Report No. 5577-VA

Vanuatu: Issues and Options in the Energy Sector

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Report No. 5577-VA

VANUATU

ISSUES AND OPTIONS IN THE ENERGY SECTOR

JUNE 1985

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ABSTRACT

Vanuatu has an open economy -- its trade accounting for about 80% of GDP. However, because the export sector is very dependent on just a few agricultural products, the economy is vulnerable to wide fluctuations in the world prices of essential imports such as petroleum products. Although Vanuatu has a diverse indigenous energy resource base consisting of hydropower, geothermal reserves and substantial natural forest, rapid development of this potential has been hampered by inadequate inventories and a shortage of skilled manpower. The result is continued overdependence on imported petroleum products for commercial energy needs. This report reviews the energy sector of Vanuatu and recommends: (a) development of a regional least-cost strategy for procuring petroleum products; (b) institutional modification in the power sector to establish guidelines for development, generation and distribution of power; (c) analysis of the economic costs of public power supply; (d) acceleration of hydropower development investigations; and (e) continued encouragement of economic use of indigenous energy resources in power generation and agroindustries.

ABBREVIATIONS

ADB	Asian Development Bank
ADO	Automotive Diesel Oil
CES	Compagnie d'Electricité de Santo
CHOGRM	Commonwealth Heads of Government Regional Meeting
EDF	European Development Fund
EEC	European Economic Community
ESCAP	Economic and Social Committee for Asia and the Pacific
GOV	Government of Vanuatu
MLERWS	Ministry of Lands, Energy and Rural Water Supply
ORSTOM	Office de la Recherche Scientifique et Technique Outre-Mer
SPC	South Pacific Commission
SPEC	South Pacific Bureau for Economic Co-operation
UNELCO-Vanuatu	Union Electrique du Vanuatu
UNPEDP	United Nations Pacific Energy Development Programme
WFPS	Wood Fired Power Station

CURRENCY EQUIVALENTS

1 US$ = VT 98.4 (March 1983)
1 US$ = VT 96.1 (April 1984)

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
p.a.	per annum		
TOE (toe)	tonne of oil equavalent		
tonne	metric ton		
Tpa (tpa)	tonnes per annum		

This report is based on the findings of an energy assessment mission which visited Vanuatu in April 1984. The mission comprised Maria Kiwana (Mission Leader), Jakob Diddens (Power Economist-Consultant), and Zahid Khan (Biomass Gasification - Consultant). The mission benefitted from discussion with staff of the South Pacific Bureau for Economic Co-operation (SPEC) and the United Nations Pacific Energy Development Programme. Assistance in reviewing technical information was provided by Messrs. Akin Oduolowu (petroleum exploration) and B. Chronowski (wood-fired steam power stations). The report was discussed with the Government in May 1985.

ENERGY CONVERSION FACTORS

		TOE Per Physical Unit 1/
Liquid Fuel	(tonnes) 2/	
	Avgas	1.04
	LPG	1.08
	Gasoline	1.05
	Kerosene/Turbo Fuel	1.03
	Diesel Oil (ADO)	1.02
Electricity	(MWh) 3/	0.25
Biomas Fuels	(tonnes)	
	Firewood	0.33 - 0.35
	Coconut Husk	0.41
	Coconut Shell	0.51
	Coconut Palm Wood	0.27
	Coconut Husk and Shell (73% husk, 27% shell)	0.44

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

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

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SUMMARY OF FINDINGS AND RECOMMENDATIONS

Introduction

1. Vanuatu is made up of 80 widely scattered islands with a population of 124,000 in mid-1983. Owing to the lack of essential infrastructure such as transportation and communication, over 80% of the people live in small, dispersed rural settlements and depend mostly on subsistence agriculture for their living. As a result electric energy demand has been concentrated mainly in the two urban centers of Port Vila (Efate Island) and Luganville (Santo Island), and the transport sector plays a vital role in the collection and distribution of commodities, with consequent emphasis on gasoline and automotive diesel oil (ADO). Fuelwood demand (80% of primary energy demand) is adequately satisfied due to the dispersed population pattern and substantial natural vegetation. Unlike some other Pacific Island countries, Vanuatu has hydropower potential, geothermal reserves and the possibility of offshore hydrocarbons in addition to its substantial fuelwood resources. However, this energy base is still largely unquantified and Vanuatu will continue to rely on imports of petroleum products to meet most of its commercial energy requirements in the medium term.

2. The main issues for the immediate future concern: (a) minimizing petroleum product import costs; (b) modifying the institutional set-up of the electricity sector to ensure the operation of the electricity systems incorporates national economic efficiency criteria as well as the financial interests of the power utilities; (c) accelerating hydro power development investigations; (d) increasing the economic use of indigenous energy resources for power generation and agro-industrial process heat requirements. Little needs to be done in the area of demand management since Vanuatu is already receiving external assistance in this area. In the long-term, Vanuatu may require further assistance in evaluating and developing its indigenous hydrocarbon and geothermal potential.

Country Background

3. Vanuatu's economic performance has exhibited steady growth over the last three years. Between 1981 and 1983, growth averaged 2-3% per year. This growth can be attributed mainly to increased agricultural production/exports and tourism. The major economic tasks facing the country are: (a) the gradual phasing-out of British and French budgetary support grants; and (b) further integration of the dualistic economy which is strikingly divided between a small modern expatriate-dominated sector and a large rural-based ni-Vanuatu sector. In view of these constraints, the Government (GOV) has widened its revenue base and contained government expenditure while at the same time emphasizing the long-term expansion of the agricultural sector and the encouragement of

private investment. The mission has used an assumed GDP growth rate of 3% p.a. beyond 1985 as a basis for its energy demand projections (paras. 1.1-1.8).

Petroleum

4. Vanuatu is totally dependent on imports for its petroleum requirements. Although the petroleum import bill is not yet critical, GOV is concerned about the potential impact of future petroleum price increases on Vanuatu's volatile export earnings e.g., the petroleum bill has ranged between 30%-60% of domestic exports as a result of fluctuating world prices for agricultural products (para. 1.9).

5. GOV has already ensured that the full cost of petroleum imports is passed on to the final consumer. Further, petroleum displacement opportunities are mainly confined to the power sector (30% of total petroleum demand). Therefore, the other major cost minimizing possibility is in the procurement and supply logistics area. Vanuatu's internal petroleum requirements are relatively modest (17.07 megalitres in 1983). However, if Vanuatu were to pool its requirements with those of other Pacific Island countries, the combined import package should provide sufficient incentive for an established major oil company to quote lower f.o.b. and freight rates. Therefore, the mission recommends a regional technical assistance mission visit Vanuatu, Fiji, Papua New Guinea, Solomon Islands, Tonga and Western Samoa, which altogether account for over 95% of the South Pacific Island petroleum demand (about 1,160 megaliters in 1981). The objective would be an economic and technical evaluation of a possible regional petroleum supply arrangement (para. 3.5-3.10).

Electricity

6. The public electric power supply system is entirely based on automotive diesel oil (ADO) and consists of two urban power systems around Port Vila (6.3 MW) and Luganville (1.1 MW), and three small rural systems (combined capacity 0.24 MW) at local government centers on Tanna and Malakula. The rural systems are operated by the Public Works Department. The Port Vila system is operated by UNELCO-Vanuatu, a private foreign-owned utility; and the Luganville system is operated by Compagnie d'Electricité de Santo (C.E.S.), a UNELCO-Vanuatu subsidiary (paras. 2.14-2.19).

Sector Administration

7. Under the Port Vila Concession Agreement, UNELCO-Vanuatu -- a technically competent foreign-owned firm -- is allowed to generate, distribute and charge for public electricity. Due to lack of financial

monitoring, GOV is unable to determine the realistic cost of public electricity supply. It is important that GOV be able to play an active role in monitoring the utility's operations and to develop a long-term strategy to deal with the power sector. Therefore, GOV and UNELCO-Vanuatu should agree upon a strategy to formulate: (a) a financial reporting provision; and (b) guidelines for future generation and distribution of power -- as distinct from routine operational policy (paras. 3.9-3.12). The mission recommends that GOV and UNELCO-Vanuatu request technical assistance for this purpose.

Power Tariffs

8. Little information was available concerning the present economic cost of power supply and only very broad observations could be made about the current power tariff structure and levels. In order to ensure that decisions about future system expansion reflect economic efficiency criteria as well as social objectives and the financial viability of the power utility, the mission recommends that GOV and UNELCO-Vanuatu undertake a joint analysis of the economic costs of power supply on the Port Vila system (paras. 3.13-3.18). This analysis should be a component of the proposal discussed in para. 7 above.

Power System Expansion

9. Indigenous energy resources for near-term displacement of diesel in power generation include biomass and hydro. Pending the development of Vanuatu's hydro resources, GOV is considering the possibility of introducing wood-fired generation capacity on the Port Vila system in an effort to reduce dependence on imported diesel. A feasibility study is being prepared by UNELCO-Vanuatu in partnership with Heilbonn GmbH, a West German supplier of wood-fired power stations (WFPS).

10. Wood-fired Power Station (WFPS). A preliminary mission evaluation, based on existing studies, concluded that a WFPS could generate electricity for between US¢10.0/kWh-US¢17.0/kWh as compared to an estimated economic cost of US¢11.0/kWh for ADO. This indicates that any upward change in WFPS cost assumptions concerning delivered fuelwood costs, operation and maintenance requirements or capital investment costs could result in wood-fired generation that is more costly than ADO generation. Several factors must be considered if any reduction in electricity generation costs is to be realized. First, since a WFPS costs more per unit of installed capacity than an equivalent ADO plant, its economic and financial viability will depend on minimizing capital outlay and operating costs. Second, the delivered cost of fuelwood, an important variable, will depend on whether there is sufficient native forest or other relatively low-cost biomass such as senile coconut stemwood within the WPFS vicinity; or if a dedicated fuelwood plantation would have to be established. Third, the institutional arrangements for: (a) ownership and operation of the WFPS, (b) tariff structure, and (c) revenue sharing between the power utility and GOV would have to be defined before any contractual agreements are made. Therefore, the

mission recommends that GOV request technical assistance to review the forthcoming WFPS feasibility study. In particular, sensitivity analyses should be carried out concerning expected capital costs; operating and maintenance costs; and reliability and delivered costs of woodfuel over the entire project life. It would then be possible to determine the expected economic cost of wood-fired power production compared to other sources of power production (paras. 3.21-3.30).

11. The mission recommends that GOV should not enter into any investment decisions until the WFPS feasibility study has been reviewed and evaluated within the context of a proposed least-cost power system development strategy that would also examine the relative costs and benefits of accelerated hydropower development and the possibility of a mixed thermal-hydro system (Table 1).

12. Hydropower. A program of hydrological surveys initiated in 1981 indicated that the flows on the main rivers on Efate and Santo measured over relatively short periods of a month or so are characterized by a flat minimum discharge volume (sufficient for power generation) interrupted by short peaks. 1983 was a very dry year and there is reasonable confidence that the 1983 flows are representative of long term minimum flows. These are important parameters since there is likely to be only limited scope for constructing significant storage reservoirs. The mission supports the proposed continuation of the hydrological studies and recommends acceleration of further studies of hydroelectric opportunities recently identified on Efate and Santo, with particular attention to optimal development sizing in view of likely demand (paras. 3.31-3.35).

Other Renewables

13. Although there seems to be no present shortage of fuelwood for domestic cooking purposes, GOV wishes to carry out a detailed fuelwood supply/demand survey (including both domestic and agro-processing sectors) aimed at identifying localized areas of shortage and assessing the potential demand for charcoal production and improved cooking stoves. Since there is the near-term prospect of wood-fired steam power generation on Efate and a current proposal to supply charcoal to Efate residents, the mission recommends that the first phase of the fuelwood survey concentrate on the fuelwood demand mix on Efate (paras. 2.26; 3.45). The second phase could then examine the other islands where there is a good prospect that the Forestry Department's Local Supply Plantation program (LSP) will adequately cover any need for fuelwood plantations (para. 2.30).

14. There are several other activities (both proposed and ongoing) in the renewables sector. The mission reviewed these activities against

the background of Vanuatu's relative lack of skilled manpower and anticipated benefits of each project. The significant ones are:

(a) Hot-air Generators. In 1981, GOV initiated the use of woodfueled hot-air generators for copra drying and in 1983 15% of copra production was dried by means of this method. The major advantages of this technique are improved fuel efficiency (70%-85%, as compared to 10% for the open-fire method) and improved quality of the finished copra product, thus fetching a premium of about US$20/ton copra at the producer's level. The mission supports the continuation of this program which is being financed by external aid donors. In the same context, the mission advises that the centralized cocoa-drying facilities at a proposed cocoa plantation on Malakula Island should incorporate a wood-fired hot-air generator instead of the oil-fired boiler currently envisaged (paras. 3.36-3.37).

(b) Power Gasification. As part of the regional EEC-financed energy programme, Vanuatu is to receive a 50 KW wood-fired gasifier/generator and a 75 kVA charcoal-fired gasifier/generator. 1/ In view of Vanuatu's widely dispersed population, the mission supports these pilot projects, which will continue investigating the viability of gasifier systems for rural electrification as an alternative to ADO-fired generation. However, proper project management, extensive performance monitoring, and detailed record-keeping will be essential (paras. 3.38-3.40).

(c) Solar Energy. A rural lighting pilot project funded by the South Pacific Commission (SPC) and based on a photovoltaic system is to be established in Vanuatu. The mission recommends that GOV monitor and evaluate the results of this project and others elsewhere in the Pacific before deciding on extensive use of public funds to finance photovoltaic lighting on a large scale (para. 3.41).

(d) Ethanol. A low-technology pilot scheme to produce ethanol from cassava on Tanna as a substitute for petroleum fuels in industry and/or an additive to petroleum in transport is at a standstill due to lack of qualified operating personnel. Activities elsewhere have indicated that ethanol production from cassava is unlikely to be economic; therefore the mission recommends that GOV should not reactivate this project (paras. 3.42-3.43).

1/ The pilot projects have now been combined into one project consisting of a 25 kVA wood-fired gasifier/generator.

Energy Resource Evaluation

Geothermal

15. A geothermal resource has been identified on Efate within reasonable distance of the main demand centre (Port Vila). Of a three-phase investigation program, the first phase consisting of a geological and geochemistry survey has been completed. New Zealand has committed funds for the second phase, which entails geophysical surveys and some drilling for shallow heat flow measurements; if the results so warrant, a third phase of deep-well drilling (200 metres) will be implemented. 2/ Although preliminary economic evaluation indicates that geothermal energy could be comparable to hydro-generation, this option cannot be included in Vanuatu's overall energy planning policy until the whole program has been completed (within 4-5 years); and can therefore only be viewed as a long-term option (para. 2.3).

Hydrocarbons

16. Evaluation of offshore geophysical surveys carried out in the Central Basin of Vanuatu in the last two decades indicates that certain sediment thicknesses and structures within the basin are promising areas for potential hydrocarbon resources. The Malakula offshore areas in particular are considered worthy of future exploration. A further offshore geophysical survey is to be undertaken in the central basin of Vanuatu; seafloor sampling will also be carried out. These will further delineate significant structures and correlate seismic stratigraphic units with seafloor lithologies. At that time, it will be possible to evaluate the need for preparing a comprehensive data package aimed at the oil industry which has already expressed interest in the ongoing surveys (paras. 3.46-3.50).

