JAPAN INTERNATIONAL COOPERATION AGENCY

ELECTRIC POWER COOPERATION
THE GOVERNMENT OF SAMOA

STUDY
ON
ELECTRIC POWER DEMAND AND SUPPLY
IN
THE INDEPENDENT STATE OF SAMOA

FINAL REPORT
MAIN REPORT

MARCH 2003

JAPAN INTERNATIONAL COOPERATION AGENCY

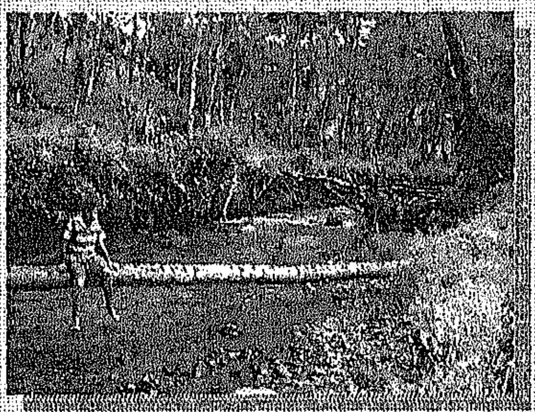
ELECTRIC POWER COOPERATION
THE GOVERNMENT OF SAMOA

JICA

STUDY ON ELECTRIC POWER DEMAND AND SUPPLY IN THE INDEPENDENT STATE OF SAMOA

FINAL REPORT

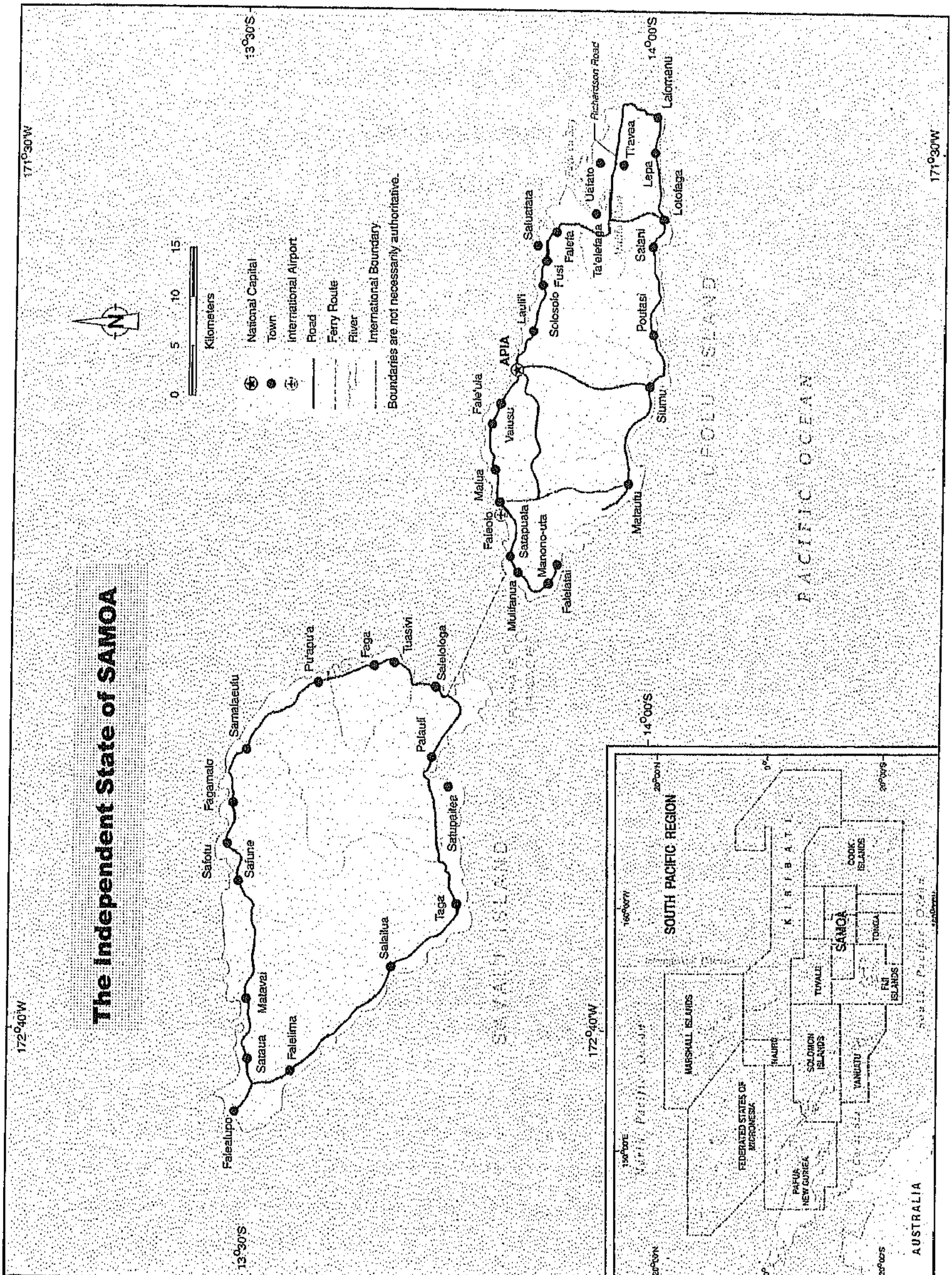
MAIN REPORT



A boy at Reafa River near Lotofaga Hydro Scheme

MARCH 2003

NIPPON KOEI CO.,LTD.



STUDY OF ELECTRIC POWER DEMAND & SUPPLY IN SAMOA	Location of Project Area
JAPAN INTERNATIONAL COOPERATION AGENCY	

JICA STUDY
ON
ELECTRIC POWER DEMAND & SUPPLY
IN
THE INDEPENDENT STATE OF SAMOA

FINAL REPORT

MAIN REPORT

TABLE OF CONTENTS

Location of Project Area

1. INTRODUCTION

1.1 Background of the Study .... 1 - 1
1.2 Purpose of the Study .... 1 - 1
1.3 Study Team .... 1 - 1
1.4 Counterpart Personnel .... 1 - 2

2. POWER DEMAND FORECAST

2.1 Availability of Power Demand Data .... 2 - 1
2.2 Verification of Previous Demand Forecast .... 2 - 1
2.3 Demand Forecast of Upolu .... 2 - 2
2.3.1 Averaged Annual Growth Rate (AAGR) .... 2 - 2
2.3.2 Demand Forecast of Upolu .... 2 - 5
2.4 Demand Forecast of Savaii .... 2 - 6
2.4.1 Averaged Annual Growth Rate (AAGR) .... 2 - 6
2.4.2 Demand Forecast of Savaii .... 2 - 8
2.5 Recommendation .... 2 - 9

3. DIESEL POWER PLANT

3.1 Diesel Power Plant .... 3 - 1
3.1.1 Operation of Existing Power Generators .... 3 - 1
3.1.2 Years of operation in existing power generators .... 3 - 2
3.1.3 Fuel Consumption .... 3 - 2
3.1.4 Superannuated Portions of Engine Generators .... 3 - 3
3.1.5 Operational Time of Generators Repair Cost .... 3 - 4
3.2 Present Status of Operation and Maintenance for Power Plants .... 3 - 5
3.2.1 Technical Level .... 3 - 5
3.2.2 Load Factor .... 3 - 6
3.2.3 Tool Control .... 3 - 7
3.2.4 History of past troubles and measures to be taken .... 3 - 7
3.2.5 Confirming reports of power generators .... 3 - 10

3.2.6 Environmental protection .... 3 - 10
ANNEX 3

4. HYDROPOWER GENERATING PLANTS & TRANSMISSION/ DISTRIBUTION SYSTEM

4.1 General .... 4 - 1
4.2 Existing Hydropower Scheme .... 4 - 1
4.2.1 Features of the Existing Hydropower Scheme .... 4 - 1
4.2.2 Operation Record of Hydropower Scheme .... 4 - 6
4.3 Present Status of Power Stations .... 4 - 8
4.3.1 Alaoa Hydropower Station .... 4 - 8
4.3.2 Samasoni Hydropower Station .... 4 - 9
4.3.3 Fale-ole-Fee Hydropower Station .... 4 - 10
4.3.4 Lalomauga Hydropower Station .... 4 - 10
4.3.5 Taelefaga Hydropower Station .... 4 - 11
4.3.6 Control Center .... 4 - 11
4.4 Organization of Hydropower Generation .... 4 - 11
4.4.1 Operation Team .... 4 - 12
4.4.2 Maintenance Team .... 4 - 12
4.4.3 Maintenance Work .... 4 - 13
4.5 Power Transmission and Distribution System .... 4 - 14
4.5.1 Rural Electrification Project .... 4 - 14
4.5.2 Present State of Power System .... 4 - 15
4.6 Fault Record on the Upolu Power System .... 4 - 17
4.7 Conclusion and Recommendation .... 4 - 19
ANNEX 4

5. HYDROPOWER DEVELOPMENT PLAN

5.1 Recommendation of Hydropower Development .... 5 - 1
5.2 General Condition of Hydropower Planning .... 5 - 4
5.2.1 Previous Study of Hydropower Scheme .... 5 - 4
5.2.2 Geographic Data .... 5 - 4
5.2.3 Hydrological Data .... 5 - 6
5.2.4 Environmental Issues .... 5 - 11
5.2.5 Existing Hydropower Civil Structures .... 5 - 13
5.2.6 Existing Hydropower Development Plan .... 5 - 14
5.3 Hydropower Planning .... 5 - 14
5.3.1 Site Reconnaissance of Hydropower Potential Site .... 5 - 14
5.3.2 Methodology of Hydropower Plan .... 5 - 15
5.3.3 Methodology of Cost Estimate .... 5 - 18
5.3.4 Methodology of Economic Evaluation .... 5 - 19

5.3.5 Recommendation and Conclusion of Hydropower Schemes .... 5 - 21
ANNEX 5

6. POWER SUPPLY PLANNING

6.1 Existing Generating Plants .... 6 - 1
6.1.1 Generating Plants in Upolu .... 6 - 1
6.1.2 Generating Plants in Savaii .... 6 - 1
6.2 Firm Capacity and Energy of Existing Hydro .... 6 - 2
6.2.1 Dependable Capacity and Energy in Previous Studies .... 6 - 2
6.2.2 Review of Dependable Output and Firm Energy in This Study .... 6 - 3
6.3 New Generation Option .... 6 - 5
6.3.1 Diesel Generating Plants .... 6 - 5
6.3.2 Recommended New Hydro Scheme .... 6 - 5
6.4 Assumption for Power Supply Planning .... 6 - 6
6.4.1 Firm Energy and Dependable Output of Existing Hydro Plants .... 6 - 6
6.4.2 Candidates of Additional Plants .... 6 - 7
6.4.3 Reserve Capacity .... 6 - 7
6.4.4 Examination of Loss of Load Probability (LOLP) .... 6 - 8
6.4.5 Least Cost Development Study .... 6 - 8
6.5 Results of Power Supply Planning Study .... 6 - 8
6.5.1 Upolu System .... 6 - 8
6.5.2 Savaii System .... 6 - 9
6.6 Recommendation 6- 10

APPENDIX

APPENDIX-1 Training Program (Diesel Plant) AP-1-1
APPENDIX-2 Training Program (Hydropower Plant) AP-2-1

LIST OF TABLES

Table 2.2.1 Summary of Previous Demand Projection of Upolu .... 2 - 2
Table 2.2.2 Comparison of Previous Projected Demand and Actual Record .... 2 - 11
Table 2.3.1 Annual Sold Energy of EPC and AAGW by Tariff Category, 1982-2002 .... 2 - 12
Table 2.3.2 Generated Energy of Upolu, 1994 – 2002 .... 2 - 13
Table 2.3.3 System Losses of Upolu .... 2 - 3
Table 2.3.4 Sample of Recorded Energy Consumed for Generating Electric Power in 1999 2 - 14
Table 2.3.5 Typical Daily Load and Load Duration in Dry Season .... 2 - 15
Table 2.3.6 Typical Daily Load and Load Duration in Wet Season .... 2 - 16
Table 2.3.7 Annual Generated Energy, Maximum Demand and Load Factor .... 2 - 4
Table 2.3.8 Annual Growth Rates of Generated Energy .... 2 - 5

Table 2.3.9	Power Demand Projection of Upolu for Study	2 - 6
Table 2.3.10	Lowest and Highest Power Demand Projection of Upolu for The Study	2 - 17
Table 2.4.1	Total Sold Energy of Savaii	2 - 7
Table 2.4.2	Generated Energy in Savaii	2 - 7
Table 2.4.3	System Loss of Savaii	2 - 7
Table 2.4.4	Typical Daily Load and Load Duration of Savaii	2 - 18
Table 2.4.5	Annual Generated Energy, Peak Demand and Load Factor	2 - 8
Table 2.4.6	Power Demand Projection for Study	2 - 9
Table 2.4.7	Lowest and Highest Power Demand Projections of Savaii for Study	2 - 19
Table 3.1.1	Condition of D/G generators in Vaipouli	3 - 3
Table 3.1.2	Condition of D/G Generator in Salelologa	3 - 3
Table 3.1.3	Condition of the D/G generators in Tanugamanono	3 - 4
Table 3.2.1	Arrangement of O&M Staff	3 - 6
Table 4.2.1	Features of Hydropower Station	4 - 3
Table 4.2.2	Outline of Hydropower Schemes	4 - 6
Table 4.2.3	Operation Record Hydropower Scheme	4 - 7
Table 4.2.4	Monthly Generation Record in 2002	4 - 7
Table 4.2.5	Monthly Generation in 2002	4 - 8
Table 4.4.1	Maintenance Work	4 - 13
Table 4.5.1	Distribution Lines Constructed under the Project	4 - 14
Table 4.5.2	Materials and Construction Equipment Supplied under the Project	4 - 14
Table 4.5.3	Features of Distribution Lines in Upolu	4 - 16
Table 4.5.4	Monthly Fault Record from 2000 to 2002	4 - 17
Table 4.6.1	Monthly Fault Record from 2000 to 2002	4 - 18
Table 4.6.2	Annual Fault Record in Upolu	4 - 18
Table 5.1.1	Advantages and Disadvantages of Hydropower Projects	5 - 1
Table 5.1.2	Recommended Hydropower Schemes in Samoa	5 - 3
Table 5.2.1	Previous Study Reports related to Hydropower	5 - 4
Table 5.2.2	Available Maps and Aerial Photos	5 - 5
Table 5.2.3	National Climate and Rainfall Network	5 - 9
Table 5.2.4	Applied Rainfall Data at River Basin	5 - 10
Table 5.2.5	Runoff Coefficient at River Basin	5 - 10
Table 5.2.6	Percentage of Land Area under Forest	5 - 12
Table 5.2.7	Existing Hydropower Plants owned by EPC	5 - 13
Table 5.2.8	Inspection Results on Existing Hydropower Civil Structures	5 - 13
Table 5.3.1	Site Reconnaissance to Hydro Potential Sites	5 - 15
Table 5.3.2	Discharge Measurement Data during Site Reconnaissance	5 - 15
Table 5.3.3	Efficiency of Turgo Impulse Type Turbine	5 - 16
Table 5.3.4	Simulation Results for Power Generation	5 - 17
Table 5.3.5	Firm Energy for Power Generation	5 - 17
Table 5.3.6	Conditions of Cost Estimate by Forms of Diagrams	5 - 18

