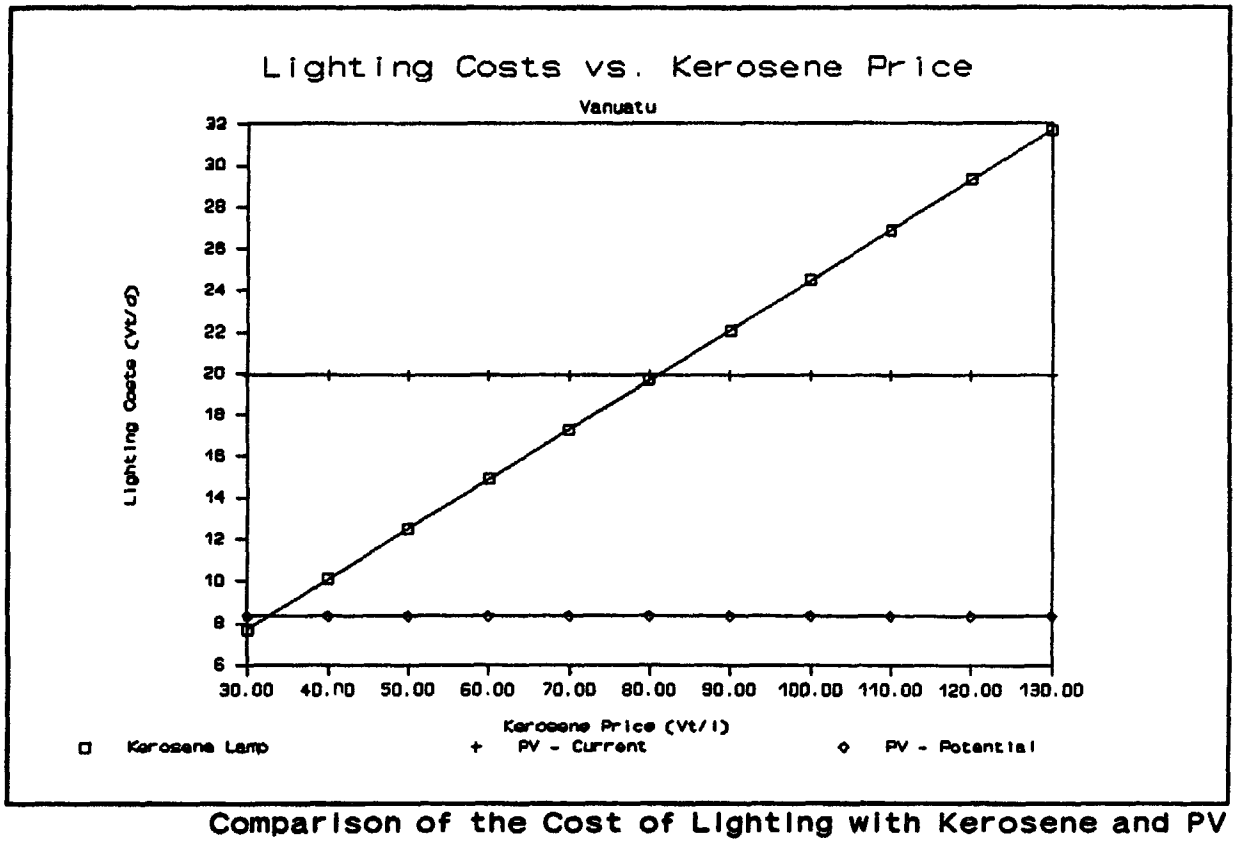
| | |
|---|---|
| Kerosene Consumption (L/hr) = | 0.02 |
| Lamp usage (hr/d) = | 6 |
| Kerosene Costs (Vt/l) = | 70 |

### KEROSENE WICK LAMP COSTS

| Components | Present Capital Costs | Daily Amortized Costs | Expected Life in Years |
|---|---|---|---|
| Wick Lamp (Vt) | 900.00 | 0.50 | 5 |
| Costs ($) | 8.33 | 0.00 | |
| Fuel Costs (Vt) | | 8.40 | |
| per Lamp ($) | | 0.08 | |
| Lamps per household | 2 | | |
| Avg. Daily (Vt) | | 17.30 | |
| Lighting Expend.($) | | 0.16 | |