Implications for External Assistance

17. A certain amount of technical assistance activity is already taking place in Vanuatu, as shown in Annex 9. However, the mission considers that the following areas warrant immediate and detailed attention: (a) least-cost petroleum supply strategy; (b) electricity sector administration; (c) review of potential wood-fired steam generation; (d) acceleration of the hydropower development program; and (e) the continued encouragement of more energy-efficient methods for crop-drying purposes. Medium to long-term technical assistance needs are for energy resource data collection and there is already some indication that these

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2/ Due to improved survey techniques, no shallow drilling will be required in the second phase.

needs will be met by some of Vanuatu's major aid donors (Table 1; Annex 10). At present, the major energy investment requirement appears to be between US$5.0-US$8 million for a 3 MW wood-fired power station. Investment needs for other capital projects such as potential expansion of petroleum storage facilities and introduction of hydropower generation can be defined once the recommended technical assistance activities are completed.

18. It is expected that the main functions of the incoming ADB-funded Energy Advisor to the Ministry of Lands, Energy and Water Supply (MLERWS), which is responsible for energy policy and planning, will be: (a) coordination between MLEWS and the various implementing agencies in the energy subsectors; and (b) the preparation of an appropriate energy policy and development program for Vanuatu. This should include supervision of the recommended technical assistance activities. The mission also recommends that local counterparts be recruited to be trained by the Energy Advisor in coordinating and monitoring developments in the energy sector (paras. 4.1-4.5).

Table 1: PRIORITY ACTION PROGRAMME

		Estimated Cost (US$)
Petroleum		
(i)	a regional mission to six South Pacific countries, including Vanuatu, to carry out a detailed economic and financial evaluation of alternative regional petroleum supply options; and to design a framework for implementing recommended supply options.	85,000 a/
Power		
(ii)	assistance to GOV in discussions with the public power supply concessionaire (UNELCO-Vanuatu) concerning modification of present concession agreement to include financial reporting requirements; and guidelines for future operation, distribution and pricing of electricity.	70,000
(iii)	an objective review of the forthcoming feasibility study for a proposed WFPS, especially fuel resource evaluation; optimal plant siting and technical configuration; and contractual arrangements proposed.	65,000
(iv)	further investigation of hydroelectric development opportunities including potential optimal sizing of developments and updating of previously established capital costs and expected benefits; and preparation of least-cost power system expansion program considering wood-fired generation, hydrogeneration and mixed hydro-thermal generation.	90,000
Renewables		
(v)	feasibility evaluation of wood-fired drying facilities (hot-air generators) at proposed cocoa plantation on Malekula Island including fuel resource evaluation over the plant life; financial and economic analysis of project merits and additional investment requirements.	25,000
Energy Resource Evaluation		
(vi)	continuation of current hydrological data collection program.	60,000 b/
(vii)	geothermal investigation program.	N/A c/
	Total	395,000

a/ To be financed and executed by the joint UNDP/World Bank Energy Sector Management Assistance Programme (ESMAP).

b/ There is a possibility that the European Development Fund (EDF) will finance this work.

c/ To be funded by New Zealand.

I. ENERGY AND THE ECONOMY

Country Background

1.1 The Republic of Vanuatu consists of 80 islands, geographically scattered in The Pacific Ocean, between Fiji and the Solomon Islands, with a land area of about 12,200 km^2. It attained independence from the joint British-French Condominium in 1980. 3/ The largest islands are Espiritu Santo (4,010 km^2); Malakula (2,053 km^2); and Efate (923 km^2). The mid-1983 population was estimated at 124,000 and growing at about 2.5% p.a. Most of the people (85%) live in scattered coastal settlements averaging about 50 inhabitants. The urban centres are the capital, Port Vila on Efate, and Luganville on Santo, with 16,000 and 5,000 inhabitants respectively.

1.2 The economy is dualistic with a large subsistence agricultural sector (80% of the work force), and a small modern sector which is dominated by agroprocessing industries and the public sector, as shown in Table 1.1. The modern sector also encompasses trading, shipping, tourism, banking (including an offshore Finance Center) and manufacturing; it accounts for much of foreign exchange earnings and government revenue.

1.3 Pre-independence disturbances in 1980 disrupted the domestic economy; however, economic performance improved steadily between 1981-83, with estimated real GDP growth of about 3% p.a. in 1983. This reflects a marked increase in the production and exports of copra and expansion of the construction, tourism and manufacturing sectors.

1.4 In the absence of official national accounts, 1983 GDP is roughly estimated at VT 8.4 billion. This translates into per capita GDP of about US$650; however, the rural per capital income (excluding expatriate income) is reckoned to be less than US$250. Table 1.1 illustrates the dualism of the Vanuatu economy, where a small modern sector including Government services provides a substantial proportion (80%) of GDP.

3/ The Condominium governed Vanuatu from 1906-1980 when it was known as the New Hebrides.

Table 1.1: VANUATU: COMPONENTS OF GDP
(percent)

	1980	1983
Agriculture a/	19	19
Government Services	42	38
Commerce	13	20
Other services b/	9	12
Other	17	11

a/ Including forestry and fisheries.
b/ Finance, insurance, business.

Source: IMF Staff Estimates.

1.5 International trade plays an important role in Vanuatu's economy; domestic exports are equivalent to about 20%-25% of GDP, while imports constitute 50%. Nearly all imports and exports are unrestricted. Vanuatu's main domestic exports are copra, cocoa, beef, and timber, as shown in Table 1.2. below.

Table 1.2: MAIN DOMESTIC EXPORT CATEGORIES
(percent)

	1980	1981	1982	1983
Copra	67	76	69	73
Cocoa	11	8	5	10
Meat Products	8	12	18	11
Timber	--	--	2	2
Coconut Oil a/	8	--	--	--

a/ The sole coconut oil mill was destroyed during the civil disturbances of 1980.

Source: National Planning and Statistics Office (NPSO).

1.6 1983 saw a major expansion of exports (73%) due to increased world prices for copra and the improved quality of Vanuatu's copra due to better copra drying methods (para. 2.27). In the same year, imports rose by 14%, reflecting rapid growth in the tourist sector and increased private sector investment. Imports are three to four times greater than exports and are heavily weighted to consumer products such as food and drink, since they reflect the demands of the relatively large expatriate and tourist population, as shown in Table 1.3.

Table 1.3: DOMESTIC IMPORT CATEGORIES, 1983
(percent)

Consumer Products a/	48
Industrial Material	18
Machinery and Equipment	20
Petroleum Products	11
Other	3

a/ Including food and drink.

Source: NPSO.

1.7 Vanuatu's balance of trade (both domestic and total balances) has recorded relatively large deficits in recent years. However, so far the deficits have been more than offset by increased tourist receipts and relatively large, albeit declining, foreign aid transfers. As a result, Vanuatu's current account registered healthy surpluses estimated at VT 1.714 billion in 1983 (about US$18 million).

1.8 The Government of Vanuatu (GOV) faces the task of integrating an economy which is strikingly divided between expatriate 4/ and ni-Vanuatu sectors (paras. 1.2-1.4). At the same time, GOV wishes to raise the country's domestic tax revenue level in order to offset the gradual phasing-out of current budget support aid from the two former Condominium powers. 5/ Accordingly, Vanuatu's First 5-Year Development Plan (1982-86) strategies include (a) better utilization of natural and human resources to achieve higher rates of economic growth and ni-Vanuatu control of the economy; (b) more balanced regional and rural growth with decentralized decision-making; and (c) enhancement of the foreign and domestic private sector contributions to national development. As agreed with GOV officials, the mission based its energy demand forecasts on the assumption that GDP will continue to grow at 3% p.a.

Petroleum Import Bill

1.9 The total petroleum import bill for internal use (excluding bunkering) increased from VT 500 million in 1980 to VT 525 million in

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4/ Including international and domestic banking, the public service, tourism and plantation agriculture.

5/ It is expected that this current budget support (estimated at 20% of total recurrent budget in 1983) gradually will be reduced to zero by 1988.

1983. However, during the same period, internal demand for petroleum products decreased by 25% (Table 2.1). This, combined with a general softening in f.o.b. prices (e.g., Singapore f.o.b. prices fell by about 13% between December 1980 and December 1983), indicates that unit freight cost must have increased significantly. 6/ Although the size of the country's petroleum bill is not yet critical (Table 1.4), GOV is concerned about its impact on volatile export earnings.

Table 1.4: VANUATU: PETROLEUM PRODUCT IMPORT BILL

	1980	1981	1982	1983
Petroleum Imports (VT million)	500	469	579	525
% of Domestic merchandise exports f.o.b	57	33	56	29
% of Imports c.i.f.	14	12	13	10

Source: National Planning and Statistics Office (NPSO).

Energy Balance

1.10 There is a lack of data on sectoral energy consumption, especially pertaining to biomass; however, the mission has attempted to estimate Vanuatu's energy balance for 1983. The balance is only approximate and should be refined once the proposed Energy Unit of the Ministry of Lands, Energy and Water Supply (MLEWS) becomes operational and able to yield more specific data (para. 3.2). The information at hand suggests that 1983 gross energy supply was about 70,400 toe, most of which was biomass (80%). Per capita net energy consumption was about 0.54 toe, which is average compared to other Pacific Island countries. 7/

1.11 Commercial energy consumption is entirely dependent on imported petroleum. Transport accounts for about 52% of total internal petroleum consumption; power generation, 33%; the domestic sector (9%), while the commercial/industrial sector accounts for only 5% of commercial energy. This reflects the low level of industrialization in Vanuatu's economy. There is no evidence of any real energy shortage in the economy and energy supplies cannot be considered to be a constraint to economic

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6/ The vatu appreciated by about 5% against the U.S. dollar between September 1981 and March 1983.

7/ Tonga, 0.37 toe (1983); Western Samoa, 0.51 toe (1983); Fiji, 0.63 toe (1982).

growth at present. For example, inefficiencies in the transport sector are caused mainly by old age of the vehicle fleet and suboptimal patterns of transporting agricultural products. However, GOV is interested in investigating opportunities to reduce the cost of petroleum product requirements. Currently, there are no economic alternatives to petroleum in the transport sector (the dominant user). Therefore, substitution possibilities are confined mainly to the power sector. However, there is the possibility of minimizing the c.i.f. cost of required petroleum imports by streamlining and consolidating Vanuatu's relatively modest petroleum requirements with other South Pacific Island countries (para. 3.5-3.7).

Table 1.5: VANUATU: ENERGY BALANCE, 1983
('000 toe)

	Fuelwood	Agric. Residues	Total Biomass	Electricity a/	Petroleum	Total Energy
Gross Supply						
Production	27.42	29.23	56.65	-	-	56.65
Imports	-	-	-	-	16.18	16.18
International Bunkers	-	-	-	-	(2.41)	(2.41)
Total Supply	27.42	29.23	56.65	-	13.77	70.42
Conversion						
Power Generation	-	-		4.48	(4.48)	-
Station Use/Losses	-	-		(3.05)	-	(3.05)
Net Domestic Consumption	27.42	29.23	56.65	1.43	9.29	67.37
Sectoral Consumption						
Transport	-	-	-	-	7.15	7.15
Industrial	-	-	-	0.07	0.27	0.34
Commercial b/	-	-	-	0.57	0.46	1.03
Domestic	20.46	-	20.46	0.37	1.23	22.06
Crop Drying c/	6.96	29.23	36.19	-	-	36.19
Other d/	-	-	-	0.42	0.18	0.60

a/ Excluding private generation.
b/ Including hotels and restaurants.
c/ Large Coconut Plantations use wood to dry copra; small holders use coconut residues to dry copra.
d/ Agricultural machinery, water pumping, etc.

Source: Mission estimates.

Energy Balance Projections

1.12 The mission has attempted energy balance projections for 1990 and 1995 based on expected GDP growth of 3% p.a. which, although crude, may serve as an indication of future maximum energy demand. The underlying assumptions are (a) transport sector petroleum requirements will grow at 4% due to increased tourism and agricultural product transport needs; (b) population growth will continue at 3% p.a. with similar growth in domestic fuelwood demand; (c) biomass use for crop drying requirements will remain stagnant as more fuel-efficient hot-air generators are introduced; (d) power demand will grow at 5% p.a. as commercial/ industrial and domestic sectors expand; (e) a woodfuel power station is commissioned on Efate to provide base load (16 GWh by 1990); and (f) overall ADO requirements will grow by less than 2% p.a. as increased transport needs are offset by biomass substitution in the power sector.

1.13 As shown in Annexes 1 and 2, gross energy supply increases from 70.42 thousand toe in 1983 to 92.08 thousand toe (1990), to 100.42 thousand toe in 1995, an average annual increase of 3.0% p.a. Net energy consumption shows an increase of only 1.8% p.a. (from 67.37 thousand toe in 1983 to 83.05 thousand toe in 1995). This can be partly attributed to the greater conversion losses involved in biomass power generation.

1.14 The major implications are that (a) imported petroleum requirements will increase at about 2.3% p.a. as transport requirements are partially offset by biomass power generation; and (b) biomass demand will grow by about 3.5% p.a. as a result of population growth and biomass power generation.

II. ENERGY SECTOR OVERVIEW

Energy Resources

2.1 Vanuatu has a diverse energy resource base which still remains to be fully quantified. Immediately available sources include biomass in the form of wood and coconut residues. In the medium term, hydro, geothermal and solar resources may play a significant role. Forest cover is estimated at about 75% of total land area and, in view of the widely scattered population, should be sufficient for national domestic and agroindustrial needs. Of particular interest is a native leucaena forest area at Port Havannah in northwest Efate. Preliminary estimates of the resources are vague (from 900-2,000 hectares); however, it is anticipated that the forest will be utilized on a renewable basis to supply boiler fuel for a proposed 3 MW wood-fired power station (WFPS) planned as the next capacity increment on the Port Vila grid. Therefore it is important that the leucaena forest be quantified as soon as possible (paras. 2.26-2.28; 3.24-3.25). Coconut cover in Vanuatu is estimated at 69,000 ha with a 25-50% senility factor. 8/ As a result, GOV has initiated a coconut replanting program which would be greatly assisted if an end use were identified for the senile coconut stemwood such as boiler fuel for the WFPS (para. 2.32).

2.2 Vanuatu's hydroelectrical potential has not yet been evaluated to a significant extent. However, a hydrological survey program initiated in 1981 and covering the major rivers and potential hydro sites indicated that there is a medium-term possibility of economic hydro generation on both Efate and Santo (para. 3.31). The mission supports GOV's wish to continue and expand its hydrological program and recommends accelerating investigation of hydroelectric opportunities (paras. 3.32-3.25).

2.3 Geothermal resources have been identified on the island of Efate, on the northern coast, and in the central river valley. A three-phase investigation program was drawn up and the first phase, which involved locating potential sites for geothermal drilling, has been completed. 9/ The temperature of the resource is relatively low (165-180). The second phase of the study will include geophysical surveys and some shallow heat-flow drilling. Encouraging results of the second phase would lead to a third phase including deep well drilling. The mission considered this work to be relevant within Vanuatu's energy context, but not of priority at this time. The timing of these activities is such that sufficient data will become available to compare to other power alternatives such as hydro for post 1995 implementation.