Table 5.3.7	Estimated Construction Cost	5 - 19
Table 5.3.8	Input Data for Economic Calculation	5 - 20
Table 5.3.9	Economic Evaluation Results	5 - 20
Table 5.3.10	Summary of New Hydropower Scheme	5 - 21
Table 5.3.11	Particular Site Condition of each Scheme	5 - 22
Table 5.3.11	Development Priority and Prospective Commission Year	5 - 23
Table 6.1.1	Details of Generating Plants in Upolu	6 - 1
Table 6.1.2	Details of Generating Plants in Savaii	6 - 2
Table 6.2.1	Firm Output and Energy Estimated in The Report	6 - 2
Table 6.2.2	Number of Monthly Generation Data	6 - 3
Table 6.2.3	Calculated Firm Energy	6 - 4
Table 6.2.4	Calculated Firm Outputs	6 - 4
Table 6.3.1	Candidates of Hydro Potential Scheme	6 - 5
Table 6.4.1	Dependable Output and Firm Energy in Wet Season	6 - 6
Table 6.4.2	Dependable Output and Firm Energy in Dry Season	6 - 6
Table 6.4.3	Dependable Output and Firm Energy for New Hydro Projects	6 - 7
Table 6.5.1	Power Supply Plan upto 2015 of Upolu (5.5% AAGR)	6 - 13
Table 6.5.2	Power Supply Plan upto 2015 of Upolu (4.0% AAGR)	6 - 14
Table 6.5.3	Power Supply Plan upto 2015 of Upolu (9.0% AAGR)	6 - 15
Table 6.5.4	Power Supply Plan w/o New Hydro upto 2015 of Upolu (6.5% AAGR)	6 - 16
Table 6.5.5	Energy Balance upto 2015 of Upolu (6.5% AAGR)	6 - 17
Table 6.5.6	Energy Balance w/o New Hydro upto 2015 of Upolu (6.5% AAGR)	6 - 18
Table 6.5.7	Required Additional Diesel Units for Upolu	6 - 9
Table 6.5.8	Power Supply Plan upto 2015 of Savaii (6.0% AAGR)	6 - 19
Table 6.5.9	Power Supply Plan upto 2015 of Savaii (3.0% AAGR)	6 - 20
Table 6.5.10	Power Supply Plan upto 2015 of Savaii (8.0% AAGR)	6 - 21
Table 6.5.11	Power Supply Plan w/o New Hydro upto 2015 of Savaii (6.0% AAGR)	6 - 22
Table 6.5.12	Energy Balance upto 2015 of Savaii (6.0% AAGR)	6 - 23
Table 6.5.13	Energy Balance w/o New Hydro upto 2015 of Savaii (6.0% AAGR)	6 - 24
Table 6.5.14	Required Additional Diesel Units for Savaii	6 - 9

LIST OF FIGURES

Figure 2.2.1	Results of Previous Projected Demand and Actual Data	2 - 11
Figure 2.3.1	Sold Energy of EPC by Tariff Category, 1982 – 2002	2 - 12
Figure 2.3.2	Generated Energy of Upolu, 1994 – 2002	2 - 13
Figure 2.3.3	Typical Daily Load and Load Duration Curves in Dry Season	2 - 15
Figure 2.3.4	Typical Daily Load and Load Duration Curves in Wet Season	2 - 16
Figure 2.4.1	Typical Load and Duration Curves of Savaii	2 - 18
Figure 3.1.1	Generation Repair Cost	3 - 4
Figure 3.2.1	Fuel Consumption/Load Factor for Cycle Diesel Engines	3 - 7

Figure 4.1.1 Location of Generating Power Plant .... 4 - 2
Figure 4.4.1 Organization of the Hydropower Generation Section .... 4 - 12
Figure 4.5.1 Power System in Upolu .... 4 - 15
Figure 4.5.2 Power System in Savaii .... 4 - 17
Figure 5.1.1 Flow Chart of CDM Procedure .... 5 - 2
Figure 5.1.2 Life Cycle CO_2 Emission by Power Sources .... 5 - 3
Figure 5.2.1 Rainfall Gauging Station in Upolu .... 5 - 7
Figure 5.2.2 Rainfall Gauging Station in Savaii .... 5 - 8
Figure 5.3.1 Efficiency Curve of Turgo Impulse Type Turbine .... 5 - 16
Figure 5.3.2 Power Output Duration Curve in case of Namo Hydropower No.3 Scheme .... 5 - 16
Figure 5.3.3 Simulation Results in case of Namo Hydropower No.3 Scheme .... 5 - 17
Figure 6.2.1 Monthly Generated Energy Duration Curves .... 6 - 11

1. INTRODUCTION

1.1 BACKGROUND OF THE STUDY

In March 2001, JICA conducted a project formulation study, which aimed to sound feasibility of development of renewal energy in Samoa such as hydropower, photovoltaic and wind power. Based on the study, the Samoa Government requested the Japanese Government to provide a technical cooperation for the Study on formulating long term power supply plan and recommendation of hydropower development. In reply to the request, JICA dispatched a study team consisting of four (4) specialists for power supply planning, diesel power generating plants, hydropower generating plant and hydropower development planning. The Study Team commenced their detail field survey and investigation on February 3, 2003 and completed their scheduled all works in Samoa on March 14, 2003.

1.2 PURPOSE OF THE STUDY

The main objective of the Study is to formulate the long-term power supply planning of Upolu and Savaii islands on the basis of the following study results provided by each specialist taking feasibility on development of new hydro potentials, especially in Upolu, into consideration.

(i) Long term demand forecast

(ii) Improvement/renewal plan of diesel generating plants

(iii) Improvement/renewal plan of hydropower generating plan

(iv) Recommendation of hydropower development plan

1.3 STUDY TEAM

The JICA study team for the Study consists of the following four (4) specialists.

(i)	Mr. Yoshiaki MIYAGAWA	Power Supply Planning	Nippon Koei
(ii)	Mr. Hiroshi KAWAKAMI	Diesel Generating Plant	HITK Enterprise Corp.
(iii)	Mr. Yoshikazu SUNAGAWA	Hydropower Plant	Nippon Koei
(iv)	Mr. Ichiro ARAKI	Hydropower Development	Nippon Koei

1.4 COUNTERPARTS PERSONNEL

In the kick off meeting between EPC and the Study Team held on February 3, 2003 at EPC's office, the counterparts team headed by Mr. Taputoa has been introduced to the Study Team and worked together throughout the study period, especially in field survey and investigation.

(i)	Moefaauo Taputoa Titimaea	Chief Engineer Development
(ii)	Galumalemana Tile Leia	Manager Generation
(iii)	Mr. Iese Toimoana	Electrical Engineer of Development Dept.
(iv)	Mr. Loloane Auala	Civil Engineer of Development Dept.
(v)	Tiafau Tafu Salevao	Mechanical Engineer of Generation Dept.
(vi)	Mr. Harman Porter	Electrical Engineer of Generation Dept.

2. POWER DEMAND FORECAST

2.1 AVAILABILITY OF POWER DEMAND DATA

EPC keep detail information on power demand in the form of monthly reports and/or computer outputs. Detail power demand data like energy sales, revenue and number of customers by tariff category for whole country are calculated monthly in detail by means of using computer system and such detail calculation results are kept only in the form of printouts of computer and magnetic tapes. No summarized detail annual information by tariff category and by power supply system (island) are provided. .

For power generation, actual detail information of energy generated by unit, daytime and night-time peak demand, daily load curve on the day of maximum peak demand recorded in the month, fuel consumption, etc. are reported in the form of a monthly report. However, same as demand data, no annual reports and statistical data book have been prepared.

In addition to the above-mentioned reporting system of EPC, most of all monthly reports and computer outputs are under the poor management in their storehouses without certain storing and recording system. There are many losses of reports in the storehouses. Under such situation, the Team spent large part of available time for the study in Samoa for collecting such operation and energy sales records.

2.2 VERIFICATION OF PREVIOUS DEMAND FORECAST

Demand forecasts are a basic input for planning of power system such as expansion plan of generating facilities, extension plan of transmission and distribution system, selection of power development plan, timing of investments, future energy sales, tariff study, etc. However, the task of predicting future demand growth is rather difficult in the case of a small power supply system, like that on Upolu (15.8 MW in 2002) and Savaii (3.0 MW in 2002) and where the connection of a single additional large customer like hotel could have a significant impact on the ability of the system to supply peak power.

In the previous study reports made by foreign consultants and EPC, two different approaches have been used. The first is based on linear (or preferably logarithmic) fitting of the past trend of actual operation and the second uses economic data such as forecasted information on population, GDP, production by sector, trading, etc. to estimate future energy sales in each market sector, namely domestic, industrial, commercial, schools, etc.

The following two previous demand forecasts are selected for verifying fitness to the actual past demand with conditions that the projected period meets with the available data collected for this study and certain forecasted figures are indicated in their reports.

Table 2.2.1 Summary of Previous Demand Projection of Upolu

Report Title	Method Used	AAGR
Gibb's report, 1991	Time trend method	5.0 % (median)
HECEC's report, 1997	Logarithmic time trend and economic method	6.0 % (median)

(Remark) AAGR: Averaged annual growth rate

Details of the actual demand data and the results of projections in the previous studies are given in Table 2.2.2 and Figure 2.2.1. The difference of AAGRs of sold energy and generated energy in the Gibb's report is caused by their assumption on energy loss, which is projected as 2.5 % pa constant improvement throughout study period. For the HECEC's projection, it is clearly mentioned that AAGR of 6.0 % pa is recommended for energy consumption, but the AAGR is applied to the required energy for power supply.

As shown on Figure 2.2.1, it is caused by their under estimation of AAGR made in 1990, especially for the period from 1990 to 1996 (actual AAGR: 6.9 % pa) that the Gibb's projection seems to be relatively low comparing with actual historical records and HECEC's projections.

2.3 DEMAND FORECAST OF UPOLU

2.3.1 AVERAGED ANNUAL GROWTH RATE (AAGR)

As explained in Clause 2.1, due to the limitation of available information, the following demand data are collected.

Monthly energy generation by plant	Jun. 1993 to Jan. 2003
Monthly peak demand (day time and night-time)	Jun. 1993 to Jan. 2003
Monthly sold energy by tariff category (whole system)	Oct. 1992 to Jan. 2003
Total monthly sold energy (Upolu and Savaii system)	Oct. 1992 to Dec. 2002

It is noted that details of monthly sold energy, revenue and number of customers by tariff category are calculated and reported by EPC for only whole system, but not power supply system basis. However, total monthly sold energy and revenue by system basis are indicated on the computer outputs up to September 1999, but no report after the modification of accounting system in 1999. However, the remaining parts of sold energy of Upolu and Savaii after September 1999 are received separately at the last stage of this study.

The remaining system losses seem to be very high level taking considerable technical losses for distributing electric energy to customers of a few percent. Non-technical losses, namely theft, poor metering, poor billing, etc. seem to share a large part of the total losses.

(4) Daily Load and Load Duration Curves

Typical daily loads of dry season, namely July 17, 2002 (Wednesday) and July 21, 2002 (Sunday), and their load duration are given in Table 2.3.5 and their curves are illustrated on Figure 2.3.3. For wet season, load curves, namely January 15, 2003 (Wednesday) and January 19, 2003 (Sunday) are given in Table 2.3.6 and Figure 2.3.4. As illustrated on the figures, daily loads of weekday have normally two peaks per day, i.e. daytime peak and night-time peak, and load curves of holiday have night-time peak only. Daytime peak occurs recently at around 11:00 AM and night-time peak at around 7:30 PM.

As for the monthly maximum peak demand, the night-time peak was bigger than that of daytime before February 1999. However, the monthly maximum demand was firstly reversed from night-time to daytime in the month of February 1999 and, after that time, monthly maximum peak load of daytime and night-time appeared in mixed.

The load duration curves show that hydro power plants are operated to share of base load part continuously without big fluctuation and remaining medium and peak portion are covered by diesel power plants.

(5) Annual Maximum Peak Demand and Load Factor

Generated energy, maximum annual peak demand and annual load factors are given in Table 2.3.7. Annual maximum peak demand appeared two times each in February, October, November and December, and one time in September for the period from 1994 to 2002.

Table 2.3.7 Annual Generated Energy, Maximum Demand and Load Factor

Year	94	95	96	97	98	99	00	01	02	AAGR
Generated Energy (GWh)	58.8	63.4	68.8	73.7	74.1	74.2	78.1	85.2	91.5	5.7%
Peak Demand (MW)	10.1	11.0	12.2	12.8	12.7	13.3	14.4	15.2	15.8	5.7%
Annual Load Factor (%)	66.3	65.9	64.5	65.6	66.4	63.8	61.8	63.9	66.0	-0.1%

Annual load factors progressed within the small range from 61.8 % to 66.4 % and its averaged load factor for the 9 years was 64.9 %. Load of Upolu is presently under a transitional period from night-time peak to daytime peak and the present load factor of around 66 % seems to be a maximum level for the Upolu system. A tendency of load factor will turn to a decline direction, but its speed will be very slow in such transitional period.