**VANUATU**

**ENERGY ASSESSMENT**




Comparison of the Cost of Lighting with Kerosene and PV Lanterns

VANUATU

ENERGY ASSESSMENT



Comparison of Diesel and Solar PV for 2.5 kWe Community Electricity

Basic Assumptions

| | |
|---|---|
| Demand (kWh/d) = | 12 |
| Duration (h/d) = | 6 |
| Base Load (kW) = | 2 |
| Diesel System operating @ 80% load = | 2.5 kWe |
| Diesel system costs ($/kWe) = | 1,000 |
| Diesel system efficiency = | 15% |
| Diesel fuel price (Vt/l) = | 100 |
| Diesel Energy Value (MJ/l) = | 36 |
| Other O&M (% of diesel costs) = | 10% |
| Solar inso. (kWh/m2/d) = | 6 |
| Array efficiency (%) = | 10% |
| Battery storage eff. = | 70% |
| Solar modules required = | 2.86 kWp |
| Solar module costs ($/kWp) = | 5,500 |
| Battery depth of discharge = | 70% |
| Storage capacity (days) = | 2 |
| Battery storage capacity = | 34.29 kWh |
| Battery costs ($/kWh) = | 125 |
| Ballance of system costs ($/kWp) = | 1,000 |
| Other O&M (% of solar system costs) | 2% |
| Currency Exchange Rate (Vt/$) = | 110 |
| Discount Rate | 10% |

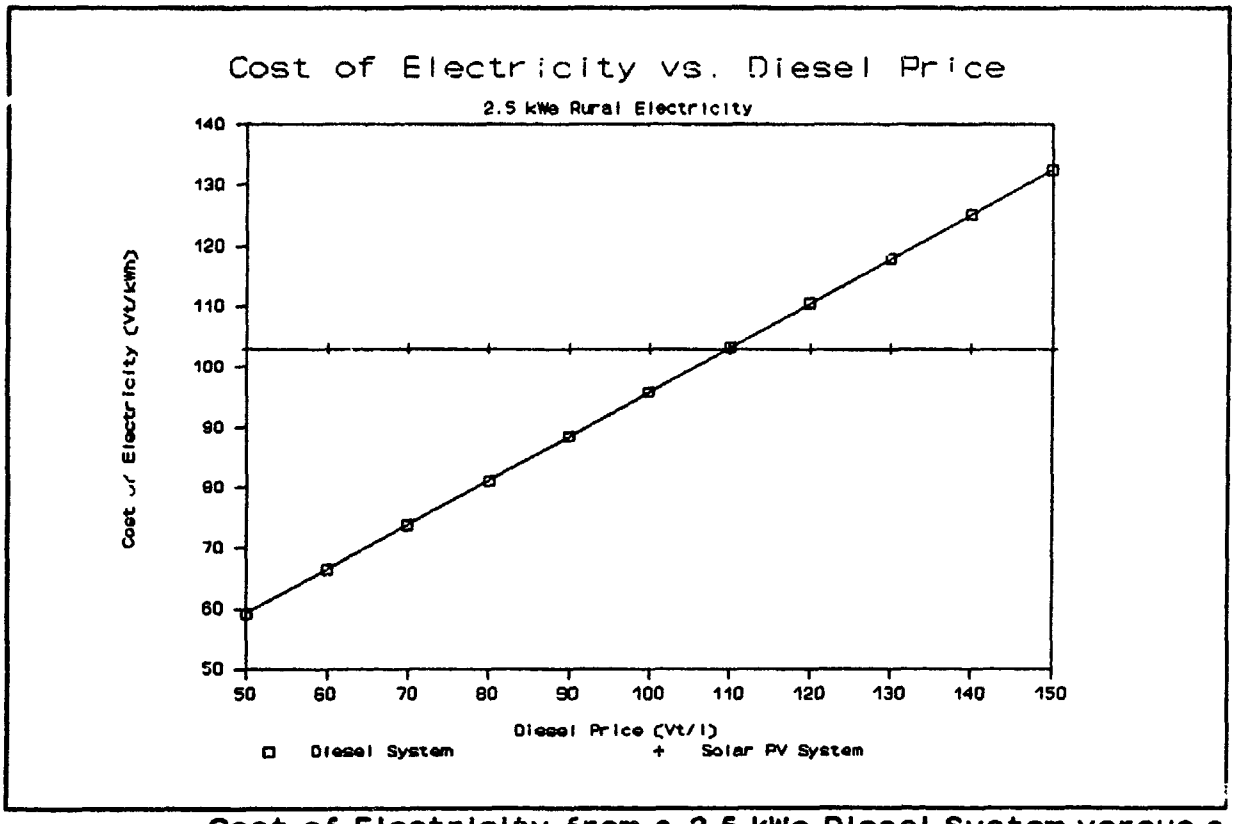
Cost of Diesel versus PV Electric System