8/ Coconut palms over 50 years old.

9/ Financed by the New Zealand Government.

2.4 The solar regime is apparently good, but poorly defined in Vanuatu. Solar energy can have a role to play in small-scale, remote power development, water-heating and crop drying. Long term monitoring of solar insolation at major population centers will prove helpful. 10/

Petroleum Sector

Historical Demand

2.5 Petroleum product imports for internal consumption consist of liquefied petroleum gas (LPG), petrol (gasoline), illuminating paraffin (kerosene), aviation gasoline (avgas), and automotive diesel oil (ADO). Turbo jet fuel and industrial diesel oil are also imported for consumption by international airlines and a foreign-owned, Santo-based fishing company (South Pacific Fishing Company) respectively. However, these products are considered to be imports for re-export and the accounts are settled externally.

2.6 As shown in Table 2.1, internal petroleum product demand dropped in 1981 with the sharp decline in economic activity due to pre-independence civil disturbances that affected the economy that year. Although total petroleum demand has since increased at about 5% p.a. it has not yet recovered to 1980 level. Gasoline is the only product that has failed to reverse its declining trend, which is probably due to a 13% price increase during the period (para. 2.12; Annex 3).

Table 2.1: PETROLEUM PRODUCT IMPORTS (megaliters)

	1980	1981	1983
AV Gas	1.37	0.26	0.79
LPG	1.67	0.57	1.10
Kerosene	1.40	1.10	1.19
Gasoline	10.00	6.69	6.31
ADO	8.39	6.80	7.68
Total Internal Demand	22.83	15.42	17.07
Jet Fuel	4.78	2.73	2.88
Total Demand	27.61	18.15	19.95

Source: NPSO.

10/ CHOGRM has provided photovoltaic equipment for water pumping and radio communication together with a pyrheliometer for recording solar radiation.

2.7 The transport sector is the dominant user of petroleum, accounting for 53% of total consumption. Currently all power generation is based on ADO, and accounted for 31% of total petroleum product consumption in 1983 (68% of total ADO requirements). The household sector accounted for 9% of direct petroleum demand, in the form of kerosene and LPG. The remaining 7% was comprised of ADO consumption by mechanized agriculture and industrial steam-raising; and LPG demand by hotels and restaurants as shown in Table 2.2.

Table 2.2: 1983 SECTORAL CONSUMPTION OF PETROLEUM a/
(megaliters)

	Transport	Power Generation	Households	Other b/	Total
AvGas	0.79	-	-	-	0.79
Gasoline	6.31	-	-	-	6.31
ADO	1.95	5.21	-	0.52	7.68
Kerosene	-	-	1.19	-	1.19
LPG	-	-	0.35	0.75	1.10
Total	9.05	5.21	1.54	1.27	17.07

a/ Based on 1983 petroleum imports.
b/ Industry, restaurants, hotels, machinery, etc.

Source: Mission estimates.

Petroleum Demand Projections

2.8 Future petroleum demand will be substantially affected by GOV's plans for expanding the tourist and small-scale industrial sectors; and increased efficiency in the production and marketing of export products (mainly agricultural). Another factor to be considered is the potential displacement of ADO by indigenous hydro and/or biomass sources in the power sector (paras. 3.21-3.34).

2.9 Preliminary estimates by the mission indicate that total internal petroleum demand will increase from 13.77 thousand toe in 1983 to 18.92 thousand toe in 1995 (Table 2.3) -- an average growth rate of about 2.5% p.a. The underlying assumptions include (a) transport demand will grow at 4% p.a. (higher than anticipated GDP growth of 3% p.a.) in line with increased tourism and agricutural product marketing; (b) the demand for kerosene and LPG by residences and hotels/restaurants will rise by 3% p.a. due to population growth and commercial expansion; and (c) overall ADO demand will stagnate as transport needs are offset by hydro and/or biomass substitution in the power sector (para. 3.21-3.30). In the event of delayed substitution of ADO generation capacity, ADO requirements will

rapidly increase to result in total petroleum demand of 22.74 thousand toe by 1995 (an average annual increase of 4.3% p.a.).

Table 2.3: PETROLEUM PRODUCT DEMAND PROJECTIONS ('000 toe)

	1983	1990	1995
AvGas	0.58	0.76	0.93
LPG	0.69	0.85	1.00
Kerosene	1.00	1.23	1.43
Gasoline	4.89	6.43	7.83
ADO	6.61	9.14	11.55
ADO substitution by indigenous a/ energy sources	-	(3.82)	(3.82)
Total Demand	13.77	14.59	18.92

a/ Anticipated ADO displacement by woodfuel power generation and/or hydro generation.

Source: Mission estimates.

Pricing

2.10 Since 1979, Vanuatu has employed an averaging system to ensure a uniform maximum wholesale and retail price throughout the country, i.e. landed prices in Port Vila and Santo are "weighted up" by the additional costs of delivery to the outer islands.

2.11 Wholesale and retail prices for gasoline, ADO and kerosene are determined by the Price Controller (Ministry of Finance). Pricing decisions are based on marketing companies' quarterly submissions regarding adjustments in company margins due to movements in c.i.f. cost, changes in distribution costs, and exchange rate variations. No internal mechanism exists to verify these submissions or various cost estimates and the final adjustments are an outcome of a negotiated level between the companies and the government. GOV wishes to improve its ability to review price adjustments and is participating in a series of workshops on petroleum pricing procedures. 11/

11/ Organized by UNPEPD for South Pacific Island countries.

2.12 The relative customs duties on each petroleum product are determined according to GOV's budget needs. For example, between 1982 and 1983, there was a 15% decrease in the c.i.f. cost of gasoline; whereupon gasoline customs duty was increased from 8 VT/liter to 16 VT/liter in February 1984. GOV has made sure that the full costs of procurement are passed on to the consumers. Therefore retail prices fully reflect the cost of imports as reported (Table 2.4). However, the mission recommends that GOV should ensure that the tax differential between gasoline and ADO does not widen to the extent of causing distortion in their relative demand-mix.

Table 2.4: PETROLEUM PRODUCT PRICING STRUCTURE
PORT VILA, FEBRUARY 1984
(Vatu per liter)

	Petrol	ADO	Kerosene
C.I.F. (Vila)	30.198	29.432	30.768
Customs a/	20.530	2.471	2.538
Onshore costs & margins	10.960	10.593	10.710
Cost adjustment b/	0.145	0.102	0.180
C.I.F. adjustment c/	0.595	0.512	0.535
Wholesale price (Vila)	62.428	43.110	44.731
Weighted average wholesale price(Vanuatu	62.95	43.822	46.195
Retail margin	6.05	3.178	3.805
Retail price	69.00	47.00	50.00

a/ 16 VT/L + 15% on c.i.f. (petrol)
1 VT/L + 5% of c.i.f. (ADO)
1 VT/L + 5% of c.i.f. cost (kerosene)

b/ Half the difference between onshore costs and margins during the previous 6 months.

c/ Variation of exchange rate during the previous period multiplied by the new, averaged c.i.f.

Source: Ministry of Finance.

2.13 There are no government controls on the pricing of LPG which is imported in bulk from Australia by Boral Gas (Vanuatu) Ltd., who also is responsible for storage and distribution. The f.o.b. cost of LPG is about US$291/tonne and is based on world parity prices. The freight cost is relatively high -- US$259/tonne -- and is probably a function of the small market volumes and the long shipping distances. The LPG depot in Port Vila is to be relocated on grounds of risk and safety. In order to minimize the costs of relocation, GOV is investigating the possibility of alternative supply arrangements including the use of 11-tonne container-

ized portable LPG tanks which could be carried as general deck cargo on multi-cargo voyagers. LPG procurement and supply options will also be evaluated under the proposed regional petroleum product procurement and supply analysis (paras. 3.3-3.8).

Electricity Sector

Supply

2.14 The electric supply system of Vanuatu is totally diesel-based and consists of: (a) an urban power system around Port Vila on Efate, operated by a private French company Société d'Union Electrique du Vanuatu (UNELCO-Vanuatu); (b) a second urban system for Luganville on Santo, operated by a private company Compagnie d'Electrique de Santo (CES) and owned 85% by UNELCO-Vanuatu; and (c) three small rural systems, two on Malekula and one on Tanna, operated by the Public Works Department (PWD). Table 2.5 shows basic 1983 electricity statistics for Vanuatu. 12/

Table 2.5: VANUATU PUBLIC POWER SUPPLY STATISTICS, 1983

	Port Vila	Luganville	Other
Installed capacity (MW) a/	4.97	1.09	0.24
Peak Demand (MW)	3.6	0.49	n/a
Load Factor (%)	50	n/a	n/a
Generation (GWh)	15.8	2.4	0.1
Losses (%)	7	4	n/a
Capacity factor (%) b/	36	25	n/a
Fuel use (megaliters)	4.39	n/a	n/a

a/ A further 1.4 MW of diesel capacity is to be installed in 1984 in Port Vila.

b/ Capacity factor is a ratio of average demand to installed capacity.

12/ A number of government agencies and private industries, institutions and persons operate their own small systems throughout the country. The largest private power generator is the South Pacific Fishing Company, an "enclave" type operation on Santo which generates about 1.7 GWh from a 900 kVA plant (1980). Data on the other systems was not available.

Urban Power Supply

2.15 UNELCO-Vanuatu provides reliable power to its Port Vila customers in a technically efficient manner. However, institutional modifications will be necessary to ensure that the urban public power sector, including the Luganville system which is operated by CES (UNELCO-Vanuatu's subsidiary), is operated within the framework of national economic efficiency (paras. 3.9-3.12).

Rural Power Supply

2.16 Overall responsibility for the small power systems on Malekula and Tanna has been transferred from the Public Works Department (PWD) to the Ministry of Lands and Energy (MLE). However, in view of its relative lack of technical capability, MLE will leave the daily operations to PWD, while retaining responsibility for electricity policy matters. The mission also recommends that PWD receive a direct allotment from rural electricity revenues to cover its operating costs, rather than the present system under which such revenues are totally incorporated into general Treasury revenue.

Demand

2.17 As shown in Table 2.6, the Port Vila system (run by UNELCO - Vanuatu) accounts for over 83% of total generation. Between 1978 and 1983, Port Vila generation grew at an average annual rate of 4.9%. Generation fell by 2.3% in 1981 due to pre-independence disturbances, but has continued its trend of growth since then. Seasonal load variations are pronounced: peak demand in January 1983 was 3.6 MW compared to 2.5 MW peak demand in July 1983. This is probably due to increased air conditioning load in the hot wet season (January-March).

Table 2.6: VANUATU PUBLIC ELECTRIC POWER GENERATION, 1978-1983
(GWh)

	1978	1979	1980	1981	1982	1983	Average Annual Growth Rate
							(%)
Generation							
UNELCO-Vanuatu	12.5	13.5	14.4	14.0	14.9	15.8	4.9
CES	2.2	2.6	2.2	2.3	N/A	2.4	1.8
Total	14.7	16.1	16.6	16.3	N/A	18.2	4.4
Sales							
UNELCO-Vanuatu	11.6	12.6	13.3	13.0	14.0	14.7	4.9
CES	2.0	2.4	1.9	2.1	N/A	2.3	1.9
	13.6	15.0	15.2	15.1	N/A	17.0	4.6

Source: UNELCO-Vanuatu.

2.18 About 15% of urban and surburban households have access to electricity; 80% of the electricity subscribers are foreign residents. Sales to final consumers grew by about 4.9% in the Port Villa system between 1978-83. Although a breakdown of sales by sector was not available, GOV and its agencies are estimated to account for 25% of electricity consumption. The two large hotels accounted for 15%, while the water-pumping station consumed 5%. The remaining 55% was divided between industry/commerce and households.

2.19 Sales on Luganville are primarily to the household sector dominated by foreign residents, and to the commercial and official sectors. As in the Port Vila system, industrial consumption of electricity is negligible. 1983 sales on Tana were about 0.04 GWh to 75 consumers; Malekula sales were about 0.04 GWh to 110 consumers.

Power Demand Forecasts

2.20 UNELCO-Vanuatu has prepared power demand forecasts for the Port-Vila system through 1990 (the expiration year of UNELCO-Vanuatu's present concession) as summarized in Table 2.7 (see Annex 4).

Table 2.7: PORT VILA SYSTEM-UNELCO-VANUATU DEMAND FORECASTS

	Actual 1983	1985	1987	1990	Average Growth p.a. (%)
Generation (GWh)	15.8	19.5	23.2	29.4	9.3
Sales (GWh)	14.7	16.9	22.0	28.0	9.6
Peak Demand (MW)	3.6	4.5	5.2	6.4	8.6

Source: UNELCO-Vanuatu.

2.21 These forecasts imply a high average annual growth rate for sales of 9.6% p.a. compared to 4.8% p.a. growth between 1978-1983; and a reduction in losses from 7% in 1983 to 4-5% after 1983. In the mission's view, there are three important but unpredictable factors that will affect load growth in Port Vila. First, there are many proposals for significant industrial and commercial development which have been investigated at various levels of intensity. However, there is a general concensus that few of the potential investment projects will be realized until the outcome of discussions between GOV and the investment community

regarding security of tenure. 13/ Second, the uncertainity regarding the institutional relationship between GOV and UNELCO-Vanuatu (para. 3.9-3.12) precludes significant power sector investment by either party during the remainder of the concession period. Further, the current practice of charging substantial capital contributions from potential power consumers and the relatively high tariffs as perceived by small industrial and commercial clients (paras. 3.14-3.19) have resulted in several cases of self-generation by relatively small commercial/industrial establishments, with more to come, although some such decisions are based on over-optimistic assessments of self-generation costs. 14/

2.22 In view of the variables discussed in para. 2.21 above, UNELCO-Vanuatu's forecasts may be considered very optimistic. In the event that the conclusion of GOV negotiations with UNELCO-Vanuatu and the investment community are delayed, the mission has prepared an alternative forecast (Table 2.8). The demand is based on: (a) the historical demand growth trend of 5% p.a.; (b) peak demand also grows at 5%; and (c) continuation of system load-factor at 1983 levels of 0.5. It is acknowledged that the forecast is extremely rudimentary and must be further refined according to future developments.

Table 2.8: REVISED DEMAND FORECAST FOR PORT VILA

	1983 (Actual)	1985	1990	1995
Generation (GWh)	15.8	17.4	22.2	28.4
Sales (GWh)	14.7	16.2	20.7	26.4
Peak Demand (MW)	3.6	4.0	5.1	6.5

Source: Mission estimates.

2.23 Summary. Because of the uncertainties described in para. 2.21, there could be a substantial latent demand that might emerge if all issues are satisfactorily settled. Therefore, the UNELCO-Vanuatu demand forecast could be viewed as an optimistic scenario, while the mission

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13/ GOV has already held discussions with the investment community over an extended period. One tangible result has been a recent move by GOV to establish security of tenure of potential land leases.