2.3.2 DEMAND FORECAST OF UPOLU

(1) Projection of Growth Rate

Demand forecast will be conducted on the basis of annual generated energy of the past 9 years, because energy sales data of Upolu from 1999 to 2002 are not available at the time of analysis. As shown in Table 2.3.2, simply calculated AAGR of the generated energy between 1994 and 2002 is 5.7 % pa and AAGR of the period from 1996 to 2002 is 4.9 % pa, even annual growth rate of each year largely fluctuates in the range between 0.4 % pa of 1999 and 9.0 % pa of 2001 as shown in Table 2.3.8.

Table 2.3.8 Annual Growth Rates of Generated Energy

Calendar Year	94	95	96	97	98	99	00	01	02	AAGR
Generated Energy (GWh)	58.8	63.4	68.8	73.7	74.1	74.5	78.1	85.2	91.5	5.7%
Annual Growth Rate (%)	-	7.8	8.4	7.2	0.5	0.4	4.9	9.0	7.5	-

Taking these AAGRs into consideration, a base growth rate for energy required in Upolu of 6.5 % pa is recommended and is used for the power supply planning study. For the high growth scenario, an AAGR of 8.0 % pa is used and for low growth scenario, an AAGR of 4.0 % pa.

(2) System Losses

As shown in Table 2.3.3, the percent system loss including auxiliary energy usage between 1994 and 2002 has been improved continuously with the rate of 4.1 % p.a. Therefore, a base rate of 0.45 % of the required energy is recommended as auxiliary energy usage for generating electric energy throughout the study horizon. For the remaining percent loss, a 4.0 % pa constant improvement is projected.

(3) Annual Load Factor

As shown in Table 2.3.1, current AAGR of Commercial demand (1996 to 2002) recorded the highest rate of 10.1 % pa among the tariff category groups, which is much higher than that of total demand of 6.2 % pa, and the second was Religion/Schools (8.1 % pa). As a result of higher growth rate of these daytime loads, the type of load of Upolu system is presently in a transitional period of turning point from night-time peak to daytime peak. It is expected that the difference of both the peaks will grow bigger and bigger with high growth of such daytime demand. However, a tendency of decreasing annual load factor will be very slow in such transitional period from the experience of the developed countries. Therefore, annual load factor was considered to remain constant at 66 % for the period from 2003 to 2015.

(4) Projected Power Demand

Projected required energy, peak load and energy sale with AAGR of 6.5 % are given in Table 2.3.9 and power demand projection for other scenarios are given in Table 2.3.10.

Table 2.3.9 Power Demand Projection of Upolu for Study

Calendar Year	Median Scenario (6.5 %)					
	Energy Generated	Auxiliary Usage	Losses	Percent Losses	Energy Sold	Max. Peak Load
2001	85.15	-	17.68	17.05	70.10	15.22
2002	91.54	-	17.89	16.96	75.16	15.84
2003	97.49	0.44	16.47	16.90	80.58	16.86
2004	103.82	0.47	17.47	16.83	85.88	17.96
2005	110.57	0.50	18.53	16.76	91.54	19.12
2006	117.76	0.53	19.66	16.69	97.57	20.37
2007	125.41	0.56	20.85	16.63	104.00	21.69
2008	133.57	0.60	22.12	16.56	110.84	23.10
2009	142.25	0.64	23.46	16.50	118.14	24.60
2010	151.49	0.68	24.89	16.43	125.92	26.20
2011	161.34	0.73	26.40	16.36	134.21	27.91
2012	171.83	0.77	28.01	16.30	143.05	29.72
2013	183.00	0.82	29.71	16.23	152.47	31.65
2014	194.89	0.88	31.51	16.17	162.51	33.71
2015	207.56	0.93	33.42	16.10	173.20	35.90

2.4 DEMAND FORECAST OF SAVAII

2.4.1 AVERAGED ANNUAL GROWTH RATE (AAGR)

For Savaii system, available information is more limited than that of Upolu and the following demand data are collected.

Monthly energy generation by unit	Partially available
Total monthly energy generation	Dec.1996 to Dec. 2002
Monthly peak demand	Jan. 1997 to Dec. 2002
Monthly sold energy by tariff category	Not available
Total monthly sold energy	Oct. 1992 to Dec. 2002

It is noted that monthly report for power generation is prepared separately with that for Upolu system and the situation of recording and keeping of the monthly reports are worse than that of Upolu explained in the previous clause.

(1) Sold Energy

No detail sold energy by tariff category is available for the Savaii system, because of EPC's accounting system. The total sold energy only is available and is given in Table 2.4.1. AAGR between 1992 and 2002 is 15.3 % pa.

The Rural Electrification Project assisted by the grant of Japanese Government was commenced in 1992 and completed in March 1995, and most of all households in Savaii were covered by EPC's distribution system. As a result of the Project, number of customers have rapidly increased and almost of all households have been presently connected to the distribution system. Actually, energy sales in

Savaii had rocketed with an AAGR of 22.1 % pa for the period from 1993 to 1996. AAGR for the remaining period from 1996 to 2002 was 11.2 % pa. This very high AAGR of 22.1 % pa shows directly effect of the Rural Electrification Project for giving benefit of electricity to almost of all populations in Savaii island.

Table 2.4.1 Total Sold Energy of Savaii

Calendar Year	92	93	94	95	96	97	98	99	00	01	02	AAGR
Sold Energy (GWh)	2.10	2.47	3.49	3.44	4.50	5.26	6.17	6.80	7.96	8.59	8.73	15.3%
Percent Increase (%)	-	17.9	41.4	-1.5	30.9	16.9	17.2	10.2	17.1	7.9	1.7	-

(2) Generated Energy

Annual energy generated in Savaii for the period from 1997 to 2002 is given in Table 2.4.2 together with annual increase rate. AAGR between 1997 and 2002 is 4.3 % pa. The AAGR of 4.3 % pa is much smaller than that of sold energy for the same period (10.0 % pa).

Table 2.4.2 Generated Energy in Savaii

Calendar Year	97	98	99	00	01	02	AAGR
Generated Energy (GWh)	8.36	8.72	8.87	9.40	9.22	10.31	4.3%

(3) Losses

System loss including auxiliary energy usage between 1997 and 2002 is given in Table 2.4.3. AAGR of the percent system loss between 1997 and 2002 is –16.2 % pa. This big improvement of system loss influenced to the low growth rate of generated energy.

Table 2.4.3 System Loss of Savaii

Calendar Year	97	98	99	00	01	02	AAGR
Generated Energy (GWh)	8.36	8.72	8.87	9.40	9.22	10.31	4.3%
Sold Energy (GWh)	5.26	6.17	6.80	7.96	8.59	8.73	10.0%
System Loss (GWh)	3.10	2.55	2.07	1.44	0.64	1.58	-12.6%
Percent Loss (%)	37.1	29.3	23.3	15.3	6.9	15.3	-16.2%

(4) Daily Load and Load Duration Curve

Typical daily loads of dry season, namely August 25, 2002 (Sunday) and August 28, 2002 (Wednesday) and wet season, namely January 12, 2003 (Sunday) and January 15, 2003 (Wednesday), and their load duration are given in Table 2.4.4. Their curves are also illustrated on Figure 2.4.1. As shown on Figure 2.4.1, load of Savaii has only one night-time peak appeared at around 8:00 PM and maximum demand of daytime is about half of the night-time peak.

(5) Annual Maximum Peak Demand and Load Factor

Generated energy, annual maximum peak demand and load factor are given in Table 2.4.5.

Table 2.4.5 Annual Generated Energy, Peak Demand and Load Factor

Calendar Year	97	98	99	00	01	02	AAGR
Generated Energy (GWh)	8.36	8.72	8.87	9.40	9.22	10.31	4.3%
Peak Demand (MW)	2.06	2.21	2.33	2.66	2.60	3.05	8.2%
Load Factor (%)	46.3	45.0	43.5	40.3	40.6	36.8	-3.6%

Annual load factor is continuously declined with AAGR of –3.6 %, even sold energy increase with very high rate. This means that such high demand growth is caused by increase of domestic demand. However, no detail information by tariff category is available to prove certain reason.

2.4.2 DEMAND FORECAST FOR SAVAII

(1) Projection of Growth Rate

In the Gibb's study, AAGR of energy sales in Savaii was projected at 10.0 % pa as a most likely rate for their power study. In the beginning of 1990's, large area remained un-electrified and EPC continued their effort for rural electrification.

Though, as explained in the previous clause, AAGRs of energy sale between 1996 and 2002 is still remained in high level of 11.2 % pa, however, AAGR of recent 3 years (2000 to 2002) is much declined to 4.8 % pa.

Taking those AAGRs and present electrification ratio more than 90 % into consideration, a base growth rate for energy sale in Savaii of 6.0 % pa is recommended and is used for the power supply planning study. For the high growth scenario, an AAGR of 8.0 % pa is used and for low growth scenario, an AAGR of 3.0 % pa.

(2) System Losses

As shown in Table 2.4.3, the system loss has been rapidly improved and reached to the level lower than that of Upolu. However, as a system loss, it is still in high level. Therefore, a 4.0 % pa constant improvement of the percent loss including auxiliary usage is projected throughout the study period.

(3) Annual Load Factor

As shown in Table 2.4.5, annual load factor has been declined for the past 6 years. However, this will be considered as temporary phenomenon and will be increased in longer range. Therefore, annual load factor was considered to remain constant at 40 % for the period from 2003 to 2015.

(4) Projected Power Demand

Projected energy sale, required energy and peak demand with AAGR of 6.0 % are given in Table 2.4.6 and power demand projection for other scenarios are given in Table 2.4.7.

Table 2.4.6 Power Demand Projection for Study

Calendar Year	Median Scenario (6.0 %)				
	Energy Sold	Losses	Percent Loss	Energy Generated	Peak Load
	(GWh)	(GWh)	(%)	(GWh)	(kW)
2001	8.59	0.64	6.89	9.22	2.60
2002	8.73	1.58	15.33	10.31	3.05
2003	9.25	1.67	15.27	10.92	3.12
2004	9.81	1.76	15.21	11.57	3.30
2005	10.40	1.86	15.15	12.26	3.50
2006	11.02	1.96	15.09	12.98	3.70
2007	11.68	2.07	15.03	13.75	3.92
2008	12.39	2.18	14.97	14.56	4.16
2009	13.13	2.30	14.91	15.43	4.40
2010	13.92	2.43	14.85	16.34	4.66
2011	14.75	2.56	14.79	17.31	4.94
2012	15.64	2.70	14.73	18.34	5.23
2013	16.57	2.85	14.67	19.42	5.54
2014	17.57	3.01	14.61	20.57	5.87
2015	18.62	3.17	14.55	21.79	6.22

2.5 RECOMMENDATION

During the course of the study, the Team came up against many difficulties of collecting operation and power demand data due to lack of reports and abnormal figures in the reports.

Power statistic data on power system operation and power demand are a basic input for a demand forecast which are used for almost of all planning of power system, namely generation development plan, transmission and distribution extension plan, tariff study, etc. In this clause, therefore, some points on recording/reporting of demand data are recommended for improving the present situation.

(1) Power Demand Data

Sold energy, revenue and number of customers are calculated monthly by computer only for whole Samoa and results of the calculation are kept in the form of computer outputs and magnetic tapes. No data by power system and/or by area are available in those computer outputs. In this connection, following countermeasures for improvement are recommended.

(i) Summary table of power demand by tariff category, by power system, by area shall be printed out together with such results of calculation, because those information are very useful for a generation development planning, transmission/distribution system extension planning, etc.

(ii) Annual summary of energy sales, revenue and number of customers by tariff category, by power system and by area shall be prepared and reported not only for easy reference, but also for making easy data collection for the study.

(iii) Reported figures on energy sales shall be strictly managed by related section, because there are some discrepancies of figures by different sources and different time.

(2) Operation Data related to Power Demand

A monthly report is prepared and issued every month, which indicates detail information on daily energy generated by each unit, daily daytime and night-time peak demand, monthly maximum daytime and nigh-time demand, daily load by time on the day when monthly maximum peak demand was recorded, auxiliary energy usage by plant, etc.

Among these data related to power demand, auxiliary energy usage recorded in the report has some abnormal figures since 1999 as shown in Table 2.3.4. A certain system for checking such abnormal figures shall be established and basic training of staff shall be made periodically.