| | PV | | Diesel | |
|---|---|---|---|---|
| CAPITAL COSTS | Array | Batteries | Generator | T & D |
| Generator Costs (Vt) | 1,728,571 | | 275,000 | 55,000 |
| Batteries/Fuel Storage (Vt) | | 471,429 | 13,750 | |
| Balance of system costs (Vt) | | 314,286 | 82,500 | 5,500 |
| Total Installed Costs (Vt) | 1,728,571 | 785,714 | 371,250 | 60,500 |
| Lifetime (yr) | 15 | 5 | 6 | 10 |
| Ann. Capital Costs (Vt/yr) | 227,262 | 207,269 | 85,242 | 9,846 |
| ANN. O&M COSTS | | | | |
| Fuel Costs (Vt/yr) | 0 | 0 | 288,000 | |
| Other O&M Costs (Vt/yr) | 4,545 | 4,145 | 28,800 | 1,969 |
| Ann. Fuel + O&M Costs (Vt/yr) | 4,545 | 4,145 | 316,800 | 1,969 |
| Annualized System Costs (Vt/yr) | 443,222 | | 413,857 | |
| Costs of electricity (Vt/kWh) | 103 | | 96 | |

VANUATU

ENERGY ASSESSMENT






**Cost of Electricity from a 2.5 kWe Diesel System versus a Solar PV System**

IBRD 22987

# VANUATU
# ENERGY ASSESSMENT
## Energy Resources

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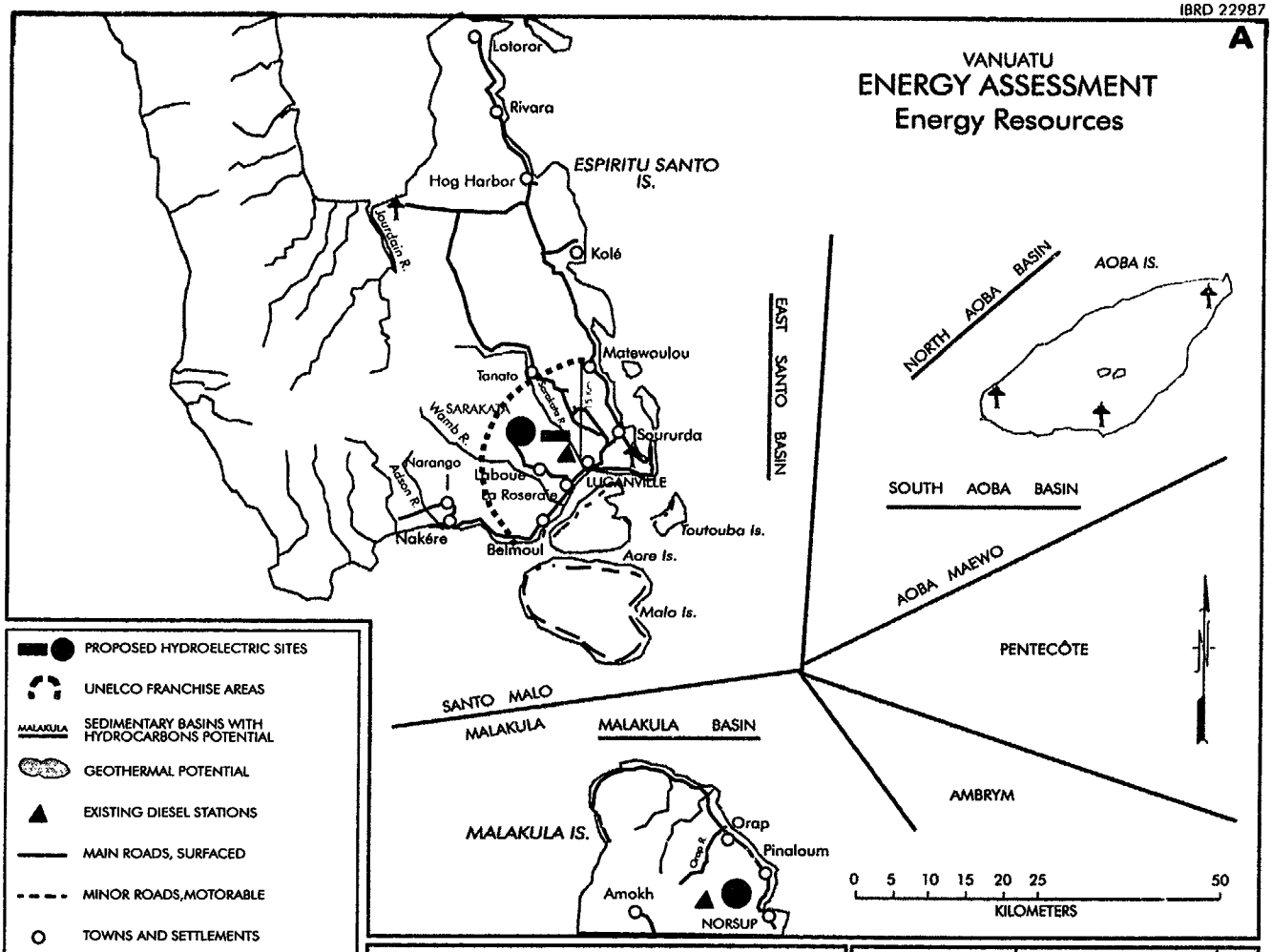