14/ For example, several enterprises in a new Industrial estate just outside Port Villa are planning to invest in their own wood-fired generation facilities.

forecast is the base-case scenario, assuming continuation of the present situation. According to mission forecasts, additional capacity for the Port Vila system will be required by 1985/86 (para. 3.20-3.34).

2.24 Lunganville System. Since this system is operated by CES (a UNELCO-Vanuatu subsidiary) along similar lines as in Port Vila, the same factors discussed in para. 2.22 make load growth in Luganville equally uncertain. Potential sources of increased demand are (a) the prospective rehabilitation of the coconut oil mill (which was destroyed in 1980) and whether it would draw on the Luganville system for a significant portion of its power needs; and (b) the "enclave" South Pacific Fishing Company which could also draw on the grid. Either of these two entities alone could nearly double the present Luganville system demand (2.6 GWh p.a.). The mission's crude demand forecast for the Luganville system was based on the assumption that sales and peak demand will exhibit growth rates similar to Port Vila (5% p.a.). The mission also assumed that the coconut oil mill would be rebuilt and in operation by 1995 with a corresponding increase in demand of 1.9 GWh p.a.

Table 2.9: POWER DEMAND FORECAST FOR LUGANVILLE

	(Actual) 1983	1990	1995
Generation (GWh)	2.4	3.5	6.5
Sales(GWh)	2.3	3.2	6.0
Peak Demand	0.5	0.7	1.3

Source: Mission estimates.

2.25 Tanna and Malakula: Independent demand estimates for the three small government-owned and operated diesel systems (total demand of 0.1 GWh in 1983) are scarely relevant at this time. Of more immediate importance is GOV's technical and financial capability to continue operating and possibly expanding these systems. Only then can the development prospects of these two islands be assessed to arrive at a reasonable estimate of potential demand.

Traditional Energy

Demand

2.26 Domestic Cooking. Vanuatu's rural population (85%) depends on fuelwood for its domestic cooking requirements. In the absence of a comprehensive national domestic fuel survey, 1983 domestic biomass

consumption was estimated at 62,000 tonnes. 15/ In view of the scattered population pattern, it can be assumed that most fuelwood is gathered "free" from nearby woodlots and that commercialized firewood trading is minimal. GOV wished to carry out a national household survey of domestic fuelwood consumption which, together with the results of the proposed biomass resources inventory (para. 2.28), would indicate areas of potential localized fuelwood shortage and the precise requirement (if any) for dedicated fuelwood plantations.

2.27 Crop-Drying. The major crop-drying use of biomass is in copra drying. The 1983 marketed copra production was estimated at 37,900 tonnes. Currently, there are no centralized copra-drying facilities in Vanuatu. Smallholder copra (77% of total production) is dried at neighborhood copra dryers using coconut husks and shells as fuel input; the large estates prefer to use wood for copra-drying and leave the husks to rot in the fields. 1983 crop-drying requirements were estimated at 66,430 tonnes of coconut residues (smallholder copra) and 21,100 tonnes of wood (plantation copra and cocoa drying). Until recently, the open-fire "smoke-dry" method was predominant, which led to inferior quality copra and depressed prices for Vanuatu's copra exports. In 1981, GOV introduced a program to improve copra quality by using hot-air generators that not only produce high quality copra, but also require less fuel input. 16/ By the end of 1983, hot-air dried copra comprised 15% of total output. The introduction of hot-air generators is a good opportunity for large scale plantations to start using coconut residues instead of wood for copra drying (paras. 2.34; 3.36-3.37).

Supply

2.28 Natural Forest. Although there is no comprehensive biomass resource inventory, there does not appear to be any short-term lack of biomass for present energy requirements in Vanuatu because of the dispersed nature of both the population and biomass resource. About 900,000 ha (75% of total land area) is estimated to be under natural vegetation. However, inventories of forest area and wood volumes have been limited to preliminary surveys in some of the better forest areas. Therefore, data on forest resources is inadequate for detailed forest planning. GOV proposes to carry out a detailed land-use/forestry inventory study which would provide a better picture of the size and location of Vanuatu's forest resource.

15/ Based on the Papua New Guinea annual domestic consumption of 500 kg per capita.

16/ "Smoke-dry" methods require about 2.5 tonnes of biomass fuel per tonne of copra, while hot-air generators require between 0.5-1.0 tonnes biomass/tonne of copra.

2.29 Sawmill/Logging Residues. According to the Forestry Department, the annual production of sawn timber is about 3000 m^3: Efate, 2000; m^3 and Santo, 1000 m^3. Accordingly, conservative estimates of timber by-products are about 6,000 m^3 p.a. of sawmill residues and 20,000 m^3 p.a. of logging residues.

2.30 The Forestry Department has two forest plantation programs: (a) local supply plantations (LSP), typically of 200 ha each, are to supply sawn timber for domestic needs in the various islands. Twenty-seven LSP were established between 1970-1980 and twenty-four more LSP are expected to be implemented by 1986; and (b) industrial plantations totalling over 10,000 ha are to be established for the timber export market. Both projects are reported to be progressing well and will be a major source of logging residues for fuelwood purposes on each individual island concerned in the future.

2.31 Coconut residues. Coconut coverage in Vanuatu is estimated at 69,000 ha, of which 47,000 ha are smallholdings; the remaining 22,000 ha are large plantation estates mostly located on Santo. 1983 marketed copra production was estimated at 37,900 tonnes. 17/ Smallholders produced 29,200 tonnes and the estates accounted for the remaining 8,700 tonnes. Assuming that one tonne of copra is equivalent to 3.5 tonnes of coconut husk and shell, the annual husk/shell resource is estimated at 132,000 tonnes. Approximately 66,500 tonnes of this resource is used for decentralized copra drying. The remaining 65,000 tonnes could be available for alternative fuel purposes.

2.32 Coconut Stemwood. About 25% of the coconut groves are considered senile (over 50 years old) and another 25% will enter this group during the next 20 years. GOV realized the negative effect such a large percentage of senile trees would have on overall coconut productivity and established a coconut development project in 1982. Its objective is to encourage the planting of improved coconut species at an annual rate of 390 ha (1982/83), rising to 1,000 ha by 1985/86. This project would be greatly assisted if a use was identified to encourage removal of the senile trees. Since coconut stemwood's resistance to "chipping" renders it unsuitable for domestic energy, another alternative would be as a fuel input for wood-fired steam plant on Efate (para. 3.24-3.25).

Biomass Supply and Demand Projections

2.33 In view of Vanuatu's substantial forest resource and the widespread distribution pattern of the population in coastal villages throughout its 80 islands, it is not likely that fuelwood shortages will be created in the foreseeable future, especially for the domestic cooking and copra drying sectors.

17/ Domestic consumption of coconuts was reckoned to be about 8,000 tonnes of copra equivalent.

2.34 The mission has prepared crude biomass supply/demand projections through 1995 as represented in Table 2.10. Although such projections are only tentative, they offer some indication of future demand. The underlying assumptions are: (a) domestic fuel demand grows at 3% p.a. in direct relationship to population growth; (b) all copra drying requirements are met by coconut residues; (c) the increased demand for coconut residues is offset by greater use of fuel-efficient hot air generators; (d) a 3 MW wood-fired power station is commissioned by 1990 on Efate; and (e) a native leucaena forest resource on Efate is utilized for power generation; and (f) a proposed centralized cocoa drying facility on Malakula uses woodfuel for its drying requirements.

Table 2.10: BIOMASS ENERGY BALANCE PROJECTIONS, 1983-1995

	1983	1990	1995
	('000 toe)		
Supply			
Fuelwood	27.42	31.51	35.52
Coconut Residues	29.23	35.76	35.76
leucaena forest a/	-	10.22	10.22
	56.65	77.49	81.50
Demand			
Domestic	20.46	25.16	29.17
Copra Drying	35.76	35.76	35.76
Cocoa Drying	0.43	0.73	0.73
Power Generation b/	-	15.84	15.84
	56.65	77.49	81.50

a/ Assuming 2000 ha with sustainable yield of 17.5 m^3 ha; and 0.885 tonnes/m^3.

b/ Assuming fuelwood requirement of 3 Kg/kWh generated.

Source: Mission estimates.

2.35 The fuelwood requirements of the proposed WFPS currently are anticipated to be met solely by the native leucaena forest resource. Pending a resource qualification survey, the mission assumed a conservative sustainable yield factor, (15.5 tonnes/ha/year) which indicates that the leucaena resource may not be sufficient for power generation requirements. As a consequence, either (a) the overall contribution from other fuelwood sources will have to increase by at least 2.2% p.a. between 1983-1995, notwithstanding the assumption that all copra-drying would utilize coconut residues (para. 2.34); or (b) a dedicated fuelwood

plantation would have to be established for WPFS with resultant increases in the delivered cost of fuelwood to the WFPS. Therefore, it is important that the resource be quantified as soon as possible as part of an overall feasibility study (para. 3.30). Another option which was not directly addressed during the mission would be to use that proportion of Efate's senile coconut stemwood resource that is within economic distance from the WFPS in an effort to reduce the need for a dedicated fuelwood plantation.

III. ISSUES AND OPTIONS

Introduction

3.1 Vanuatu's energy resource endowment for the medium term is substantial but requires further quantification. Natural vegetation is estimated at 75% of total land area and is considered adequate for the needs of the widely dispersed population, especially in view of ongoing plantation programs. As far as large-scale projects such as the proposed WFPS wood-fired power station are concerned, the major obstacle will be not so much the theoretical availability of biomass, but the land-tenure system which is based on communal or traditional ownership. 18/ This implies that procurement of large quantities of biomass will be dependent on successful lease negotiation with customary land owners. In the medium term, there is the strong possibility of commercial hydro generation on the two major islands, Efate and Santo Espiritu. Hydrocarbon exploration in the offshore waters is continuing; and there is a geothermal investigation program for Efate. However, in the short-term, petroleum displacement options are mainly confined to biomass in the power sector and Vanuatu will continue to rely on imports for its petroleum requirements.

3.2 Certain essential ingredients of a national energy policy stem from these considerations. Of immediate concern are (a) the evaluation of least-cost petroleum product supply options; (b) the operation of the power sector within the context of national economic efficiency; (c) the potential for partial displacement of ADO by indigenous energy resources in power generation; (d) acceleration of hydropower development investigations; and (e) continued efficient use of biomass residues in the agro-processing industries. The medium to long-term aspects involve development of indigenous energy resources, particularly geothermal and hydrocarbons. It is expected that the incoming ADB-funded Energy Advisor to the Ministry of Lands and Energy (MLE) will work in close cooperation with the economic planning authorities (National Planning and Statistics Office) to formulate an overall energy policy within Vanuatu's macro-economic framework.

Petroleum Supply Arrangements

3.3 The liquid petroleum product market in Vanuatu is shared among three major oil companies that are directly responsible for importation, internal storage and distribution: Shell and Mobil on Santo; and Shell, Mobil and British Petroleum on Efate. Total storage capacity is 8,423

18/ Since independence in 1980.

tonnes, representing about 160 days demand coverage (at 1983 demand levels) which is adequate for most situations.

3.4 Vanuatu has two points of entry for petroleum imports: Port Vila on Efate, and Luganville on Santo; the other islands draw their requirements from these two centers. Santo is supplied from medium-sized tankers (25,000 DWT) originating in Singapore (33% of Vanuatu's petroleum imports). Port Vila draws its supplies (67% of total imports) from regional storage in Fiji (or occasionally, New Caledonia); these products originate mostly from Australia. Due to draught restrictions in Port Vila harbor, shipments into Efate are limited to small consignments of about 1,000 tonnes/vessel. As a result, the c.i.f. cost of products in Santo is cheaper than in Port Vila, as shown in Table 3.1.

Table 3.1: PETROLEUM IMPORT COSTS, FEBRUARY 1984
Vatu/Liter

	Gasoline	ADO	Kerosene
c.i.f. Port Vila	30.198	29.432	30.768
c.i.f. Santo	25.970	25.124	26.840

Source: Ministry of Finance.

3.5 The c.i.f. price differential between Port Vila and Santo clearly demonstrates that economies of scale (as a function of distance travelled and size of pay load) are possible in petroleum supply. On a larger scale, consolidation of Vanuatu's relatively modest petroleum requirements with those of other South Pacific Island countries could result in savings in unit petroleum import cost. GOV is interested in exploring regional supply options but wishes to maintain the security of supply enjoyed under the present arrangement.

3.6 There is considerable scope for minimizing Vanuatu's petroleum bill through streamlined supply arrangements without disrupting security of supply. The restructuring could be achieved as follows: a single supply arrangement would be used to import the country's entire petroleum product requirements; and onshore functions of product storage, distribution and marketing would be separated from the importation arrangement. Once this separation is achieved, Vanuatu could further reduce its unit cost of petroleum imports by joining with other South Pacific countries to pool their respective import needs under a single contract. This contract would be used to seek competitive bids from established international oil companies who, with their diversified sources of petroleum products, could guarantee minimum risk of supply disruption. Potential supplier(s) to such a combined market would have sufficient incentive to quote competitive f.o.b. and freight rates.

3.7 The mechanism involved in such a regional petroleum procurement would need to be worked out jointly between participating Pacific countries. Therefore, as a first step the mission recommends a proposed technical assistance mission to six South Pacific countries: Vanuatu, Fiji, Papua New Guinea, Solomon Islands, Tonga and Western Samoa, which together account for more than 95% of South Pacific petroleum requirements 19/ -- about 1,160 megaliters in 1981. 20/ According to preliminary estimates, freight costs could be reduced by 5-10% by developing an optimum regional procurement strategy. 21/

3.8 The primary objectives of the technical assistance mission which will be financed and executed by the joint UNDP/World Bank Energy Sector Management Assistance Program (ESMAP) will be to: (a) review previously completed preliminary studies; 22/ (b) examine current supply and transport arrangements; (c) identify and evaluate the economic feasibility of alternative procurement options; (d) determine the optimal least-cost combination of procurement and transport logistics; and (e) define medium-term technical assistance and training requirements to enable government agencies to implement the recommended option (Annex 10).

Power Sector Administration

Background

3.9 Under a 1939 agreement, the Condominium powers granted UNELCO a monopoly concession to supply public power in Port Vila and its immediate surroundings. This agreement was renewed in 1976 for a 14-year period ending in 1990. By decision of cabinet (GOV) of November 1982, UNELCO was authorized to transfer the concession agreement and its associated "Cahier des Charges" to the newly-formed power utility UNELCO-Vanuatu, which is owned by UNELCO and one of its subsidiary companies, Socivan, in a ratio of 7:3. Similarly, Luganville (on Santo) is supplied with power by CES (owned 85% by UNELCO-Vanuatu). However, Luganville power supply is not covered by the original concession agreement which pertained only to Port Vila. The position of the Government of independent Vanuatu with respect to the Agreement has not yet been clarified. An official pre-

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19/ UNDP/IBRD Energy Assessment missions have made similar recommendations for all six countries.

20/ Most of this is accounted for by Papua New Guinea (56%) and Fiji (28%).

21/ East-West Center (Hawaii).

22/ Carried out by UNPEPD (Fiji) and the East-West Center.

independence statement indicated GOV's desire to re-negotiate the terms of the Agreement. Since then GOV has received advice regarding possible renegotiations of the Agreement. 23/ However, to date no formal discussions have taken place.