Table 2.2.2 Comparison of Previous Projected Demand and Actual Records

Calendar Year	Actual Record			Gibb's Report (5%)			HECEC's Report (6%)		
	Sold Ene. (GWh)	Gene. Ene. (GWh)	Peak Load (MW)	Sold Ene. (GWh)	Gene. Ene. (GWh)	Peak Load (MW)	Sold Energy (GWh)	Generated Energy (GWh)	Peak Load (MW)
94	44.16	58.82	10.13	46.13	53.60	9.76	-	-	-
95	49.12	63.43	10.98	48.43	56.09	10.22	-	-	-
96	53.20	68.77	12.18	50.85	58.70	10.69	-	-	-
97	58.99	73.75	12.84	53.40	61.43	11.19	61.46	72.89	13.21
98	59.14	74.14	12.74	56.07	64.30	11.71	65.26	77.26	14.00
99	*4	74.45	13.27	58.87	67.31	12.26	69.31	81.90	14.84
00	-	78.13	14.43	61.81	70.46	12.84	73.60	86.81	15.73
01	-	85.15	15.22	64.90	73.77	13.44	78.15	92.02	16.67
02	-	91.54	15.84	68.15	77.32	14.08	82.99	97.54	17.67
03	-	-	-	71.56	81.18	14.79	88.13	103.40	18.74
04	-	-	-	75.13	85.24	15.53	93.58	109.60	19.86
05	-	-	-	78.89	89.50	16.30	99.37	116.18	21.05
AAGR	94/98	94/02 5.68%	94/02 5.75%	94/05 5.00%	94/05 4.77%	94/05 4.77%	97/05 6.1895%	97/05 6.00%	97/05 6.00%

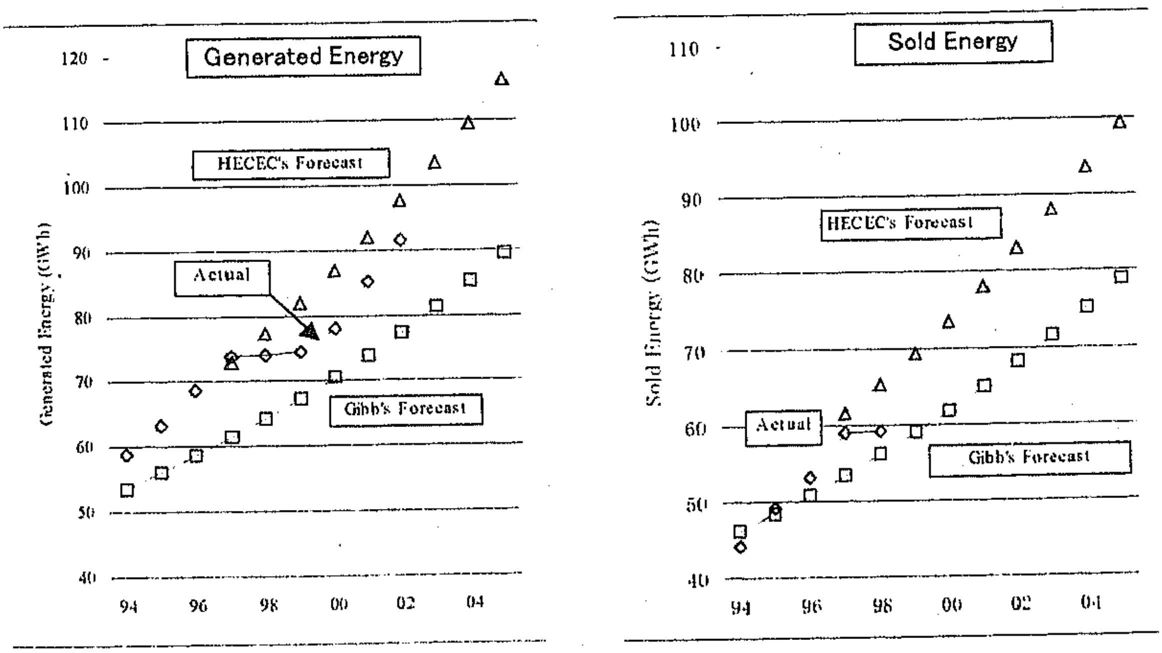


Figure 2.2.1 Results of Previous Projected Demand and Actual Data

Table 2.3.1 Annual Sold Energy of EPC and AAGW by Tariff Category

Year	Commerce	Domestic	Hotel	Industry	Religion & School	Total
82	11.96	6.51	1.55	2.92	1.52	24.46
83	10.32	7.05	1.40	3.38	2.29	24.44
84	12.51	7.34	1.68	3.89	2.86	28.28
85	12.55	7.40	1.69	3.73	3.33	28.70
86	12.94	8.29	1.70	3.65	3.48	30.06
87	13.74	8.97	1.71	3.80	3.70	31.92
88	15.28	9.99	1.79	4.04	4.04	35.14
89	15.45	10.44	1.92	4.31	4.00	36.12
90	15.81	10.94	2.10	3.78	4.00	36.63
91	16.37	11.78	2.39	3.62	3.99	38.15
92	16.42	13.15	2.37	3.44	4.13	39.51
93	18.56	15.25	2.77	3.84	4.50	44.91
94	18.91	17.44	2.70	4.10	4.50	47.65
95	22.22	18.42	2.76	4.24	4.92	52.56
96	23.49	20.72	2.57	5.91	5.04	57.72
97	26.14	23.63	2.76	6.51	5.26	64.29
98	26.65	24.08	2.70	6.16	5.76	65.36
99	28.54	25.40	2.42	4.85	6.47	67.68
00	31.43	26.76	2.67	5.19	5.30	71.35
01	33.07	30.25	3.00	5.92	6.45	78.68
02	41.74	24.20	3.09	5.85	8.01	82.89
AAGR						
82/02	6.45%	6.79%	3.51%	3.54%	8.67%	6.29%
82/91	3.55%	6.70%	3.87%	3.28%	12.86%	5.18%
82/96	4.94%	8.62%	3.67%	5.16%	8.93%	6.33%
92/02	9.78%	6.29%	2.70%	5.47%	6.86%	7.69%
92/96	9.36%	12.03%	2.04%	14.51%	5.10%	9.94%
96/02	10.05%	2.62%	3.13%	-0.16%	8.05%	6.22%

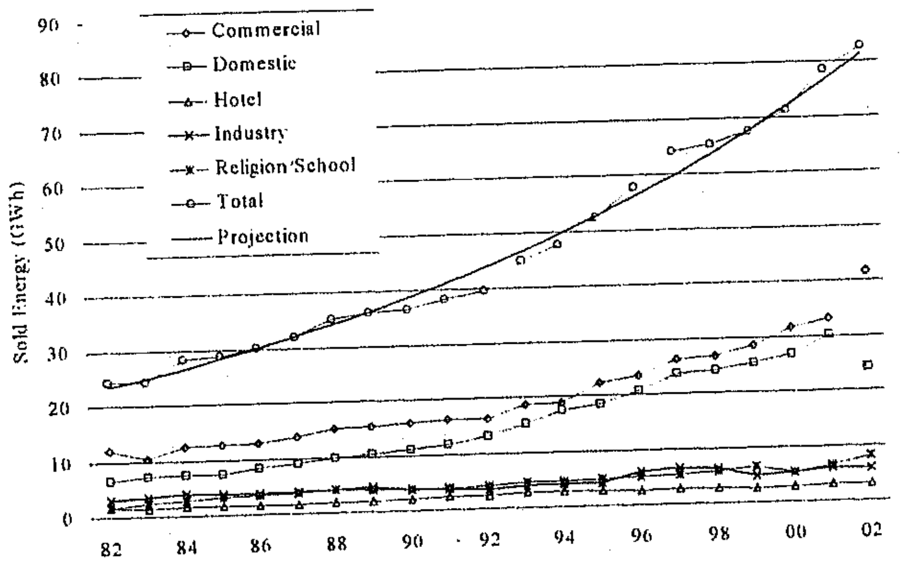


Figure 2.3.1 Sold Energy of EPC by Tariff Category, 1982 - 2002

Table 2.3.2 Generated Energy of Upolu, 1994 - 2002

C. Year	Hydro	Diesel	Generated
94	52.07	6.75	58.82
95	49.97	13.46	63.43
96	42.78	25.99	68.77
97	53.91	19.84	73.75
98	38.64	35.50	74.14
99	43.98	30.21	74.45
00	41.65	36.47	78.13
01	34.76	50.39	85.15
02	43.10	48.44	91.54
AGGW			
94/02	-2.34%	27.94%	5.68%
96/02	0.13%	10.93%	4.88%

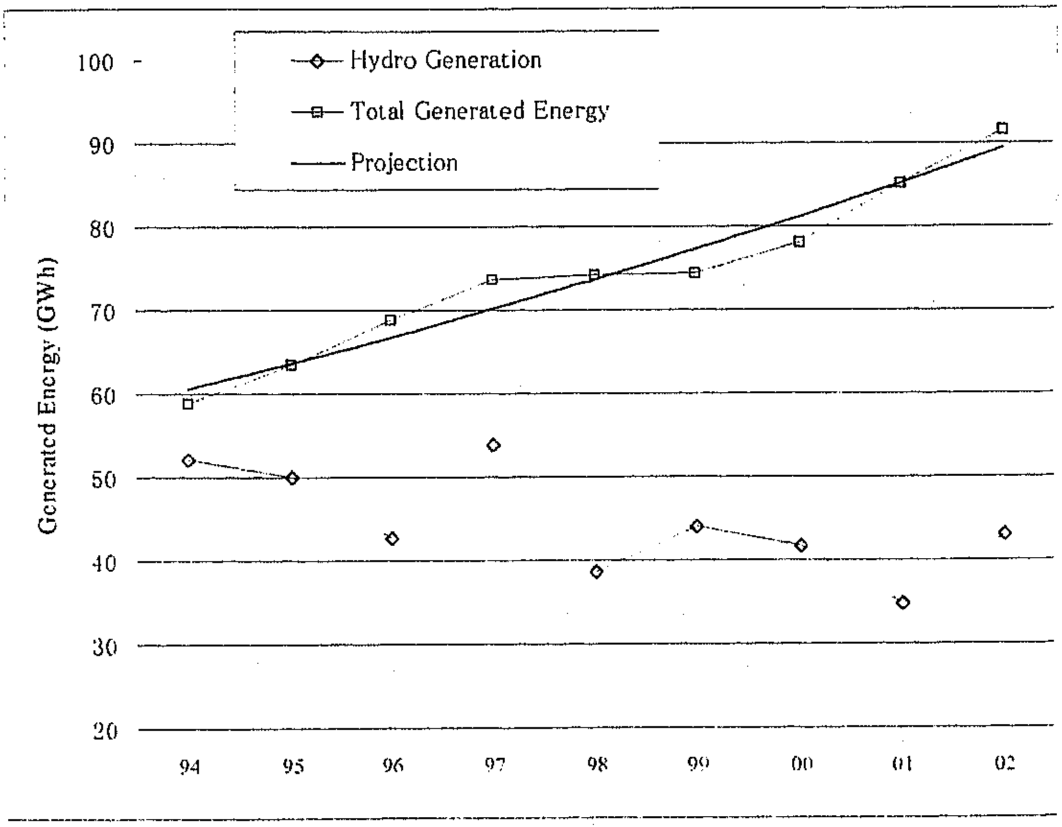


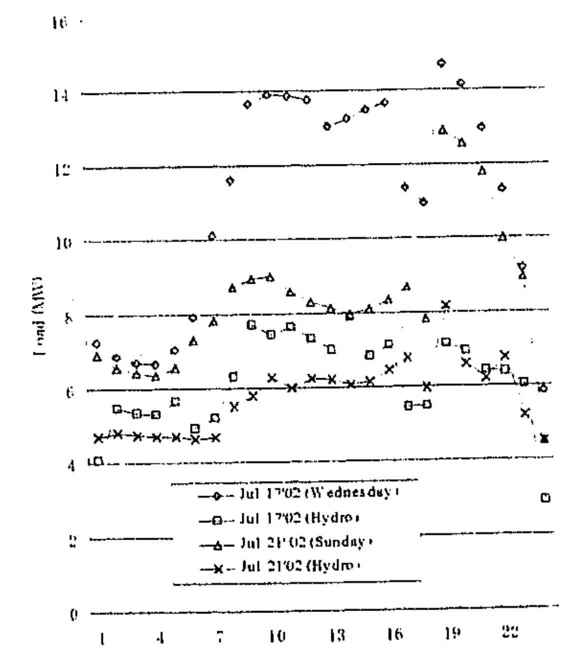
Figure 2.3.2 Generated Energy of Upolu, 1994 - 2002

Table 2.3.4 Sample of Recorded Energy Consummed for Generating Electric Power in 1999

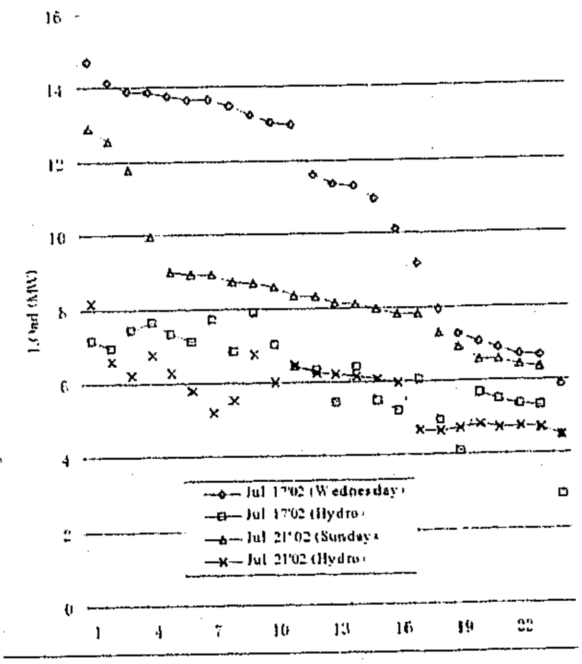
Year 1999	Local Consumption (kWh)											Attentants' Consumption (kWh)									Hydro Total
	Diesel				Hydro																
	Siemen	Fuji	Magi-agi	Total	Alaoa	Sama-soni	Lalo-maga	Taelefg	Af.Dam	FOF	Total	Alaoa	Alaoa H.Pond	FOF	Sama-soni	Lalo-mauga	Sauni-atu	FOF H.Pnd	Afulilo	Total	
Jan.	8,928	3,127	3,746	15,801	908	3,217	4,390	222	581	1,182	10,500	246	123	7,092	3,141	131	126	54	77,956	88,869	99,369
Feb.	7,922	2,501	3,368	13,791	797	2,900	4,312	193	554	1,057	9,813	185	98	133	159	35	103	53	209	975	10,788
Mar.	8,955	17,418	3,927	30,300	830	3,262	3,777	216	515	1,069	9,669	185	131	137	173	48	114	48	240	1,076	10,745
Apr.	12,087	44,584	3,955	60,626	830	3,427	3,939	198	495	790	9,679	212	174	75	161	52	98	41	204	1,017	10,696
May	11,791	5,251	3,779	20,821	865	3,390	4,343	191	568	821	10,178	255	680	n.a	159	n.a	106	29,222	195	30,617	40,795
Jun.	9,409	3,385	3,608	16,402	838	3,353	4,801	191	496	1,008	10,687	147	347	206	146	799	95	862	209	2,811	13,498
Jul.	13,366	5,224	4,140	22,730	848	3,397	6,493	205	538	389	11,870	207	180	110	128	9,662	117	41	198	10,643	22,513
Aug.	7,343	6,205	296,983	310,531	867	3,475	5,998	205	590	163	11,298	149	187	132	154	148	110	42	143	1,065	12,363
Sep.	7,367	4,905	423,800	436,072	854	3,293	5,513	194	835	886	11,575	2,318	170	2,013	134	132	228	37	145	5,177	16,752
Oct.	6,514	4,331	91,832	102,677	1,193	3,440	5,234	2,247	612	891	13,617	547	154	-1,618	149	131	586	85	242	276	13,893
Nov.	5,687	4,879	4,559	15,125	830	3,358	5,231	2,100	430	998	12,947	196	99	32,787	141	115	99	321	154	33,912	46,859
Dec.	10,441	5,923	5,462	21,826	844	3,485	5,705	2,001	454	754	13,243	222	128	137	142	125	105	-3,019	162	-1,998	11,245
Total	109,810	107,733	849,159	066,702	10,504	39,997	59,736	8,163	6,668	10,008	135,076	4,869	2,471	41,204	4,787	11,378	1,887	27,787	80,057	174,440	309,516