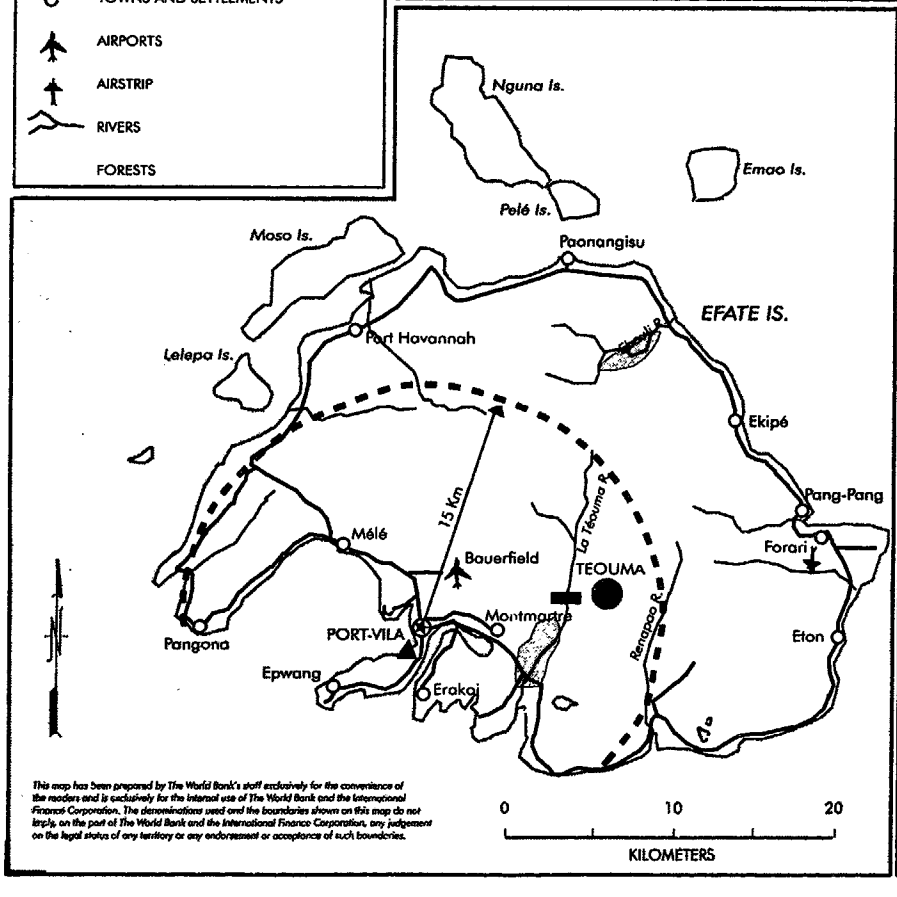


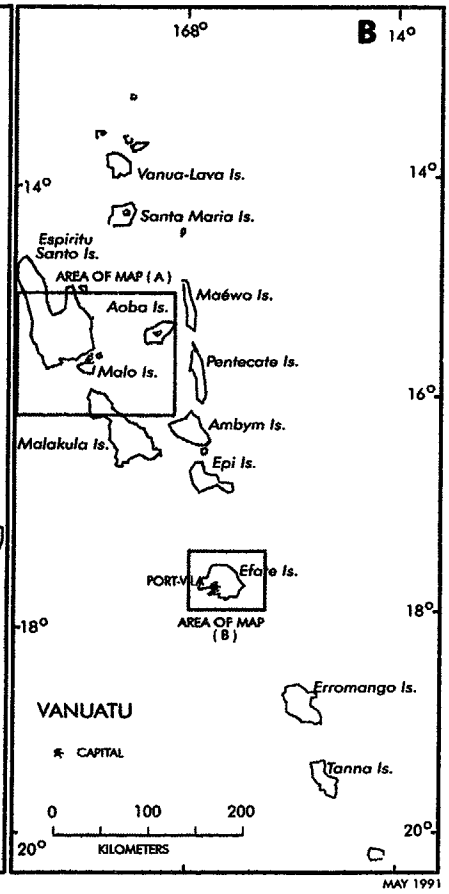


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