Concession Agreement

3.10 The principal features of the agreement are: (a) the concessionaire has exclusive rights to produce and supply public electricity in the Port Vila area until 1990; (b) the concessionaire is responsible for financing all investments in generation facilities, but only a portion of the distribution facilities; 24/ (c) tariffs would be determined on a tax-exempt basis and would be revised every 6 months, according to an agreed formula; (d) the concessionaire would keep financial accounts according to French law which would be subject to verification by an external auditor appointed by the concessionaire; (e) in addition to normal depreciation, an additional charge ("caducite") will apply to all investments financed by the concessionaire, revalued annually, to faciliate recovery of funds at expiry of the concession; (f) subject to two years' notice the Government may at any time "repurchase" the concession by reimbursing the concessionaire for the undepreciated value of concessionaire-financed facilities and for loss of profits over the remaining life of the concession. Finally, the agreement stated that should a subsequent government of Vanuatu (after independence) repudiate the concession, the Condominium powers would be obliged to recompensate the concessionaire. 25/

3.11 In the mission's view, the 1976 Agreement is deficient in two main aspects. First, although it is stipulated that the concessionaire shall keep financial accounts, there is no provision for submission of such accounts to the national authorities. 26/ Thus, accordingly, UNELCO-Vanuatu does not submit its detailed accounts for inspection by

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23/ "Report on Electricity Supply" November 1981, Cooper and Lybrand Associates. This report was sponsored by the United Nations Centre on Transnational Corporation (UNCTC).

24/ Approximately 25% of the cost of total distribution facilities. The rest is financed by public and private consumers as a condition for connection to the grid.

25/ Sources: 1976 Concession Agreement, "Cahier des Charges" (1976); "Report on Vanuatu Electricity Supply" (1981).

26/ These are defined as the Condominium powers (1976-1980); and GOV thereafter.

GOV or its representatives, 27/ nor does GOV have the right to approve the selection of UNELCO-Vanuatu's external auditor. Second, there are no established channels of communication between GOV (the national authority) and UNELCO-Vanuatu (the monopoly concessionaire) to ensure that the national power system is operated in accordance with the Agreement and in an economically efficient manner from a national viewpoint with regard to such matters as electricity pricing, tariff structure and system expansion.

3.12 In principle, operation and partial financing of the public power system in Vanuatu by a competent private foreign company is an attractive proposition in view of the present scarcity of skilled technical and managerial resources. However, the institutional relationship between GOV and Unelco-Vanuatu should be regularized as soon as possible before the existing concession expires. The mission recommends that GOV seek technical assistance to pursue discussions with UNELCO-Vanuatu regarding a modified agreement that is equitable to both parties. Important factors to be considered should include: (a) the desirability of maintaining the involvement of UNELCO-Vanuatu as an investor in the power sector; (b) formulation of guidelines for future generation and distribution of electricity; and (c) determination of the economic cost of electricity supply (para. 3.13-3.18).

Electricity Tariffs

3.13 Port Vila. UNELCO-Vanuatu does not publish financial statements, nor are such statements submitted to GOV. In the absence of other information, the mission has attempted to estimate the economic cost of power generation in the Port Vila system based on expansion of diesel capacity since diesel plants will continue to be operated at the margin, at all times of the day, despite projected investments in non-diesel capacity. As shown in Table 3.2, the mission estimated the economic generation cost at about 11 VT/kWh.

3.14 The current UNELCO-Vanuatu tariff for Port Vila is shown in Annex 6 and summarized in Table 3.3. Economic efficiency criteria for allocating scarce resources indicate that tariffs should be structured, so that consumers pay the full economic cost of supply. In practice, other factors must also be considered, especially social objectives and the financial viability of the power utility. In the absence of data on the economic costs of transmission and distribution as well as consumer-related costs, only very broad observations can be made about the current tariff levels. Further, no detailed information was made available on the consumption patterns of different consumer groups e.g., daily load

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27/ UNELCO-Vanuatu does submit a brief statistical report on an annual basis which provides little information for control purposes.

curves for typical domestic, commercial and industrial users. Therefore, it is difficult to offer detailed comments on tariff structures.

Table 3.2: PORT VILA SYSTEM: ESTIMATED ECONOMIC COST OF GENERATION, 1983 (Vatu/kWh)

Capital costs a/	1.5
Fuel cost b/	8.3
Operating and maintenance c/	1.0
	10.8

a/ 1.5 MW at US$700/kW installed; economic life of 20 years; interest rate of 10%; with 60% load factor.
b/ Assumed fuel efficiency of 0.28 liter/kWh generated.
c/ 7% of capital costs.
Source: Mission estimates.

3.15 Tariff Structure. The current tariff structure has two desirable features: (a) a time-of-day general tariff which enables the utility to signal the costs of power consumption as a function of time-of day, thus influencing consumer behavior; and (b) the domestic tariff is an increasing bloc structure unlike the normal declining bloc type used in many other countries. An increasing bloc domestic tariff structure usually ensures that "life-line" bloc consumers are subsidized by higher income domestic consumers and not by the commercial/industrial sectors, thus avoiding distortion of the input prices of productivity.

3.16 Tariff Levels. (a) The high-tension basic tariff is about 35% above the economic cost of generation as estimated by the mission and appears to be at a reasonable level above the economic cost of power supply when transmission costs are taken into account; and (b) the low tension general tariff has a differential of about 65% between the basic and night rates. Although the economic cost differential in meeting the load during the day and night on a small system could well be of this magnitude, a load profile of each consumer category would be necessary for detailed evaluation.

Table 3.3 UNELCO-VANUATU TARIFF STUCTURE, APRIL-OCTOBER 1984
VT/kWh

	Low Tension	High Tension a/
Domestic Tariff		
Less than 60 kWh/month	14.42	-
61-120 kWh/month	24.93	-
More than 120 kWh/month	36.04	-
General Tariff		
Basic Tariff	24.03	14.42
Night Tariff	14.42	12.01
Demand Charge/Subscribed kVA	360-384	481
Public Lighting (all units)	16.82	

a/ Although there are only 30 high-tension consumers, they account for 50% of sales.

3.17 Conclusion. In 1983, revenue reported by UNELCO-Vanuatu in a brief statistical report represented an average revenue of VT22.75/kWh sold. Thus, from a financial standpoint, current tariffs appear to be providing adequate returns to UNELCO-Vanuatu in accordance with the Concession Agreement (para. 3.12). However, several economic issues arise:

(a) the "life-line" domestic tariff bloc is almost certainly too big; 60 kWh/month is well above consumption levels normally associated with low-income consumers who would be expected to require only about 25-30 kWh/month;

(b) the size of the third bloc in the domestic tariff might well be too small at 120 kWh/month. However, it is difficult to determine an appropriate size in the absence of a detailed load profile which would specify the demand patterns of different consumer classes;

(c) the application of a demand and energy tariff to medium and large consumers is theoretically sound, given the sharp load variation on both a daily and a seasonal basis. 28/ It is impossible to assess the relative weight of the demand tariff in the total charges to each consumer. This will depend on the amount of kVA demand the subscriber has subscribed to. In

28/ Daily peak load is about 45% higher than base load. In 1983, monthly peak load varied from 2.6 MW (July) to 3.6 MW (January).

1983, a total of 12,559 kVA was subscribed to, which is high compared to the peak demand of 3.6 MW which includes the peak demand from the small domestic consumers. This suggests that many consumers are subscribing to a high artificial demand which bears little relationship to their actual demand.

3.18 In order to ensure that decisions about future system expansion reflect economic efficiency criteria, the mission recommends that GOV and UNELCO-Vanuatu undertake a joint analysis of the economic costs of power supply on the Port Vila system (Annex 10).

3.19 Other. In the absence of any relevant financial information about the Luganville system, the mission could only assume that its economic supply costs are likely to be higher on a per unit basis than in Port Vila (20-25%) since it is a smaller system using less fuel efficient engines. At the PWD generating units on Tanna and Malekula, costs would be higher still, given the small size of the units and the additional cost of supplying fuel.

Power System Expansion

Introduction

3.20 According to the power demand forecasts in paras. 2.21-2.23, additional generation capacity will be required on Efate before 1990. Although there is a possibility for hydro generation in the early 1990s, short-term generation options require a choice between ADO-fueled power and wood-fired steam generation. GOV is actively pursuing the wood-fired option as a viable alternative to diesel capacity. A 3 MW plant is anticipated and a feasibility study was completed by UNELCO-Vanuatu (the public power supply company) in partnership with Heilborn GMBH, a West German supplier of wood-fired power stations. 29/

Wood-Fired Power Generation

3.21 Power generation utilizing wood-fired steam is a proven technology that is already in commercial operation elsewhere in the Pacific. 30/ However, it is essential to ascertain that the anticipated benefits of wood-fired power generation include not only displacement of imported petroleum but also contribute to minimizing the cost of power production. Factors to be considered include: (a) capital costs;

29/ The feasibility study was funded by the EEC on the basis that Heilborn would engineer and construct the facility and UNELCO-Vanuatu would operate it.

30/ Philippines.

(b) availability and delivered cost of fuelwood over the wood-fired power station (WFPS) life cycle; and (c) institutional arrangements for power production and distribution.

3.22 Capital Costs. The capital costs of a wood-fired power station (WFPS) can vary greatly as a function of basic design criteria, use of packaged hardware, source country of hardware, and bid procedures. Therefore, a range of US$1,500 to US$2,500 per installed kW can be expected in an open competitive bid situation (compared to diesel capacity at about US$700/installed kW). 31/ Site selection also plays a part: questions to be asked include: (a) possible seismic activity in the area; (b) historic high-water conditions resulting from rainstorms; (c) anticipated problems concerning the heavy foundations required for power plant equipment; (d) analysis of fresh water supplies to be used by the plant; (e) distance from source of woodfuel supplies; and (f) distance from transmission facilities.

3.23 Given the high capital cost of a WFPS, such a plant should supply baseload at a fairly high load factor (0.6 or more). Technically, excessive cycling with larger steam units or running smaller units for relatively short periods per day is not desirable and would certainly add significantly to the cost of operation. A reasonable balance must be struck between maximum diesel displacement and the desirability of running the WFPS at a relatively high load factor.

3.24 Delivered Cost of Fuelwood. It is proposed that the WFPS would obtain its woodfuel requirements from an existing stand of leucaena forest in the Port Havannah area. The ownership of the forest resource is not clear; if communal or private, a realistic market price must be established for the wood, or a cost set for purchase of the land. In any case, the cost of wood must include an amount sufficient to provide for optimum conditions of regrowth and repeated future harvests (para. 2.28).

3.25 There is no definitive quantification of the leucaena forest land that is to be used as a source of woodfuel. Estimates vary from 900 ha to 2000 ha. According to mission estimates, a 3-MW WFPS operating at 13% system efficiency with a load factor of 0.6 to produce 16 GWh p.a. would require a reliable supply of about 48,000 tonnes woodfuel p.a. throughout its project life. 32/ This indicates a conservative estimate of required forest coverage of about 3,000 ha assuming annual sustainable yield of 15.5 tonnes/ha/year (17.5 m^3/ha/year). Therefore, should the existing leucaena resource prove insufficient, there would be a need to establish a dedicated fuelwood plantation which would increase the total

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31/ Based on other bids for similar stations in the Pacific over the last 12 months.

32/ Assuming a power generation requirement of 3.0 kg/kWh generated at 50% moisture content, wet basis.

capital cost by about US$1,500 - US$3,000 per ha of plantation, depending on the level of mechanization and expected productivity levels. Harvesting, logging and transport costs also have to be incorporated into the final cost estimate of delivered fuelwood.

3.26 Institutional Organization. The third issue relates to ownership and management of the WFPS and its associated fuelwood sources. It is not yet certain whether the WFPS will be financed by GOV, UNELCO-Vanutu or as a joint venture. Any decision taken on plant ownership will have an effect on the investment requirements of the participants and on the tariff structure/levels. Another question with investment implications is whether the fuelwood resources will be owned and managed in conjunction with the WFPS in the interests of ensuring the availability of woodfuel required or whether a separate contract will be negotiated with a third party concerning harvesting and delivery of woodfuel to the plant.

3.27 Cost Sensitivity Analysis. As discussed in paras. 3.22-3.26 above, there are several areas of uncertainty that can affect both the short-term capital outlay costs and the long-term operating costs of a WFPS; such costs would subsequently affect the cost of power generation. Therefore, the mission has prepared a crude sensitivity analysis for a 3-MW WFPS (producing an average 16 GWh p.a. with a fuelwood requirement of 3.0 kg/kWh generated) compared to diesel generation. Table 3.4 demonstrates the effect of different assumptions about capital outlay costs and delivered woodfuel costs on the overall cost of power generation.

3.28 The "optimistic" case assumes a low capital cost of US$4.5 million (or US$1,500/kW installed) due to open competitive bid procedures, and a low delivered cost of woodfuel (US$10/tonne) due to the availability of ample leucaena and other woodfuel resources. On the other hand, the "pessimistic" case assumes a high capital cost of US$7.5 million (or US$2,500/kW installed) as a result of closed bidding tied to a financing source, and a high delivered cost of fuelwood (US$30/tonne) due to the necessity of establishing a fuelwood plantation to complement existing native leucaena forest.

3.29 As shown below, WFPS generation costs can vary over a wide range between about US¢10.0/kWh and US¢17.0/kWh. At the upper end of the range, WFPS generation costs would be much higher than present estimated ADO generation costs of about US¢11.0/kWh (para. 3.13). Although diesel import savings of 4.5 million liters p.a. are achieved in both scenarios, 33/ the "optimistic" scenario represents the optimum in both

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33/ Based on 3.6 kWh/litre.

short term benefits (less capital outlay) and long-term benefits (lower operating costs, lower tariffs and higher reserve revenues). 34/

Table 3.4: POWER GENERATION COSTS
(US¢/kWh)

	WFPS "Optimistic Case"	WFPS "Pessimistic Case"	Diesel
Annualized Capital Cost a/	2.9	4.5	1.5
Delivered Fuel Cost	4.5	9.0	8.6
O & M Costs	2.8 b/	3.3 c/	0.1
Total Cost	10.2	16.8	11.2

a/ Interest rate is assumed to be 10% p.a. Economic life of the WFPS is assumed to be 30 years, while that of the diesel plant is only 20 years. Therefore the annualized capital costs of the diesel plant are adjusted to reflect this fact.
b/ 10% of capital cost outlay (includes insurance).
c/ 8% of capital cost outlay (includes insurance).

3.30 Summary. If a WFPS is to generate electric power at a cost lower than that of diesel-fired generation, several factors must be addressed. Capital investment and operating/maintenance requirements cost more per unit of installed WFPS capacity than for an equivalent diesel-fired plant (paras. 3.24-3.25). Therefore the reliability of supply and final delivered cost of fuelwood assume particular importance. The harvesting, logging, and transport arrangements selected will affect the fuelwood cost, while a definitive resource evaluation -- and possibly replanting provisions -- are necessary to guarantee that sufficient woodfuel will be available over the projected life-cycle of the WFPS (paras. 3.24-3.25). Institutional arrangements for fuelwood delivery, power generation and distribution would also have an effect on the reliability and cost of power. Therefore the mission recommends that technical assistance be provided to GOV to review and evaluate the forthcoming WFPS feasibility study within the framework of a least-cost power development strategy before any investment commitments are made (para. 3.34; Annex 10).