Table 2.3.5 Typical Daily Load and Load Duration in Dry Season

No.	Load (MW)				Load Duration (MW)			
	Jul. 17, 2002 (Wednesday)		Jul. 21, 2002 (Sunday)		Jul. 17, 2002 (Wednesday)		Jul. 21, 2002 (Sunday)	
	System	Hydro	System	Hydro	System	Hydro	System	Hydro
1	7.24	4.08	6.89	4.70	15.58	5.31	12.90	8.15
2	6.86	5.47	6.57	4.80	15.57	5.89	12.56	6.60
3	6.70	5.32	6.43	4.75	15.31	5.65	11.78	6.22
4	6.66	5.30	6.34	4.70	15.07	5.47	9.98	6.76
5	7.05	5.65	6.54	4.70	14.97	5.30	9.01	6.28
6	7.93	4.90	7.29	4.62	14.92	6.65	8.94	5.80
7	10.10	5.19	7.82	4.67	14.65	4.96	8.92	5.20
8	11.60	6.31	8.71	5.52	14.61	5.02	8.71	5.52
9	13.65	7.70	8.94	5.80	14.47	4.86	8.68	6.77
10	13.90	7.44	9.01	6.28	14.01	5.38	8.57	6.01
11	13.89	7.65	8.57	6.01	12.48	3.57	8.34	6.44
12	13.75	7.31	8.30	6.23	12.38	5.03	8.30	6.23
13	13.02	7.02	8.13	6.21	12.34	5.50	8.13	6.21
14	13.25	7.87	7.95	6.05	12.12	3.99	8.09	6.14
15	13.48	6.83	8.09	6.14	12.00	3.93	7.95	6.05
16	13.66	7.12	8.34	6.44	10.61	4.73	7.82	5.96
17	11.37	5.45	8.68	6.77	8.96	5.30	7.82	4.67
18	10.95	5.47	7.82	5.96	8.92	5.03	7.29	4.62
19	14.71	7.15	12.90	8.15	8.26	3.15	6.89	4.70
20	14.16	6.94	12.56	6.60	7.97	4.02	6.57	4.80
21	12.95	6.42	11.78	6.22	7.61	3.65	6.54	4.70
22	11.31	6.38	9.98	6.76	7.44	3.40	6.43	4.75
23	9.18	6.02	8.92	5.20	7.36	3.46	6.34	4.70
24	5.86	2.90	4.51	4.51	7.14	3.25	4.51	4.51



(a) Daily Load Curves

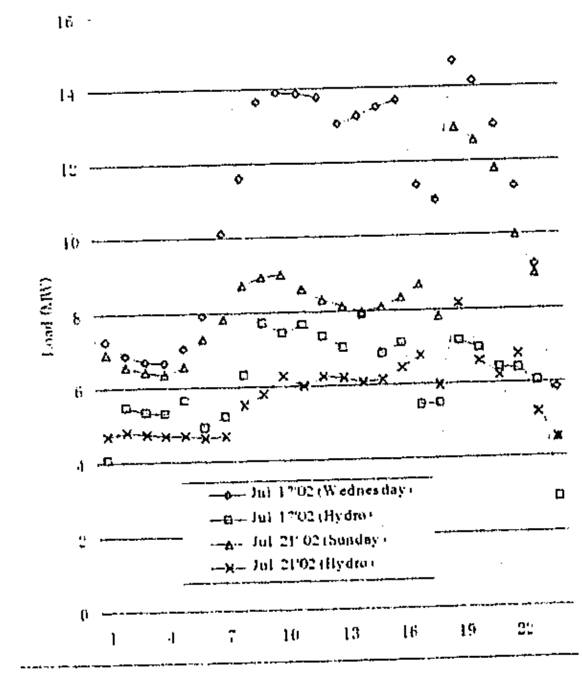


(b) Load Duration Curves

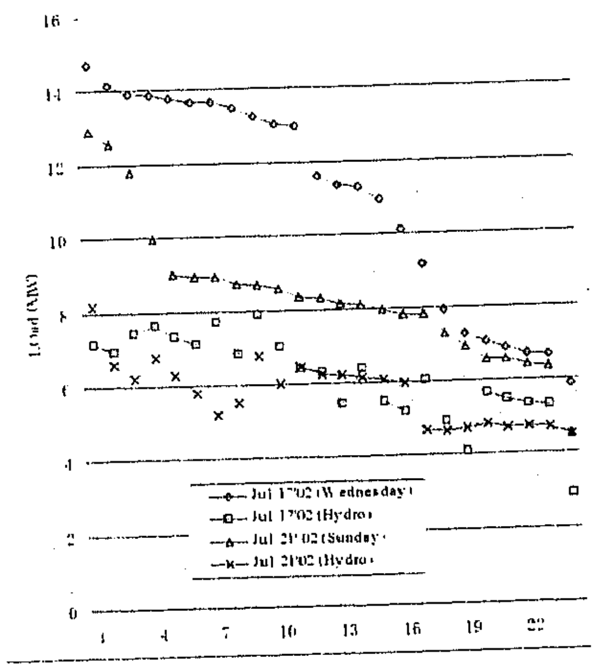
Figure 2.3.3 Typical Daily Load and Load Duration Curves in Dry Season

Table 2.3.6 Typical Daily Load and Load Duration in Wet Season

No.	Load (MW)				Load Duration (MW)			
	Jan. 15, 2003 (Wednesday)		Jan. 19, 2003 (Sunday)		Jan. 15, 2003 (Wednesday)		Jan. 19, 2003 (Sunday)	
	System	Hydro	System	Hydro	System	Hydro	System	Hydro
1	8.26	3.15	7.95	4.76	15.58	6.65	13.18	7.06
2	7.44	3.40	7.89	4.36	15.57	5.89	12.27	6.27
3	7.14	3.25	7.75	4.22	15.31	5.65	11.01	6.13
4	7.36	3.46	7.45	3.84	15.07	5.50	10.70	5.23
5	7.61	3.65	7.58	3.99	14.97	5.47	9.87	4.94
6	7.97	4.02	7.65	3.55	14.92	5.38	9.58	4.91
7	8.92	5.03	8.42	4.09	14.65	5.31	9.52	4.90
8	12.34	5.50	9.29	4.91	14.61	5.30	9.43	4.90
9	15.31	5.65	9.52	4.53	14.47	5.30	9.40	4.81
10	15.58	5.31	9.58	4.78	14.01	5.03	9.30	4.78
11	15.57	5.89	9.43	4.64	12.48	5.03	9.29	4.76
12	14.97	5.30	8.92	4.81	12.38	5.02	9.02	4.73
13	14.61	5.02	9.02	4.90	12.34	4.96	8.92	4.64
14	15.07	5.47	8.91	4.73	12.12	4.86	8.91	4.62
15	14.65	4.96	8.71	4.36	12.00	4.73	8.71	4.54
16	14.47	4.86	8.70	4.62	10.61	4.02	8.70	4.53
17	12.48	3.57	9.40	4.94	8.96	3.99	8.42	4.50
18	12.00	3.93	9.87	4.54	8.92	3.93	7.95	4.36
19	12.12	3.99	11.01	6.13	8.26	3.65	7.89	4.36
20	14.92	6.65	13.18	7.06	7.97	3.57	7.75	4.22
21	14.01	5.38	12.27	6.27	7.61	3.46	7.65	4.09
22	12.38	5.03	10.70	4.90	7.44	3.40	7.58	3.99
23	10.61	4.73	9.30	5.23	7.36	3.25	7.45	3.84
24	8.96	5.30	4.50	4.50	7.14	3.15	4.50	3.55



(a) Load Curves



(b) Load Duration Curves

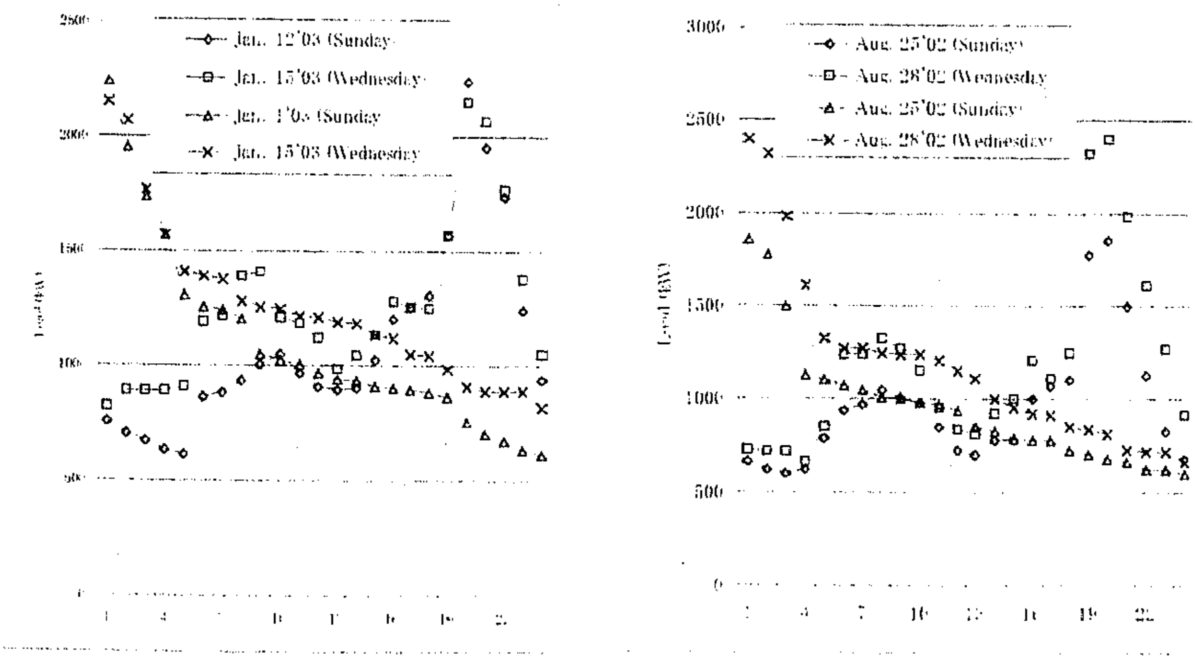
Figure 2.3.4 Typical Daily Load and Load Duration Curves in Wet Season

Table 2.3.10 Lowest and Highest Power Demand Projection of Upolu for The Study

Calendar Year	Lowest Scenario (4.0 %)						Highest Scenario (9.0 %)					
	Energy Generated (GWh)	Auxil. Use (GWh)	Losses (GWh)	Percent Loss (%)	Energy Sold (GWh)	Peak Load (MW)	Energy Generated (GWh)	Auxil. Use (GWh)	Losses (GWh)	Losses (%)	Energy Sold (GWh)	Peak Load (MW)
2001	85.15	-	15.06	17.68	70.10	15.22	85.15	-	15.06	17.68	70.10	15.22
2002	91.54	-	16.38	17.89	75.16	15.84	91.54	-	16.38	17.89	75.16	15.84
2003	95.20	0.43	16.95	17.80	77.82	16.47	99.78	0.45	17.76	17.80	81.57	17.26
2004	99.01	0.45	17.54	17.71	81.03	17.12	108.76	0.49	19.26	17.71	89.00	18.81
2005	102.97	0.46	18.15	17.62	84.36	17.81	118.54	0.53	20.89	17.62	97.12	20.50
2006	107.09	0.48	18.78	17.53	87.83	18.52	129.21	0.58	22.66	17.53	105.97	22.35
2007	111.37	0.50	19.43	17.45	91.44	19.26	140.84	0.63	24.57	17.45	115.64	24.36
2008	115.82	0.52	20.11	17.36	95.20	20.03	153.52	0.69	26.65	17.36	126.18	26.55
2009	120.46	0.54	20.81	17.27	99.11	20.83	167.33	0.75	28.90	17.27	137.68	28.94
2010	125.28	0.56	21.53	17.19	103.18	21.67	182.39	0.82	31.35	17.19	150.23	31.55
2011	130.29	0.59	22.28	17.10	107.42	22.53	198.81	0.89	34.00	17.10	163.92	34.39
2012	135.50	0.61	23.06	17.02	111.83	23.44	216.70	0.98	36.87	17.02	178.86	37.48
2013	140.92	0.63	23.86	16.93	116.43	24.37	236.21	1.06	39.99	16.93	195.15	40.85
2014	146.55	0.66	24.69	16.85	121.21	25.35	257.47	1.16	43.37	16.85	212.93	44.53
2015	152.42	0.69	25.55	16.76	126.18	26.36	280.64	1.26	47.04	16.76	232.34	48.54

Table 2.4.4 Typical Daily Load and Load Duration of Savaii

No.	Daily Load (KW)				Load Duration Curve (KW)			
	Aug. 25'02 (Sun)	Aug. 28'02 (Wed)	Jan. 12'03 (Sun)	Jan. 15'03 (Wed)	Aug. 25'02 (Sun)	Aug. 28'02 (Wed)	Jan. 12'03 (Sun)	Jan. 15'03 (Wed)
1	665	725	754	820	1,855	2,400	2,245	2,157
2	625	720	707	890	1,775	2,320	1,955	2,071
3	600	720	670	890	1,500	1,985	1,735	1,769
4	620	660	636	890	1,130	1,610	1,569	1,570
5	790	850	614	910	1,105	1,326	1,310	1,409
6	940	1,240	864	1,190	1,070	1,275	1,257	1,390
7	970	1,240	886	1,220	1,050	1,270	1,245	1,376
8	1,050	1,326	939	1,390	1,010	1,245	1,208	1,280
9	1,010	1,275	1,004	1,409	1,000	1,240	1,050	1,255
10	980	1,150	1,050	1,210	980	1,240	1,025	1,250
11	850	955	970	1,186	970	1,210	1,004	1,220
12	725	840	912	1,125	940	1,150	970	1,210
13	700	810	895	990	850	1,110	945	1,190
14	785	920	902	1,048	825	1,005	939	1,186
15	780	1,005	1,025	1,135	790	955	912	1,135
16	1,000	1,210	1,208	1,280	785	920	902	1,125
17	1,070	1,110	1,257	1,255	780	915	895	1,050
18	1,105	1,245	1,310	1,250	725	850	886	1,048
19	1,775	2,320	1,569	1,570	700	840	864	990
20	1,855	2,400	2,245	2,157	680	810	754	910
21	1,500	1,985	1,955	2,071	665	725	707	890
22	1,130	1,610	1,735	1,769	625	720	670	890
23	825	1,270	1,245	1,376	620	720	636	890
24	680	915	945	1,050	600	660	614	820