Hydropower Development

3.31 Although Vanuatu's hydroelectric potential has not yet been evaluated to a significant extent, a number of studies have been prepared

34/ It is acknowledged that woodfuel costs in both WFPS scenarios could be reduced by about 0.8¢/kWh if woodfuel requirements were reduced from 3 kg/kWh to as low as 2.2 kg/kWh.

covering the major rivers and some potential hydroelectric sites. In 1981, the European Development Fund (EDF) initiated a program of flow measures of the Colle and Te'ouma rivers on Efate; and the Sarakata and Jourdain rivers on Santo. 35/ Although the period of river flow measurements was too short to allow significant conclusions with respect to potential hydro development, two important observations were made. First, apart from sharp variable peak flows caused by rainstorms, the rivers are characterized by rather steady levels of minimum flow discharge with moderate seasonal variation; this is a positive factor for hydro development. The reason for this behaviour was ascribed to the porous nature of the underlying volcanic soil formation which has the capacity for temporary water storage. Second, the 1983 rainfall measurements at Port Vila were 1226.4mm (the second dryest year since 1953); and at Luganville, 1018.4mm (the dryest year since 1951) as shown in Table 3.5. Therefore, it is reasonable to assume that 1983 flows were representative of long-term minimum flows; a very important parameter since there is likely to be minimum scope for constructing significant storage reservoirs. The mission supports GOV's proposal to continue the hydrological data collection program. It is expected that it will be financed by the European Development Fund.

Table 3.5: VANUATU RAINFALL DATA, 1951-1983 a/
(mm)

	Port Vila (Efate), 1953-82		Luganville (Santo), 1951-81	
	Annual Rainfall	Average monthly rainfall	Annual Rainfall	Average Monthly
Average	2,261.4	188.5	2,947.8	245.7
Highest	3,544.6 (1971)	357.6 (Mar)	4,638.1 (1971)	367.1 (Mar)
Lowest	1,091.0	106.9 (Aug)	1,590.3 (1978)	129.5 (Aug)

a/ The dry season generally falls between May/June and October, but significant rainfall does occur throughout the period in most years.

Source: ORSTOM.

Hydro Development Studies

3.32 Some opportunities for hydro development on Efate and Santo were recently reviewed in a preliminary report with the objective of assisting GOV in formulating an additional study program including

35/ Carried out by Office de la Recherche Scientifique et Technique Outre-Mer (ORSTOM).

continuation of the hydrologic survey discussed in para. 3.31 above. 36/ The report concluded that:

(a) future hydro development would generally have to be based on run-of-river plants with some daily storage capacity, since the river valleys are narrow and deeply incised without significant falls. Further, the permeability of the underlying volcanic formations, the frequency of Kastic formations, and the high level of seismic activity contribute to making reservoir construction prohibitively expensive in most cases.

(b) the seasonal distribution of rain and riverflows tends to coincide with the seasonal distribution of power demand. That is, power demand is highest during the warm, wet season and about 30% less during the cooler, dry season (para 2.17).

3.33 Several existing hydroelectric development proposals were also reviewed with the recommendation that future hydrological data collection and hydroelectric development attention should be focused on three rivers: the Teouma (Efate); the Sarakata (Santo); and the Brenwe (Malekula):

(a) Teouma River (Efate). A potentially attractive scheme is proposed for a site approximately 14 km. from Port Villa. It involves a 2.1-MW hydro complex with an annual output of 16 GWh (equal to Port Vila's present demand), which would exploit a 75 meter fall by means of a simple intake structure, a 2,700 meter tunnel and a 700 meter penstock. With estimated costs of VT 10/kWh, the scheme is considered economically attractive. 37/ However, the scheme is only in the conceptual stage, based on map studies alone and there are technical reservations about the level of Karstic development in the underlying formation which might inhibit tunnel construction. Therefore, a thorough field exploration is warranted to determine the Karstic features of the soil formation (para. 3.44).

(b) Sarakata River (Santo). The review report proposes a first phase hydro development near Luganville, based on the second of two earlier studies. 38/ Subject to confirming feasibility field studies, a 1.84 MW hydro facility could generate 16 GWh p.a. aimed at Luganville (12 km) and the South Pacific Fishing

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36/ The review was carried out by Electricite de France.

37/ Total costs of VT 1500 million at 10% p.a. interest rate (1982 prices).

38/ La Société d'Etudes et d'Enterprises (1950s); Sir William Halcrow and Partners (1962).

Company (13 km). Although the original study called for a minimum river flow of 3.7 m^3/second, 1983 measured flows of 2.76 m^3/second are considered sufficient to produce the same output. However, there are technical reservations about geological conditions; and the economic viability of the scheme (VT6.2/kWh generated) 39/ is dependent on rapid expansion of demand (paras. 2.24). 40/

3.34 The mission agrees with the recommendation to further investigate small, run-of-river hydroelectric development opportunities. More emphasis should be given to the possibility of hydro projects which could be more suitable for present demand levels. For example, with the present Port Vila system peak demand of 3.6 MW, a 1 MW hydro plant would probably cover the base load, while thermal generation would cover the peak load. Installed costs of such hydro plants are likely to be significantly less than the installed cost of US$5,000-US$7,000 per kW implicit in the existing proposals (para. 3.33). Therefore, the mission recommends technical assistance for GOV to carry out an economic and technical evaluation of various hydroelectric options -- taking into account previously completed work -- as an input to developing a least-cost system expansion program. The required expertise would be: (a) a geotechnical engineer with experience in hydro development in Karstic areas; (ii) a civil engineer, knowledgeable about small hydro structures in relatively isolated areas; and (c) a systems planning engineer (para. 3.30; Annex 10).

Other Renewable Energy Options

Biomass Gasification

3.35 During recent years, significant efforts have been made to improve biomass gasifier technology as part of the worldwide effort to develop better means of exploiting the energy potential of biomass. Gasification involves the conversion of solid fuels such as wood or charcoal and certain crop residues into producer gas. This gas can (a) substitute partially or wholly for liquid fuels in internal combustion engines; or (b) provide process heat in boilers, furnaces and other heating appliances.

3.36 Hot-air Generators. Vanuatu has already initiated the use of hot-air generators for the copra drying; 15% of the copra produced in

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39/ Total costs of VT 975 million at 10% p.a. interest rate (1982 prices).

40/ A subsequent second phase development could generate an additional 14 GWh p.a.

1983 was by means of this method. The major advantages of hot air generators compared to open fires are fuel efficiency and improved quality of the dried copra. Hot air generators have a thermal efficiency of 70-85%, compared to 10% for open-fires; therefore, they consume much less wood. 41/ The hot-air dried copra quality was also much better, fetching a 10% premium on the world market as compared to the smoke-dried copra that was selling at 10% below world prices. 42/ This program is being intensified in 1984 and 1985.

3.37 The Agricultural Department is currently preparing a project for a 1700 hectare cocoa plantation with associated centralized drying facilities which include a diesel-fired boiler. At full production, the plantation is expected to produce 3,000 tonnes of dried cocoa p.a. This would require about 240 kiloliters of ADO p.a. An alternative drying method to be considered would be wood-fired, hot-air generators. 43/ Assuming 50% moisture content, woodfuel requirements would be about 1,000 tonnes p.a. Such hot-air generators are being used elsewhere in the Pacific for cocoa drying. Potential foreign exchange savings would be VT 7.2 million p.a. at full capacity, giving a pay-back period of between one and two years. 44/ Therefore, the mission recommends that the Agricultural Department evaluate the feasibility of substituting a wood-fired, hot-air generator for the ADO-fired boiler. This includes (a) a survey of woodfuel availability on a long-term basis and definition of any need for fuelwood planting to estimate the delivered cost of fuelwood; and (b) capital cost estimates for the hot-air generator along with woodfuel handling and also removal systems; and (c) economic analysis of expected benefits and additional investment needs (Annex 8).

3.38 Power Generation Gasifiers. Some types of gasifiers can be used for retrofitting diesel generator sets to run on producer gas in rural areas remote from the grid. However, this application is more complex technically and economically -- than the direct-heat application discussed above: (a) careful testing is required to establish the compatibility of particular engine-gasifier combinations; (b) the low energy content of producer gas results in significant power output losses ranging from 30%-40%; and (c) careful operation and maintenance, plus an

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41/ A smoke-dried tonne of copra requires about 2.5 tonnes of biomas fuel; a hot-air generator would require only 0.5 tonnes biomass.

42/ In recent years, f.o.b. prices for copra in the Pacific have ranged from US$180 - 235/tonne.

43/ In view of the relatively modest production scale envisaged, the mission considered that a hot-air generator would be preferable to a wood-fired steam drier.

44/ Assuming a c.i.f. direct cost of VT 29.4/litre, and a hot-air generator installed cost of VT 6,000/KW.

efficient gas cleaning system are all essential to ensure that clean, high-quality gas reaches the engine.

3.39 Vanuatu has gained some experience with the use of small engine gasifiers retrofitted to small internal combustion engine generators. A high school in Efate operates a homemade 25 kW gasifier fitted to a 100 hp spark ignition engine to produce electric power for the school's needs. 45/ Wood chips are fired in a home-made downdraft oil drum gasifier; the ensuing producer gas is cooled in a shell and tube heat exchanger and is then drawn through a fillet mesh for removal of ash particles. The relatively clean and cooled gas is then injected into the engine to produce power. However, the equipment has operated only intermittently and little data on performance and maintenance is available.

3.40 In this context, the mission support the proposed EEC-financed gasifier program for Vanuatu which involves the installation and demonstration of a 50 kW biomass gasifier for power generation at Onesua High School. The feedstock will be dry woodchips from surrounding woodlots. The second component of the EEC program is a 75 kVA gasifier for the rural government centre at Isangel on Tanna Island utilizing charcoal feedstock. 46/ The mission advises that proper management and extensive performance monitoring 47/ and detailed record-keeping is essential, if the pilot project is to achieve its objectives of: (a) investigating the feasibility of retrofitting internal combustion engine-generators with biomass gasifiers; and (b) a training programme for gasifier operators.

Photovoltaics

3.41 A small solar PV system is in operation at a tourist hotel on Tanna Island; it provides energy to sixteen 12-watt bulbs in place of kerosene lamps. 48/ No records exist as to the economic feasibility of this system. Several GOV departments have also installed PV systems in selected areas throughout the country, mainly for communication purposes. However, there is a lack of data on their performance and

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45/ The homemade gasifier followed an unsatisfactory experience with a Fluidyne gasifier purchased from New Zealand.

46/ During Government discussions, the mission was informed that this project component would not be implemented due to the uneconomic cost of the proposed feedstock. Instead, the funds were to be reallocated to the Onesua gasifier.

47/ As part of the EEC gasifier program, the projects in Vanuatu will be tied into the UNDP/World Bank Global gasifier monitoring program and significant data feedback should occur.

48/ Funded by the South Pacific Commission.

economic viability. Activities are going on elsewhere in the Pacific 49/ concerning the economic viability of solar-powered systems that can be monitored by GOV with special reference to operating and replacement costs. The mission recommends that GOV monitor and evaluate the results of these ongoing activities before committing any of its own resources to solar PV systems for lighting and other power purposes.

Ethanol

3.42 A low-technology pilot scheme was proposed in 1980 to produce ethanol from cassava as a potential substitute for diesel oil in industry or as a feedstock input to a process for producing ester of coconut oil as a diesel substitute in the transport sector. A site was selected on Tanna Island for the 100,000 liter p.a. plant and several major pieces of equipment were ordered. 50/

3.43 Activities elsewhere have indicated that producing ethanol from cassava is uneconomic, largely because there is no waste product to act as a "free" energy source for producing the ethanol (unlike bagasse in the case of sugarcane), therefore requiring fuel oil or wood as energy sources. Also, ethanol has a low cetane number and thus can be used in compression ignition diesel engines only through substantial engine modification or through mixing of ethanol with special additives. In view of the opportunity cost of scarce capital and manpower resources, the mission recommends that GOV should discontinue the project.

Coconut Oil

3.44 At present, there is a small, private oil mill that processes copra to produce coconut oil for its own power generation needs on Efate Island. 51/ UNELCO-Vanuatu has also conducted research into the viability of this fuel from the private mill, since there are no centralized oil mills operating in Vanuatu. The competitiveness of coconut oil as a substitute for diesel in power generation and transport depends to some extent on the requirement for a higher level of engine maintenance 52/ and on the production costs of coconut oil vis-a-vis the delivered cost of diesel oil. However, even if production costs are

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49/ E.g., the EEC regional program has provided funding for photovoltaic systems in two remote villages in Tonga.

50/ New Zealand funded NZ$40,000 of the project.

51/ Diesel and coconut oil are injected into a motor diesel engine in a ratio of 1:4. This mixture is supposed to have provided over 10,000 hours of reliable engine service.

52/ To date, experience has shown a need for increased engine maintenance needs even with mixtures in a ratio of 1:1.

comparable to the delivered cost of diesel (as has been indicated in some remote regions) and skilled manpower is available for maintenance needs, the deciding factor is the opportunity cost i.e. the prevailing world market prices for coconut oil and for copra. Assuming an f.o.b price of about US$450 per tonne of coconut oil, comparison with the current c.i.f. cost of diesel of US$360/tonne indicates that coconut oil is not competitive with diesel. The export value of copra and/or coconut oil is subject to international influences beyond the control of the GOV. Therefore the mission recommends that GOV should not implement any investigation into the power generation aspects of coconut oil at this time.

Charcoal Production

3.45 Some interest has been shown in the development of charcoal production and the introduction of improved charcoal stoves as a substitute for kerosene to meet the cooking needs of low-income urban dwellers. 53/ At present, charcoal is produced on Tanna Island by KITOW at an estimated cost of VT 10,000/tonne. About 0.2 tonne/month are shipped for sale in Port Villa -- mostly to expatriates. Estimates of the delivered cost are around VT 18,750/tonne, or 50% of the equivalent kerosene cost. 54/ However, the mission agrees with GOV that in view of the absence of a substantial commercialized firewood market in Vanuatu, first priority in the household sector should be given to carrying out a comprehensive biomass consumption/supply study (including both domestic and agro-processing sectors) for each Island in Vanuatu starting with Efate (para. 2.26). This would indicate any localized fuelwood deficit areas, and potential demand for charcoal.

Hydrocarbon Exploration

3.46 Geophysical investigations for evaluating hydrocarbon resources in the offshore regions of the central basin of Vanuatu began in the late 1960s. Several oil companies undertook exploration activities consisting of both single- and multi-channel seismic-reflection data in the central basin of Vanuatu between 1972 and 1982. 55/

3.47 Evaluation of data collected during this period on offshore geophysical surveys indicated that certain sediment thicknesses and structures within the central basin of Vanuatu were promising areas for

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53/ The rural population has access to significant amounts of "free" firewood from natural forests.

54/ PEDP Report.

55/ Including joint OPSTOM-CCOP/SOPAC investigations in 1980 and 1982.

potential hydrocarbon deposits. Therefore, in order to carry out further evaluation and to restimulate the interest of the oil industry, in 1982, a hydrocarbon and mineral resources investigation was carried out by the U.S. Geological Survey. 56/

3.48 The results of the survey delineated specific sub-basins with sediment thickness of over 2 km which are folded and faulted to produce traps that could be considered promising targets for hydrocarbon generation and accumulation. Areas identified include: North Aoba, South Aoba, East Santo and Malakula basins. The Malakula basin, in particular, appears to contain the desirable sediment types, structures, and stratigraphic continuity to deeper water basins for the migration and accumulation of hydrocarbons. Its structure is simple, with sediments dipping gently from east and west into the basin forming a broad syncline. These sediments consist of well-layered to discontinuously and chaotically layered sedimentary rocks that have been correlated with upper Miocene to Pliocene calcareous sandstones and mudstones, coarse detrital limestones and conglomerates on land. These on-land equivalent rocks appear to have fair porosity and permeability, although some are quite compacted and well cemented. Its eastern boundary structure is a broad anticline that is not faulted or fractured on its upper flanks or crest with closure that appears to be good. Although source rock analyses indicate a slight promise of oil and gas, further investigations need to be done to obtain a comprehensive evaluation. Before any basin can be considered for further exploration, source rock potential must be thoroughly analyzed.

3.49 Another offshore geophysical survey is to be undertaken by the U.S. Geological Survey in the central basin of Vanuatu in late 1984 and it is hoped that this will complement the existing data base by further declineating significant structures and correlating seismic stratigraphic units within the basin.

3.50 Once the results of the forthcoming survey are established, it will then be possible to evaluate the promotional, and technical assistance needs for GOV to prepare a comprehensive data package aimed at the oil industry which already has expressed interest in the ongoing survey. Such a package could advance GOV's interest in attracting more oil companies and accelerating the exploration program.

56/ Arranged by the 1982 ANZUS (Australia, New Zealand, U.S.A.) Tripartite Agreement in association with CCOP/SOPAC (the United Nations-sponsored Committee for the Co-ordination of Joint Prospecting for Mineral Resources in South Pacific offshore areas).

IV. ENERGY INSTITUTIONS AND TECHNICAL ASSISTANCE

Energy Planning and Administration

4.1 The Ministry of Lands, Energy and Rural Water Supply (MLERWS) is responsible for energy planning and policy, legislation and administration. MLERWS is also responsible for issues pertaining to the development of hydropower, hydrocarbon and geothermal resources, as well as issues pertaining to land allotments and surveys (Annex 8). Therefore MLERWS is well placed to deal with the energy issues identified in this report.

4.2 MLERWS is aware that (a) it lacks the technical capacity to implement diverse energy projects; and (b) energy planning and policy functions should be kept separate from implementation when possible. Therefore MLERWS intends to concentrate on its role of planning and policy and to act as coordinator between the other agencies involved in the energy sector; i.e. Ministry of Finance (petroleum product pricing), Ministry of Agriculture and Forestry (fuelwood plantations), the Public Works Department (rural power supplies), and UNELCO-Vanuatu (urban power supply).

4.3 An Energy Advisor (funded by ADB) is expected to join MLERWS as the nucleus of an energy planning unit. The mission recommends that the prime functions of the Energy Advisor should be to: (a) act as coordinator between the various energy subsectors and (b) prepare an appropriate energy policy and program, including future review and evaluation of current energy sector proposals for investments and/or technical assistance. MLERWS is aware of the need for coordinating energy policy with national macro-economic objectives and has arranged for the Energy Advisor to work in close cooperation with the National Planning and Statistics Office (NPSO) in the Prime Minister's Office. In view of MLERWS's present lack of technical capacity, the mission recommends that first priority be given to locating and recruiting local counterparts to assist in coordinating and monitoring energy sector developments.

Implications for External Assistance

4.4 Vanuatu has received financial and technical assistance from multilateral and bilateral sources over a wide range of energy subsectors, as shown in Annex 9. However, many of the ongoing programs are regional, spread over several South Pacific countries; therefore the overall contribution to and impact on Vanuatu's energy situation cannot yet be determined. The mission has focussed on those energy aspects that require immediate further detailed technical assistance (totalling about US$380,000) as shown in Annex 10. The areas affected are: (a) regional least-cost petroleum product supply analysis; (b) power sector adminis-

tration and tariffs; and (c) evaluation of least-cost power system expansion options including acceleration of hydro power development investigations.

4.5 At present, the major energy investment requirement appears to be between US$5.0 million and US$8.0 million for a 3 MW wood-fired power station. However, this will depend on the results of the forthcoming feasibility study (para. 3.20). Investment needs for other capital projects such as the possible need to expand petroleum product storage facilities and introducing hydropower capacity can be further defined once the recommended technical assistance proposals have been carried out.

Annex 1

VANUATU: ENERGY BALANCE PROJECTIONS, 1990
('000 toe)

	Fuelwood	Agric. Residues	Total Biomass	Electricity	Petroleum	Total Energy
Gross Supply						
Production	41.73	35.76	77.49	-	-	77.49
Imports	-	-	-	-	17.84	17.84
International Bunkers	-	-	-	-	(3.25)	(3.25)
Total Supply	41.73	35.76	77.49	-	14.59	92.08
Conversion						
Power Generation	(15.84)	-	(15.84)	18.32	(2.48)	-
Losses/Station Use	-	-		(16.33)	-	(16.33)
Net Domestic Consumption	25.89	35.76	61.65	1.99	12.11	75.75
Sectoral Consumption						
Transport	-	-	-	-	9.40	9.40
Industrial	-	-	-	0.14	0.30	0.44
Commercial a/	-	-	-	0.80	0.62	1.42
Domestic	25.16	-	25.16	0.55	1.46	27.17
Crop Drying	0.73	35.76	36.49	-	-	36.49
Other b/	-	-	-	0.50	0.33	0.83

a/ Including hotels and restaurants.
b/ Agricultural machinery, water pumping, etc.

Source: Mission estimates.

Annex 2

VANUATU: ENERGY BALANCE PROJECTIONS, 1995
('000 toe)

	Fuelwood	Agric. Residues	Total Biomass	Electricity	Petroleum	Total Energy
Gross Supply						
Production	45.74	35.76	81.50	-	-	81.50
Imports	-	-	-	-	22.78	22.78
International Bunkers	-	-	-	-	(3.86)	(3.86)
Total Supply	45.74	35.76	81.50	-	18.92	100.42
Conversion						
Power Generation	(15.84)	-	(15.84)	20.07	(4.23)	-
Losses/Station Use	-	-		(17.37)	-	(17.37)
Net Domestic Consumption	29.90	35.76	65.66	2.70	14.69	83.05
Sectoral Consumption						
Transport	-	-	-	-	11.45	11.45
Industrial	-	-	-	0.22	0.40	0.62
Commercial	-	-	-	1.08	0.73	1.81
Domestic	29.17	-	29.17	0.76	1.70	31.63
Crop Drying	0.73	35.76	36.49	-	-	36.49
Other	-	-	-	0.64	0.41	1.05

Source: Mission estimates.

Annex 3

PETROLEUM RETAIL PRICE TRENDS, 1981-84
(VT/litre; at end of period)

	1981	1982	1983	February 1984
Gasoline	61.0	66.0	61.0	69.0
ADO	47.0	51.0	47.0	47.0
Kerosene	50.0	54.0	51.0	50.0
LPG (VT/kg)	110.0	110.0	102.0 a/	113.0 a/

a/ Estimates.

Source: Ministry of Finance.

Annex 4

GROWTH OF DEMAND AND DEMAND FORECAST BY UNELCO-VANUATU

Year	Generation	Sales	Annual Sales Increase	Peak Demand	Peak Demand Annual Increase
	(mln kWh)	(mln kWh)	(%)	(kW)	(%)
1978	12.5	11.6	-	2829	-
1979	13.6	12.6	8.6	2998	6
1980	14.4	13.3	5.6	3338	11.3
1981	14.0	13.0	-2.3	3168	-5.0
1982	NA	14.0	7.7	3338	5.4
1983	15.8	14.7	5.0	3621	8.5
1983	15.8	15.1	-	3650	-
1984	17.8	16.9	11.9	4100	12.3
1985	19.5	16.9	9.5	4500	9.8
1986	21.4	26.2	9.2	4825	7.2
1987	23.2	22.0	8.9	5170	7.2
1988	25.5	24.3	10.5	5540	7.2
1989	27.5	26.1	7.4	5940	7.2
1990	29.4	28.0	7.3	6370	7.2

Losses were around 7% to 8% in the period prior to 1983. The sudden drop to around 4% to 5% projected after 1983 is surprising. This is a very low percentage, unlikely to be realized. Between 1979 and 1983, the load factor decreased somewhat, from 0.52 to 0.50 and this factor is assumed to increase gradually to 0.53 by 1990.

Source: UNELCO-Vanuatu.

Annex 5

REVISED LOAD FORECAST FOR PORT VILA

Year	Sales	Peak Demand a/
	(GWh)	(MW)
1983 (Actual)	14.70	3.62
1984	15.44	3.80
1985	16.21	3.99
1986	17.02	4.19
1987	17.87	4.40
1988	18.77	4.62
1989	19.70	4.85
1990	20.69	5.09
1991	21.72	5.35
1992	22.81	5.62
1993	23.95	5.90
1994	25.14	6.19
1995	26.40	6.50

a/ Assuming 1983 load factor of 0.50.

Source: Mission estimates.

Annex 6

UNELCO-VANUATU

Tariff Port Vila, April 1, 1984 - October 1, 1984

		Per kWh
Domestic Tariff (small domestic consumers)		
First block of 60 kWh per month	0.60 p	= 14.42 Vt
Second block of 61 - 120 kWh per month	p	= 24.93 Vt
Third block of more than 120 kWh per month	1.50 p	= 36.04 Vt
General Tariff (all others incl. large domestic at low voltage)		
Basic tariff	p	= 24.03 Vt
Night tariff (22:30 - 6:30 hrs.)	0.6 p	= 14.42 Vt
Demand charge per subscribed kVA: 15-16 p = 360-384 Vt per kVA		
High Tension		
Basic tariff	0.6 p	= 14.42 Vt
Night Tariff (22:30 - 6:30 hrs.)	0.5 p	= 12.01 Vt
Demand charge per subscribed kVA 20 p = 481 Vt per kVA		
Public lighting	0.7 p	= 16.82 Vt

Note: p = 24.03, a factor derived from a tariff formula. The formula is:

$$p = p0\ [0.07 + 0.43\ \frac{G}{Go} + (0.25\ \frac{M}{Mo} + 0.375\ \frac{K}{Ko})\ (0.5 + 0.5\ \frac{Vo}{V})]$$

Where po, Go, Mo, Ko, and Vo are coefficients and

G is average price of diesel oil in a recent, specified period.
M is average wage in Port Vila as specified in two businesses.
K is an index of prices of industrial products in France.
V is recent sales of energy, as specified.

The tariff derives from the formula, shown above. The actual tariff is derived by applying certain multipliers which are specified in the "Cahier des Charges", an annex to the Concession agreement.

Annex 7

VANUATU GEOLOGICAL DATA

Methods

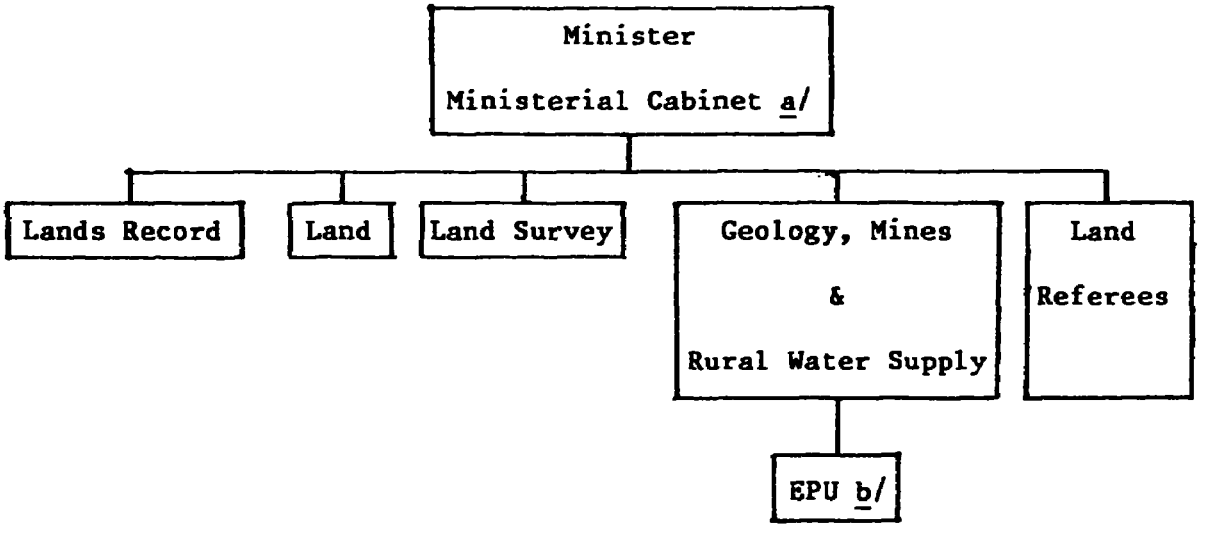
The primary methodology used in this investigation is seismic-reflection profiling, including both multichannel (24-fold) and single-channel data. In addition, gravity, magnetic, and bathymetric data were collected and sea floor samples were taken in selected areas to correlate seismic stratigraphy with lithology.

Data	
12 kWh, 3.5 kHz	4,500 km
Uniboom	4,400 km
Gravity, magnetic data	4,400 km
Single-channel seismic-reflection profiles	4,400 km
24-fold multichannel seismic-reflection profiles	2,500 km
Wide-angle sonobuoy seismic reflection-refraction profiles	33
Sampling stations:	
dredge hauls	1
gravity cores	2

Source: United States Geological Survey.

Annex 8

MLERWS ORGANIZATION CHART



a/ Comprised of Minister and three Permanent Secretaries. The Second Permanent Secretary has routine responsibility for the Directorate of Energy and Water.

b/ Comprised of ABD-funded Energy Planner and his local counterpart.

Source: MLERWS.

CURRENT AND PROPOSED TECHNICAL ASSISTANCE

Activity Code	Date	Cost ($000)	Description
1. Subsector Planning			
UNPEDP-2	Late 84	N/A	Electricity Authority Planning and Legislation: Provide assistance to revise existing legislation and/or provide guidelines as required.
UNPEDP-14	Nov. 83	N/A	Wood Power Review: Consultant, in response to a request from Government, carried out review of Wood Power options/potential for Vanuatu.
UNPEDP-14	End 83	N/A	Geothermal Costs: Consultant evaluated and reported on the economies of the possible viability of geothermal energy and alternatives on Efate Island.
2. Energy Resource Assessment			
ESCAP	End 82	$6	Fuelwood Survey: Assessment of fuelwood resource and use.
EEC-1	Mid 84	ECU 347	Power Gasification Systems: Purchase, supply and installation of a 75 kVA charcoal gasifier and generator plus another 50 kW wood gasifier and generator for electricity generation.
CHOGRM-8	End 84	N/A	Photovoltaic Applications: Depending on availability of funds provision of PVC systems for rural lighting.
SPC-1	Mid 84	N/A	Photovoltaic Applications: Solar electrification of a small hotel on Tanna Island.
UNPEDP-5	85	N/A	Wood & Charcoal Stoves: Supply of materials and moulds and demonstrate the fabrication and use of these stoves.