(a) Dry Season (b) Wet Season

Figure 2.4.1 Typical Load and Duration Curves of Savaii

Table 2.4.7 Lowest and Highest Power Demand Projections of Savaii for Study

Calendar Year	Lowest Scenario (3.0 %)					Highest Scenario (8.0 %)				
	Energy Sold (GWh)	Losses (GWh)	Percent Loss (%)	Energy Generated (GWh)	Peak Load (kW)	Energy Sold (GWh)	Losses (GWh)	Percent Loss (%)	Energy Generated (GWh)	Peak Load (kW)
2001	8.59	0.64	6.89	9.22	2.60	8.59	0.64	6.89	9.22	2.60
2002	8.73	1.58	15.33	10.31	3.05	8.73	1.58	15.33	10.31	3.05
2003	8.99	1.62	15.27	10.61	3.03	9.43	1.70	15.27	11.13	3.18
2004	9.26	1.66	15.21	10.92	3.12	10.18	1.83	15.21	12.01	3.43
2005	9.54	1.70	15.15	11.24	3.21	11.00	1.96	15.15	12.96	3.70
2006	9.83	1.75	15.09	11.57	3.30	11.88	2.11	15.09	13.99	3.99
2007	10.12	1.79	15.03	11.91	3.40	12.83	2.27	15.03	15.10	4.31
2008	10.43	1.83	14.97	12.26	3.50	13.86	2.44	14.97	16.29	4.65
2009	10.74	1.88	14.91	12.62	3.60	14.96	2.62	14.91	17.58	5.02
2010	11.06	1.93	14.85	12.99	3.71	16.16	2.82	14.85	18.98	5.42
2011	11.39	1.98	14.79	13.37	3.82	17.45	3.03	14.79	20.48	5.85
2012	11.73	2.03	14.73	13.76	3.93	18.85	3.26	14.73	22.11	6.31
2013	12.09	2.08	14.67	14.16	4.04	20.36	3.50	14.67	23.86	6.81
2014	12.45	2.13	14.61	14.58	4.16	21.99	3.76	14.61	25.75	7.35
2015	12.82	2.18	14.55	15.01	4.28	23.75	4.04	14.55	27.79	7.93

3. DIESEL POWER PLANT

3.1 DIESEL POWER PLANT

Rise in energy prices has a great influence on the economy of Samoa and the life of the people, and the preparation of such infrastructures as can allow variation in energy cost and power cost is a matter of social concern.

In these situations of energy, Samoa also needs to proceed with reduction of energy demand and power cost, but improvement of power economy, complete execution of station management, enhancement of technology, and environmental protection are required for this purpose at the same time. Stable and continuous supply of electric power will have to account for the accomplishment of social infrastructures and the technological development in this country.

To realize stable power supply, a wide variety of educational training and practical plans including high level plant control and enhanced technology will be required. A matter of excess, a direct cause of accidents, including environmental protection (natural disaster, power generators, waste oil treatment, etc.) can not be solved for full play of plant functions without enough supply of necessary spare parts and tools for power generator maintenance when seeing that power plants generally are operated under the severe conditions.

3.1.1 OPERATION OF EXISTING POWER GENERATORS

EPC's existing power generating units are listed below (Table 3-1-1).

Diesel engine generators under operation are: 3 unit of Vaipouli P/S and 5 units of Salelologa P/S in Savaii Island and 5 units of Tanugamanono P/S. and also 3 units in Manono Island and 1 unit in Apolima Island. But in the latter tow islands restrictions on power consumption by time limiting are put into practice.

Layout drawing of generators intended in the this site survey.

(i) Vaipouli Power D/G Station Layout drawing (Table 3-1-a)

(ii) Salelologa Power D/G Station Layout drawing (Table 3-1-b)

(iii) Tanugamanono Power D/G Station Layout drawing (Table 3-1-c)

3.1.2 YEARS OF OPERATION IN EXISTING POWER GENERATORS

As seen in the years of operation (Table 3-1-1), power generators of Vaipouli, Salelologa and Tanugamanono power Station have been operated over their standard term of periodical overhaul, and their parts and implements also have passed the limit of use and adjustment Occurrence of cavitations (pinhole phenomena) are found in a part, as the quality of cooling water has not been controlled for a long time to prevent corrosion in engine cooling water. The state of plant control, the present generator output, spare parts supply, etc. are not clear due to no provision of reports, and even the availability factor is unknown. Insufficient training of skill for repair and inadequate planning for plant control have further superannuated the power generating units and have accessibly increased the rate of wear in the internal part of engines, except at Tanugamanono P/S.

3.1.3 FUEL CONSUMPTION

When seeing the present situation of fuel consumption in the existing engine generators, Vaipouli, Salelologa Engine Power Plant (all units are for emergency use)does not show its original power capacity, except only 60 to 70 percent of rated capacity at the most, due to the past in execution of adjustment and correction of fuel injection timing (dial indicator calibration). Accordingly the data of excessive fuel consumption shows that fast arrangement of special tools for fuel injection timing adjustment is needed to restore the generator output to some extent,(Refer to Table 3-1-2a,b,c, Operational Data in 1997 to 2002).

Dismantling and repair of used generators, however, have been ignored in the past operation and their long term operational history is not clear. Depending on the handling of generator units in the past, the cruising operation using emergency generator to meet the future power demand will invite incredible values of KWh/L due to the increased repair expenses.

(i) Fuel consumption of generating units in Savaii and Upolu

(ii) The comparison chart of each power generator attached shows the fuel consumption of Engine Generators in Savaii Island and Upolu Power plant. (Table 3-1-3) (Table 3-1-4)

(iii) As seen from the comparison chart of fuel consumption, the low-speed engine (600 rpm) for cruising use is different in output and economical operation from the emergency high-speed engine (1500 rpm), but the 4000kw class generators are hardly different in fuel consumption from the 800kw and 200kw class ones. This fact shows a significant economical loss, from which it can be judged that the group of high-speed engine generators in Savaii Island is inferior in economical performance.

(iv) Fuel consumption of low-speed, middle-speed and high-speed engines is generally as in Table 3-1-5, which shows that a lower-speed engine (300 to 600 rpm) generator for cruising operation can provide higher efficiency than the existing generators.

(v) According to the present situation of the existing engine generators in Savaii Island, the power output reduction is approximately 17 percent in comparison with their former output, Introduction of used machines involves shortage of parts supply and inferiority in maintenance work together with superannuating in generator performance and financial grounds. Bad performance of generator governors (synchronized operation is impossible and connection to external lines is difficult) will also be found and critical wear in parts life can be presumed for fuel injection equipment in the fuel system. These are certified by the fuel consumption against black color of exhaust gas and the abnormal quantity of blow-by gas. From the fact that long-term maintenance is impossible due to the shortage of special tools for local adjustment and calibration, the existing power generating capacity is quite short in reliability on the power output at the required load.

3.1.4 SUPERANNUATED POTIONS OF ENGINE GENERATORS

The following table shows the present engine conditions of Vaipouli Engine Generators No.1 to No.4. These units have been operated continuously for 14 year without any dismantling and inspection. Their usual overhaul time has passed away and the wear rate measured after dismantling should be studied for appropriate repair so that abnormal fuel consumption will be urgently improved. The superannuated potions of engine generators presumed from their visual inspection and fuel consumption are as below:

Table 3.1.1 Condition of D/G generators in Vaipouli

Eng, No.	Place of Superannuated	Condition of Engines	Measures to be taken
No.1 No.2 No.3	· Abnormal condition of fuel system · Decreased compression pressure · Protective device is defective	· Increased fuel consumption (Exhaust gas increased) · Combustion efficiency reduced (Output reduction) · Increased blow-by gas and oil up(Gas leak)	· Overhaul of engines Adjustment of fuel · Injection timing and Parts replacement around combustion chamber
No.4 Stopped	· Overload of engine · Protective device is defective	· Parts have been taken off to be Used for other generator.	· It is impossible to Repair.

Table 3.1.2 Condition of D/G Generator in Salelologa

Eng, No.	Place of Superannuated	Condition of Engines	Measures to by taken
No.1A Operated No.2B Operated No.3A Operated No.5A Operated	· Abnormality of fuel system · Compression pressure power · Decrease Protective device is defective	· Increased fuel consumption (Exhaust gas increased) · Combustion efficiency reduced (Output reduction) · Increased blow-by gas and oil-up(Gas leak)	· Overhaul of engines Adjustment of fuel · Injection timing and Parts replacement around combustion chamber
No.6 Stopped	Generator damaged	Generator overload	It is impossible to repair
No.7A Stopped	Cam damaged	Superannuation	It is impossible to repair
No.8 Operated	No problem in Visual inspection		

The combustion efficiency of internal combustion engines which is read from their data of fuel consumption clearly reduces in Salelologa power Plant same as in Vaipouli power plant, where its fuel consumption is higher than usual, and on periodical inspection nor overhaul inspection and replacement of parts has taken place until now. Actually partial dismantling for parts exchange has been carried out when a generator is defective. This may come from the insufficient study of such inspection results and shortage of special measuring tools, etc. The maintenance and control planning has not been made in recent years under the present situation that any cause of basic troubles cannot be identified. (Since 2002 partial improvement has proceeded in support of JICA volunteers)

Table 3.1.3 Condition of the D/G generators in Tanugamanono

Eng. No.	Place of Superannuated	Condition of Engines	Measures to be taken
No.4A Operated		Good Run	Continues
No.5A Operated	None	Good Run	Continues
No.7A Operated	None	Good Run	Continues
No.8 Stopped	Turbocharger problem	Complete disassembly	No result
No.9A Operated		Good Run	Continues
No.12 Operated		Good Run	Continues

Tanugamanono Power Plant has relatively new power generators compared with those of Vaipouli, Salelologa Power Plant in Savaii Island. They have been operated for 3.5 years in average, but initial troubles seem to have happened to all the generators. These troubles are caused by inexperienced operation and maintenance of new machines, as seen in the recent reports of frequent occurrence of troubles due to the same cause (Rocker arm damaged)

3.1.5 OPERATIONAL TIME OF GENERATORS AND REPAIR COST

Shown below is a graph of general generator repair cost, and the average life of diesel engines (differs in load factor) is supposed to be about 15 to 20 years, the maintenance costs followed by which will change and increase as the load factor changes. (The following table shows general maintenance costs.)

Increase of costs for maintenance and repair cannot be avoided (for used generators) when considering stable power supply in future.

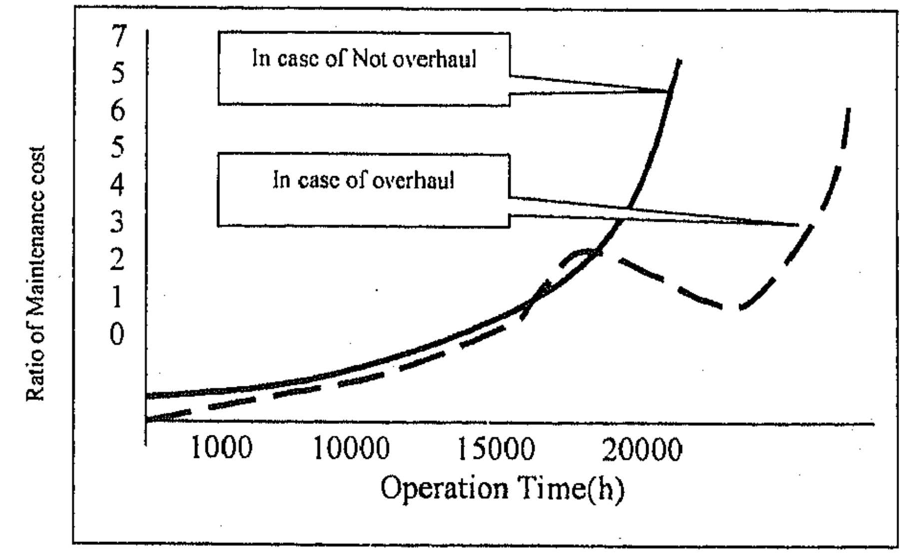


Figure 3.1.1 Generation Repair Cost

3.2 PRESENT STATUS OF OPERATION AND MAINTENANCE OF POWER PLANTS

3.2.1 TECHNICAL LEVEL

Technical level can basically be confirmed in studying the records of operation and maintenance of the existing generators, but no report of inspection and overhaul of them is found, which means that there is no reliability in safe operation of engine generators and economical management of a power plant.

Technical level was confirmed by fact-finding of power shortage and analysis of technical ability of EPC side, where parts replacement and economical operation in the past were inspected of the following items:

(i) Confirmation of the present status of generator operation & maintenance and the specification

(ii) Existing power plant engineers and their technical level (Vaipouli and Salelologa)

(iii) Existing power plant engineers and their technical level (Tanugamanono)

(iv) Years of experience in generator repair

(1) Confirmation of the present status of generator operation & maintenance and the specificatic

As a result of having confirmed the manual for operation and maintenance to existing operators, they did not receive it from the manufacturer of power generators until they got it in recent year (from JICA volunteer in 2002), because these generators are used ones. Thus they have operated them without the maintenance reference for each generator until the recent year.

In particular, adjustment of fuel injection timing is indispensable to generator operation.

(2) Existing power plant engineers and their technical level (Vaipouli and Salelologa)

Education for inspection and overhaul of plant equipment has not taken place in these power plants since their power generators were installed. The EPC settlement of standard/reference for inspection and maintenance must newly be made as soon as possible to realize the long-term control and maintenance of power plants.

The fact is that the engine generators are put into simple operation and that repair work is done without any planning for maintenance.

As shown in photo (6-2-1)(6-2-2), there are only 3sets of measuring tools for electrical use. The reason why the long term control and maintenance of power generating units have not been established exists in the circumstances of no provision for the control, estimation and procurement of consumables for power generators, electrical repair and instrumentation.

(3) Existing power plant engineers and their technical level (Tanugamanono)

At Tanugamanono Power Plant a young engineer has performed fundamental training for generators to maintaining personnel so that the availability factor of this plant has been improved in recent years. E-filing system, however, is not yet realized for systematic control of parts, tools and repair reports for the reason of financial grounds.

(4) Arrangement of O&M staff and repair experience

The organization chart of the whole EPC is shown in Table (6-2-5/6-2-6) the following table is the arrangement of O&M staff at Salelologa/Vaipouli and Tanugamanono.

Table 3.2.1 Arrangement of O&M Staff

	Salelologa PS	Vaipouli PS	Tanugamanono PS
Unit Capacity and Number of Units	400kw×1set, 800kw×2sets. 1,000kw×1set 1400kw×1set	130kw×1set, 200kw×1set, 400kw×1set	2200kw×1set 4200kw×3sets 3500kw×1set
Operation Engineer Operators	0 25		0 13
Maintenance Engineer Skilled Workers Laborers	0 7 8		0 12 4
Total of O&M Staff	40		19

Table (No.3-2-1) clearly shows that there is no engineer at these power station, In order to proceed with the plant control and maintenance planning including fact-finding of troubles and improvement of plant efficiency and availability factor, such personnel as are educated of mechanical engineering and electrical engineering will be required.

3.2.2 LOAD FACTOR

Economical operation of generators depends on the performance of their engines. but generally engine generators are designed to produce the optimum operational performance in fuel consumption and rate at normal load running (60 to 80 % load). As a matter of fact, the generators of these stations are operated at 40 to 60% load in average. (Refer to the following table 4-II)

Fuel Consumption vs. Load Factor for 4 Cycle Diesel Engines for Power Plant Service (Table 4-II) dismantling of an engine, the life of parts for replacement may possibly be shortened. It is because parts must be selected and purchased in undersize or oversize dimensions matching with their wear Yates, and because standard size parts purchased do not necessarily fit the joint of counter-parts when assembling them.

Due to the actual repair work experienced unit now, it can be said that repair of engine generators will be possible to some extent, but frequent occurrence of troubles owing to the same reason in EPC power stations can never be ignored.

The history of troubles in the past should be put to practical use as the manual book for training of repair, protection and safety for the future to prevent troubles and accident to occur. The same thing can be said about the management of plant operation which should proceed with improvement of the load factor of generators.

Provided in the history of troubles in the past, are a list of important troubles listed in the reports from 2000 up to now, description of problems to be paid special attention to, and results of thorough investigation of accident and troubles neglected in the report of EPC. To build up the control and maintenance system of Salelologa and Vaipouli power stations, an engineer who can analyze these actual examples in details from a details from a technical point of view should be dispatched as soon as possible. (As shown in photo No.3-2-4)

(2) From a case of Salelologa P/S trouble

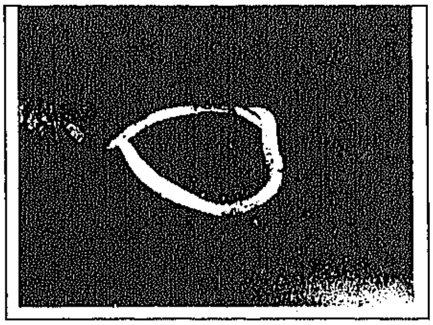
Situation: Lube oil doesn't function due to cooling water mixture into cylinder block.

Details : Cavitations occurred in generator cylinder liner. (A small pin hole in the side of cylinder liner made cooling water pass through combustion chamber,)

Measure : Replacement of the cylinder liner in which cavitations occurred.

This trouble seems to be a simple one, but it is a trouble characteristic of diesel engines. The cause of cavitations occurrence is supposed to be determined by 1) generator vibration, 2) generator cooling water flow, and 3) electrical shock characteristic of power generators, but it is difficult to decide the cause in later investigation. Problem solution, however, would not be difficult if the direction of cavitations occurrence in the cylinder liner can be confirmed in dismantling for trouble shooting (in the direction perpendicular to engine, at the right angle to engine or in the direction of cooling water flow).

In actual dismantling of engine, however, cavitations occurrence could Not be confirmed of its direction and the cylinder liner was replaced with a new one because the cause was not clear.



Cavitations occurred in generator cylinder liner.

(3) From a case of Vaipouli P/S trouble

Situation : Power output reduction and fuel consumption increase

Details : Synchronized operation is difficult .

Measure to be taken now: None

Fuel injection adjustment never fails to be performed after overhaul of Generators, but as a fact Cummins diesel generators are quite different in fuel timing adjustment from other ones. It is true, however, that the fuel consumption in Savaii Island is different so much compared to that of 4000kw class generators as no appropriate adjustment is performed.

(4) From a case of Tanugamanono P/S trouble

Situation: Owing to the shortage of cooling water flow for generator use, the engine was stopped by motion of cooling water temperature protecting device of the generator body.(eng, No.12)

Details: Inlet pipe of secondary cooling water was filled up with soil and sands, thus short flow of secondary cooling water (cooling tower) caused a trouble due to no cooling.

Measures: Installed a bypass pipe for secondary cooling water pipe.

This case in which the soil and sand filling up the secondary cooling water pipe caused a trouble will make us anticipate that other 4 generators may possibly fall into the engine stop due to abnormal high temperature caused by the secondary cooling water stop.

The reason why this trouble happened is that the secondary cooling Water inlet pipe could not be cleaned because its strainer for removing soil and sands did not work. Now that a temporary bypass pipe is provided from the upper side of that secondary cooling water pipe, an orthodox measure for stopping the inflow of soil and sands or the complete cleaning of the main cooling water pipe would be needed without doing with such inlet pipe cleaning only. Water mixed with soil and sands in the pondage for secondary cooling Water will inevitably cause the same trouble in rainy seasons.

3.2.5 CONFIRMING REPORTS OF POWER GENERATORS

As result of the site survey of existing power generators and their auxiliary equipment, it became clear that repair work, periodical inspection, details of accidents were reported in writing in the past 1 or 2 years, but the data of long term operation and maintenance for the whole power generating units were hardly ever found.

There are many defaults and defects in values of monthly reports including the totaling and numerical analysis of generator operation reports which are the only reports left.

The fact is that these data are not edited and used for future planning and saving energy, and also high efficiency operation of generators, and that the operation is left to chance.

Generator control documents

The following items are those of generator control documents that were found and made sure of in this site survey:

(i) Reports of generator operation: Monthly reports 1997-Now

(ii) Monthly reports of operation: Monthly power report 1997-Now

(iii) Report of accidents: Details of accident and how to be dealt with 2000-Now

(iv) Control of spare parts: None (general consumables only,)

(v) Tool control : None(No special tool, except some) kinds of tools)

(vi) Control of measuring tools: None (No measuring tool exists)

(vii) Repair plan of generators: Inspection and repair plan in consideration of operation time 2000-Now

(viii) Specification of generators: Handling and repair manuals of generators 1999-Now

3.2.6 ENVIRONMENTAL PROTECTION

Photo(Table 6-1 ・ 6-2)shows the present status of waste oil treatment at Salelologa /Vaipouli P/S It can be said that the waste oil is not treated at all.

The waste oil exhausted from generators is left as it flows out into creeks around the power station, Just as seen at Tanugamanono Power Station,

Waste oil should be collected in an underground tank and delivered to an oil tank vehicle to transport waste oil to treatment facilities. This step most be taken as soon as possible.