Activity Code	Date	Cost ($000)	Description
3. Energy Conservation & Demand Management			
CHOGRM-2	Mid 83	N/A	Energy Conservation & Management: Consultants carried out energy audits on selected sites and recommended/initiated measures to reduce energy waste.
4. Pricing/Tariff Study			
UNPEDP-3	Dec. 82	N/A	Petroleum Supply & Pricing: Consultant advised on petroleum supply and pricing arrangements in December 82.
UNPEDP-3	Sept. 83	N/A	Consultant carried out a valuation of the Petroleum Storage facilities in Port Vila in September 1983.
5. Training & Manpower Planning			
CFTC-1	July 83	N/A	Training Course on Energy Planning: Vanuatu representative attended this exercise held in Suva, Fiji in July 83.
ESCAP-6	Nov. 83	N/A	Petroleum Supply/Pricing - Training Workshop: Vanuatu was also represented at this course in November last year.
CHOGRM-4	Mid 85	N/A	Workshop in Coconut Oil as Diesel Fuel: Vanuatu will be invited to be represented at this workshop scheduled around mid 85.
6. Institutional Development			
ADB-1	Mid 84	N/A	Energy Planner: Resident expert support to organize the Energy Planning Unit and re-set in motion the national energy planning process.

Source: Mission estimates.

Annex 10

PRIORITY ACTION PROGRAMME

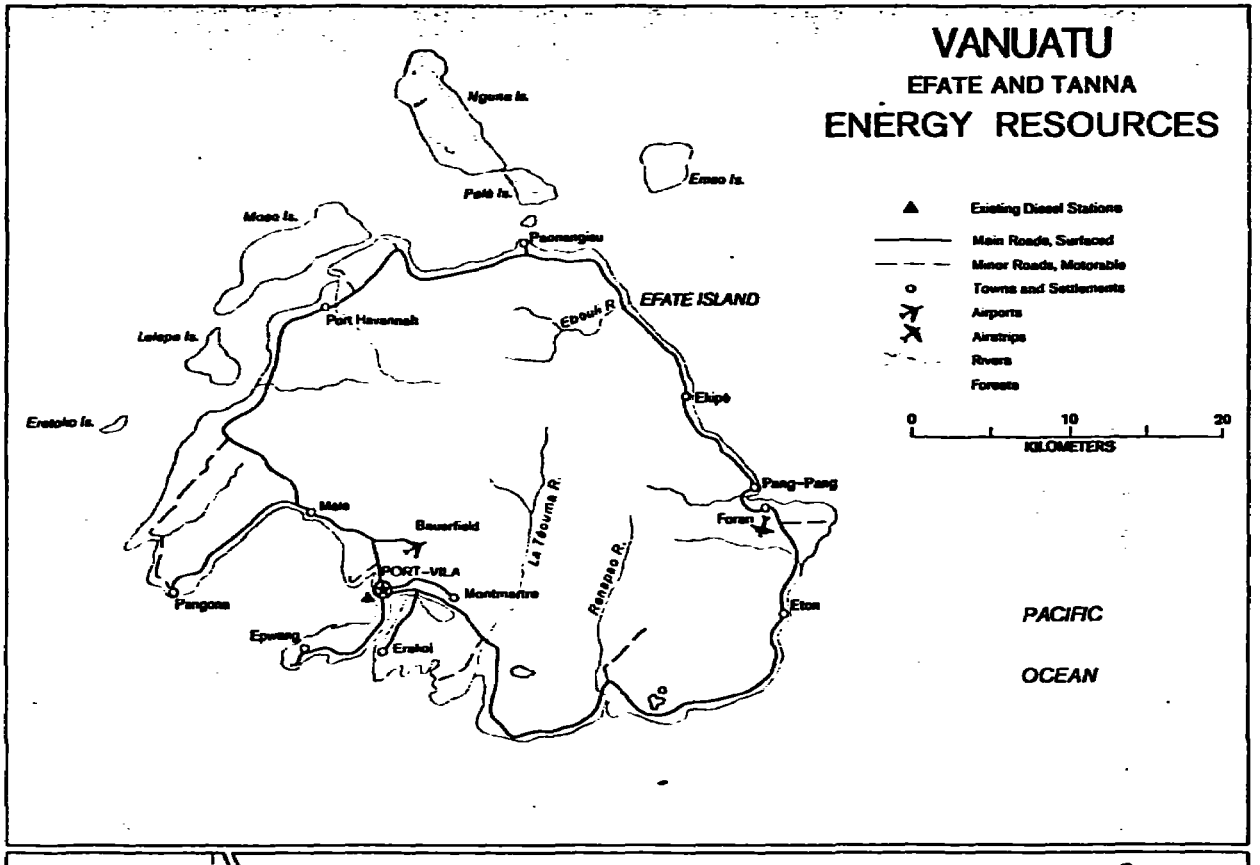
	Estimated Cost (US$)
Petroleum Sector	
1. Regional Petroleum Supplies Arrangement - review of current supply arrangements; identification and evaluation of possible least-cost supply options; and recommendations as to optimal supply strategy and institutional requirements for implementation	85,000 a/
Power Sector	
2. Sector Administration - Assistance to GOV in disccusions with the public power supply concessionaire (UNELCO-Vanuatu) concerning modification of present concession agreement to incorporate: (i) financial reporting requirements; (ii) policy guidelines for future operation; and (iii) determination of the economic cost of electricity supply	70,000
3. Objective review of forthcoming feasibility study for a proposed wood-fired power station -- especially fuel resource evaluation; optimal planning location and technical configuration; and contractual arrangements proposed	65,000
4. Hydro Power Development - further investigation of hydroelectric development opportunities, paying particular attention to potential optimal project sizing in view of likely demand; updating of previously established capital costs and expected benefits; and establishing estimates of reliable energy levels and maximum firm capacity	60,000
5. Least-Cost Power Expansion - preparation of a least-cost power system expansion program, taking into account the expected costs and benefits of wood-fired generation, hydrogeneration and mixed hydro-thermal generation	30,000
Other Renewables	25,000
6. - feasibility evaluation of wood-fired drying facilities (hot-air generators) at proposed cocoa plantation on Malekula Island, including fuel resources evaluation over projected plant-life; financial and economic analysis of project merits and additional investment requirements	
Energy Resource Data Collection	
7. - continuation of current hydrological data collection on selected major rivers	60,000 b/
8. - completion of the three-phase geothermal potential investigation program	n/a c/

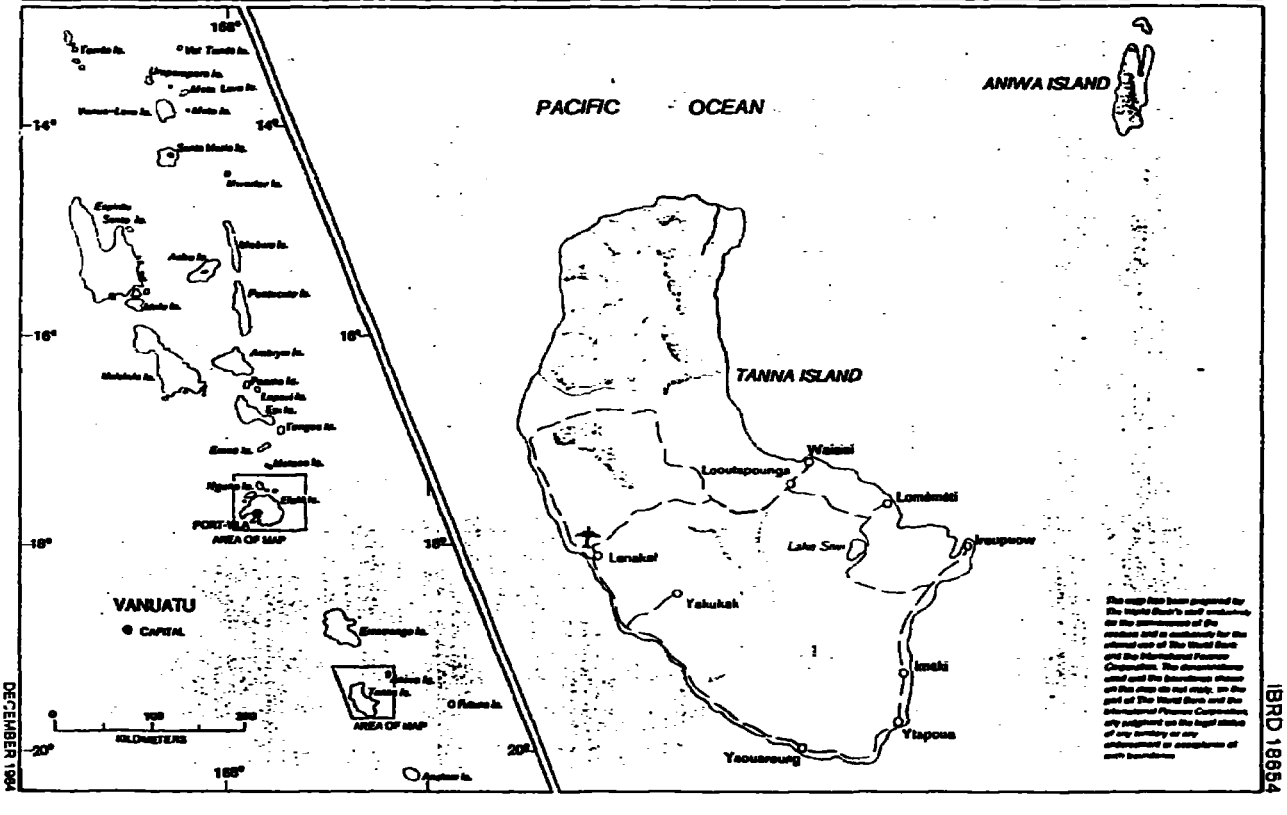
a/ To be financed and executed by the joint UNDP/World Bank Energy Sector Management Assistance Program (ESMAP).

b/ The European Development Fund (EDF) is expected to continue financing this program.

c/ To be funded by New Zealand.

VANUATU
EFATE AND TANNA
ENERGY RESOURCES





DECEMBER 1984

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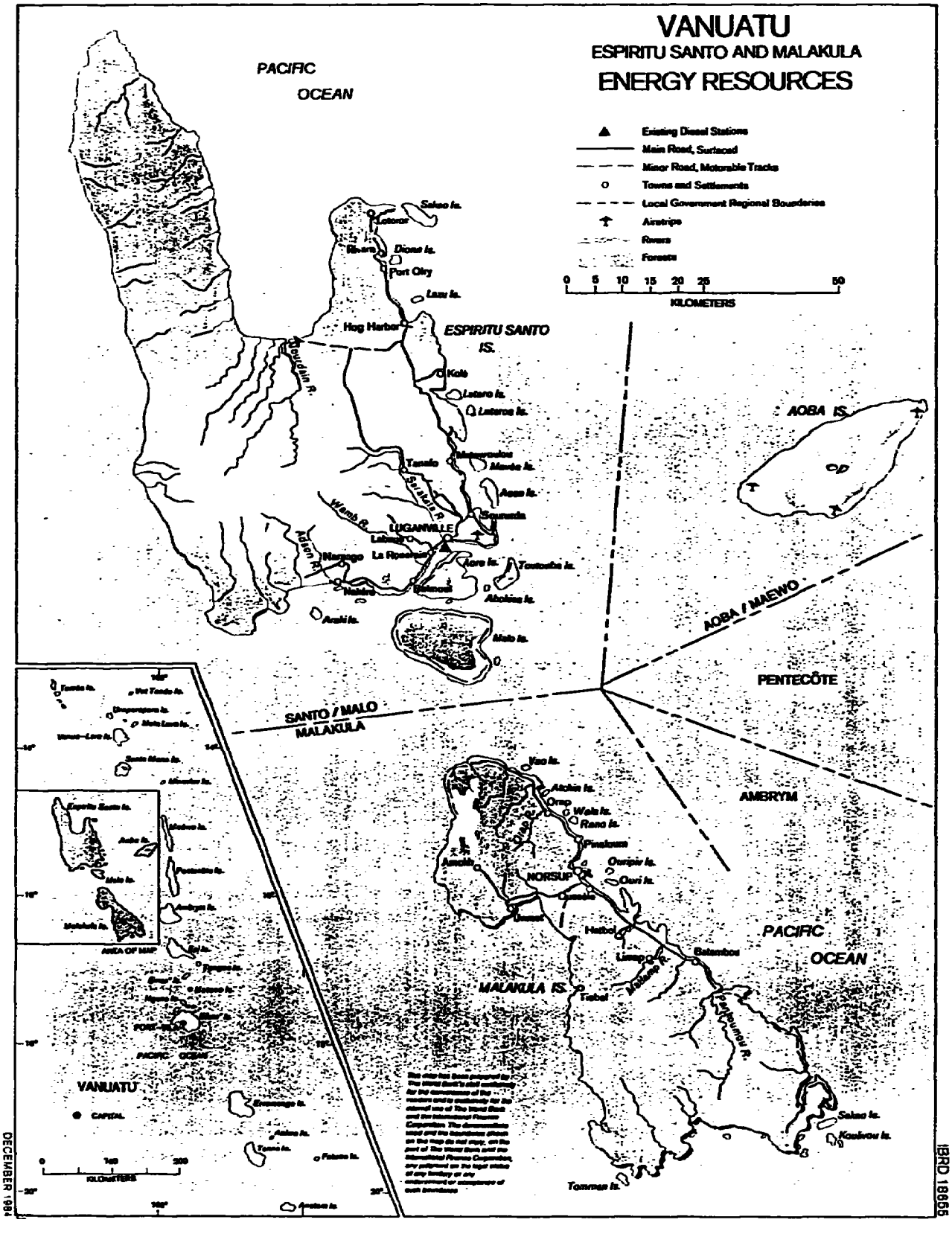
VANUATU
ESPIRITU SANTO AND MALAKULA
ENERGY RESOURCES
Existing Diesel Stations
Main Road, Surfaced
Minor Road, Motorable Tracks
Towns and Settlements
Local Government Regional Boundaries
Airstrips
Rivers
Forests
0 5 10 15 20 25 50
KILOMETERS
PACIFIC OCEAN
ESPIRITU SANTO IS.
Hog Harbor
Port Olry
Luganville
Nambe
Aore Is.
Malo Is.
Aoba Is.
AOBA IS.
AOBA / MAEWO
PENTECÔTE
SANTO / MALO
MALAKULA
AMBRYM
NORSUP
MALAKULA IS.
Lakatoro
Tebel
Limap
Batambou
Pentecost R.
Malekula Is.
Tommen Is.
Salsa Is.
Koulivou Is.
AREA OF MAP
PACIFIC OCEAN
VANUATU
CAPITAL
KILOMETERS
OCCEMBER 1984
IBRD 18655