*List of photograph of EPC, power generating units and equipment

Table No.3-1-1 **Statistical Data and Operation/Maintenance Records**

Check Date:14/Feb/03

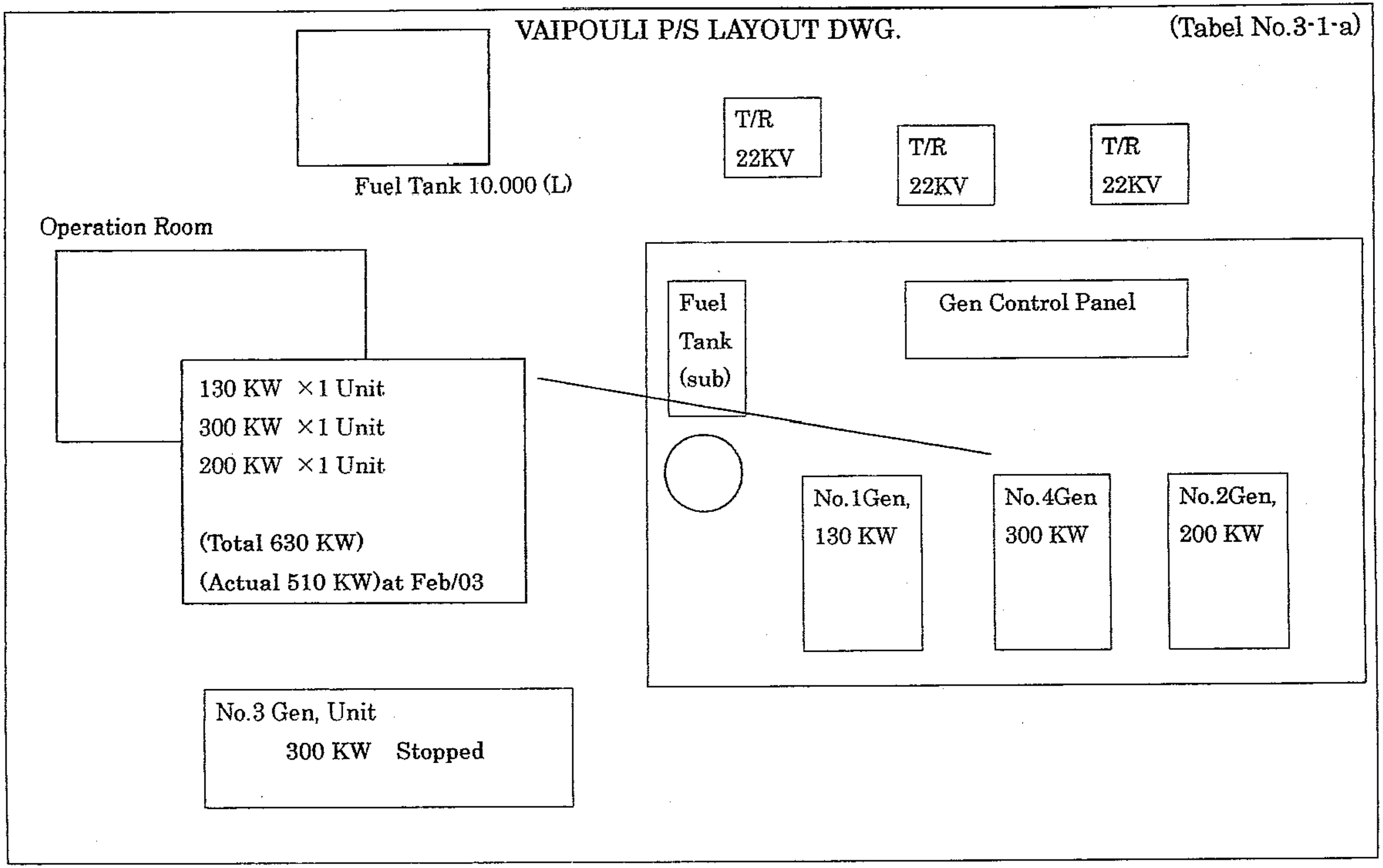
Notes: (shaded) Stopeed Engines

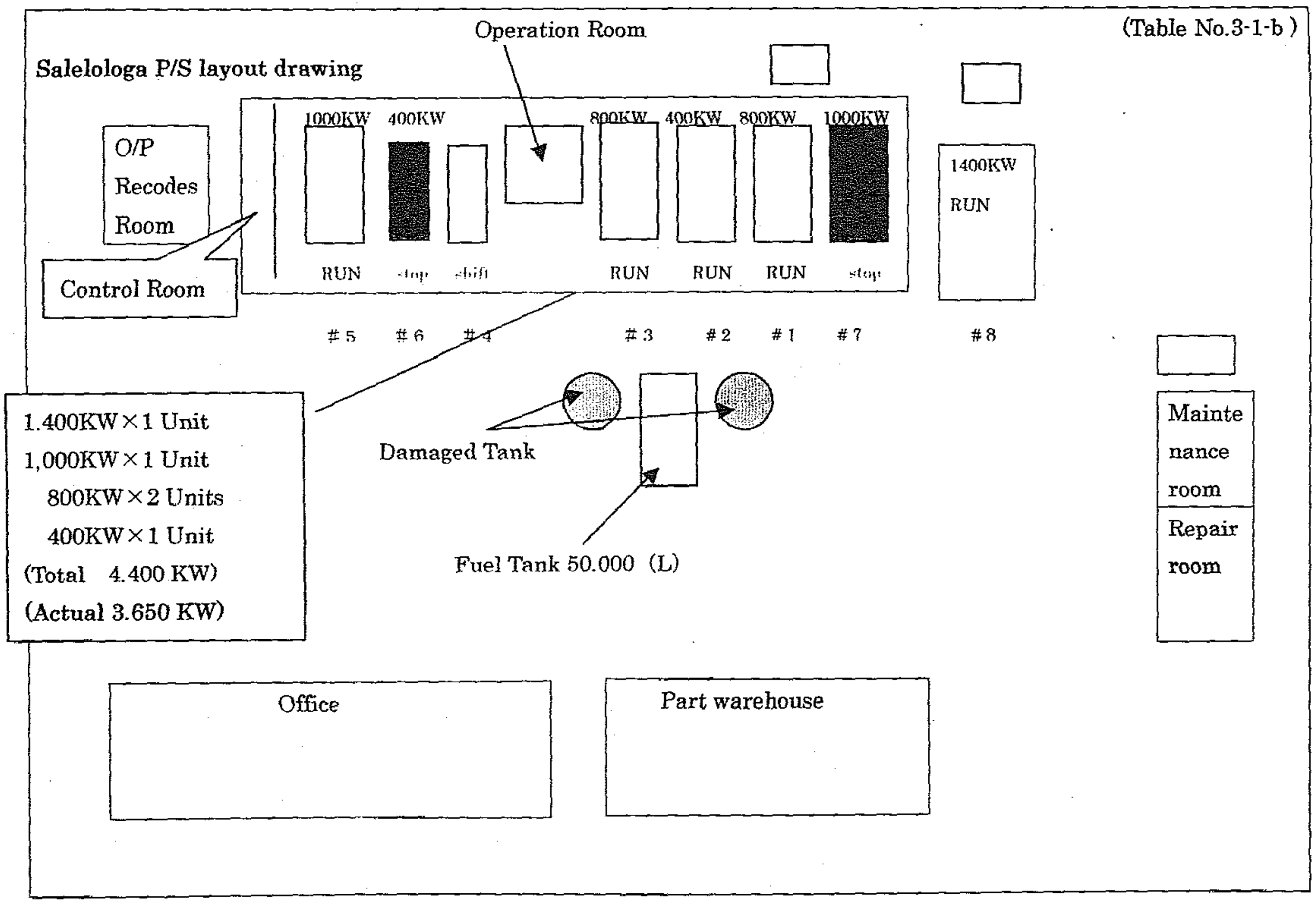
Q2-1

	TANUGAMANONO P/S						SALELOLOGA P/S								VAIPOULI P/S			
Eng. Unit No.	4A 500r	5A 600r	7A 600r	8	9A 600r	12 600r	1A	2	3A	4	5A	6	7A	8A	1	2	3	4
Eng. Service	RUN	RUN	RUN	STOP	RUN	RUN	RUN	RUN	RUN	Shift Vaip	RUN	STOP	STOP	RUN	RUN	RUN	STOP	RUN
Gen,Output, (KW)	2200	4200	4200	2000	4200	3500	800	400	800	400	1000	400	1000	1400	130	200	300	400
Actual Output,KW	1800	4200	4200		4200	3500	750	350	750	350	800		700	1000	80	150	200	280
Instaled at New		NW	NW		MW	NW		NW		NW		NW			NW	NW		
Second-hand	SH						SH		SH		SH		SH	SH			SH	SH
Date of Mfg,(Eng.)	1968	2000	1998	1977	2001	1991	07/94	11/94	07/94		12/93	11/94	1980	03/93	07/89			
Date of Mfg,(Gen.)		2001	1999	1978	2002	1992												
Date of Installed (EPC)	1996	2001	1999	1978	2002	1992	2001 JAN	2001 JAN	2001 JAN	1992 JAN	1999	1996	1997	2002 DEC	1989	1989	1997	1989 1992
Eng.Maker	BLKS	BLKS	BLKS	NIGAT	BLKS	BLKS	CMMI	CMMI	CMMI	CMMI	CAT	CMMI	BLKS	CAT	CMMI	CMMI	DET/D	CMMI
Eng.Model							KTA 38	KTTA 19G2	KTA 38-G3		3512		ESL8M	3516 TA				KTTA 19G2
Eng.Fuel consumption (KWh/Lit)							3.22	3.33	3.1		3.13		3.32		2.76	2.69		3.04
D/G Operation Time	20537	9801	16496		2713	48190	(×10) 5573	(×10) 10170	(×10) 2641		24510	(×10) 6429	24510	3.054	25468	47113	5872	43323
EPC Operation time	6y	1y	3y	–	1y	2.8y	2y	2y	2y	11y	4y	7y	6y	0.3y	14	14	6	14
Operation time(Total)	6y	1y	3y	–	1y	2.8y	8.5y	8.5y	8.5y	11.0y	9.0y	7.0y	23.0y	9.0y	14.0y	14.0y		14.0y
Gen.Output(KVA)								563	1000		1275	563	1100			250		563
Voltage(V)	6600	6600	6600		6600	6600	420	450	420		400	450	415	420	420	420		420
Frequency (HZ)	50	50	50		50	50	50	50	50	50	50	50	50	50 60Hz	50	50	50	50
Problem point Past repair	Gen. Damage	Rocker arm Damage	Damage	T/b Damage	Rocker arm Damage	Sleev Damage		AVR Damage				GEN. Damage	CAM Damage			Exciter Damage	GEN Damage	GEN Exchange

VAIPOULI P/S LAYOUT DWG.

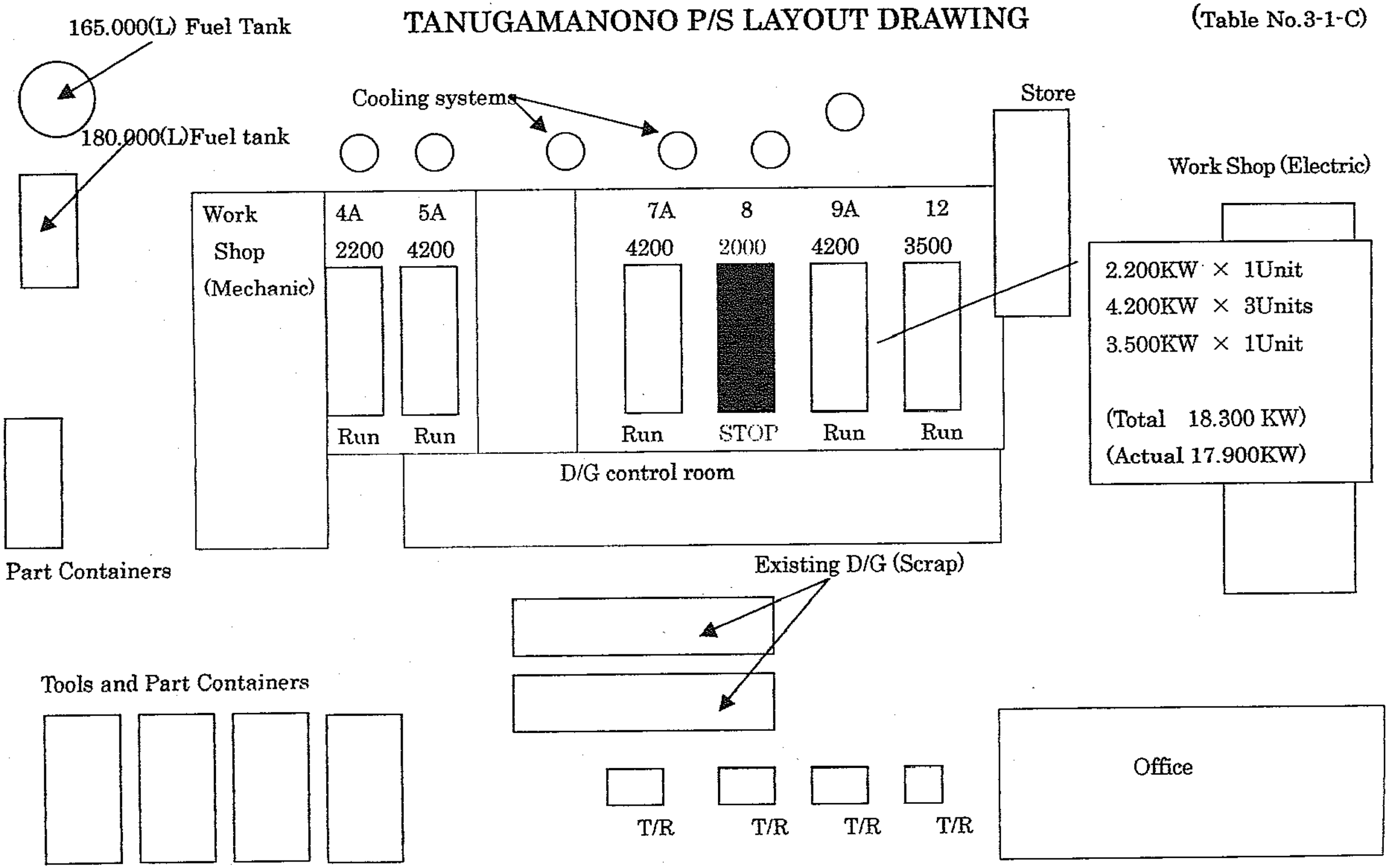
(Tabel No.3-1-a)




(Table No.3-1-b)
Salelologa P/S layout drawing
Operation Room
O/P Recodes Room
Control Room
1000KW
400KW
800KW
400KW
800KW
1000KW
RUN
stop
shift
RUN
RUN
RUN
stop
1400KW
RUN
#5
#6
#4
#3
#2
#1
#7
#8
1.400KW×1 Unit
1,000KW×1 Unit
800KW×2 Units
400KW×1 Unit
(Total 4.400 KW)
(Actual 3.650 KW)
Damaged Tank
Fuel Tank 50.000 (L)
Mainte nance room
Repair room
Office
Part warehouse

(Table No.3-1-C)

TANUGAMANONO P/S LAYOUT DRAWING

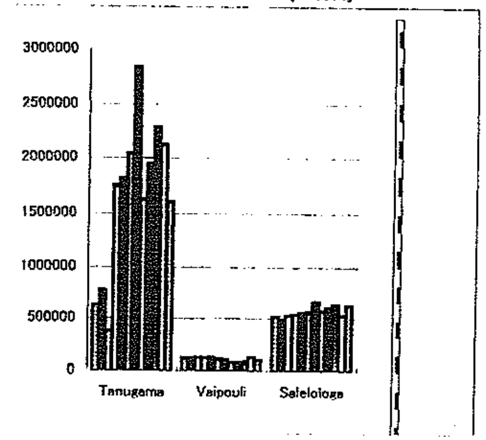


(Table No.3-1-2a)

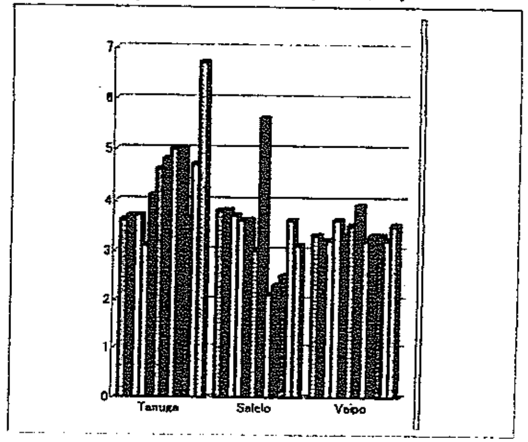
1997	Kwh Monthly			Fuel consumption/L			KWh/L		
	Tanugama	Vaipouli	Salelologa	Tanugama	Salelologa	Vaipouli	Tanuga	Salelo	Vaipo
Jan	637403	119840	521856	110626	156000	31560	3.6	3.8	3.3
Feb	780362	117920	488320	166054	154220	30800	3.7	3.8	3.2
Mar	375737	126400	534200	104096	167130	34500	3.7	3.7	3.2
Apr	1748469	122880	541120	351206	169800	34100	3.1	3.6	3.6
May	1815756	124680	560320	358937	171600	34600	4.1	3.6	3.3
Jun	2040661	112640	567760	425628	161200	37480	4.6	3	3.5
Jul	2839380	104328	672222	615897	170445	18795	4.8	5.6	3.9
Aug	1631598	74012	575916	396515	178880	34700	5	2.1	3.2
Sep	1944196	80023	610050	521967	185970	34905	5	2.3	3.3
Oct	2288848	86035	644096	613859	193060	35110	3.6	2.5	3.3
Nov	2124622	126400	534200	566753	167130	34500	4.7	3.6	3.2
Dec	1610480	101907	633940	440888	181570	32930	6.7	3.1	3.5
							4.3	3.4	3.4

Average

Power demand in 1997(Kwh)



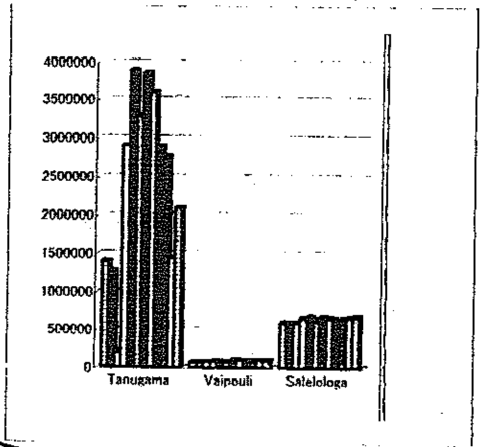
Fuel consumption in 1997 (Kwh/L)



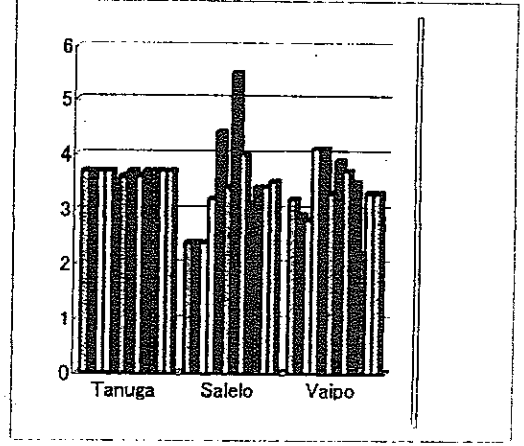
1998	Kwh Monthly			Fuel consumption			KWh/L		
	Tanugama	Vaipouli	Salelologa	Tanugama	Salelologa	Vaipouli	Tanuga	Salelo	Vaipo
Jan	1397440	81808	597846	378423	188380	34700	3.7	2.4	3.2
Feb	1265680	80474	597343	338779	199765	33750	3.7	2.4	2.9
Mar	190168	79140	596840	516055	211150	32800	3.7	2.4	2.8
Apr	2897000	84248	651068	783936	156995	25785	3.7	3.2	4.1
May	3892340	83296	668878	1066405	161810	18770	3.5	4.4	4.1
Jun	3280240	80912	626180	898795	166910	23544	3.6	3.4	3.3
Jul	3863040	104328	672222	1058255	170445	18795	3.7	5.5	3.9
Aug	3592840	103117	653081	995182	175852	25862	3.6	4	3.7
Sep	2883420	101907	633940	781841	181260	32930	3.7	3.1	3.5
Oct	2758288	100260	645765	748627	200450	29270	3.7	3.4	2.2
Nov	1441854	98614	657590	385528	203235	28905	3.7	3.4	3.3
Dec	2101676	99184	680797	568183	206020	28540	3.7	3.5	3.3
							3.7	3.4	3.4

Average

Power demand in 1998(Kwh)



Fuel consumption in 1998 (Kwh/L)



(Table No.3-1-2b)

Sheet No.3-1-2 b

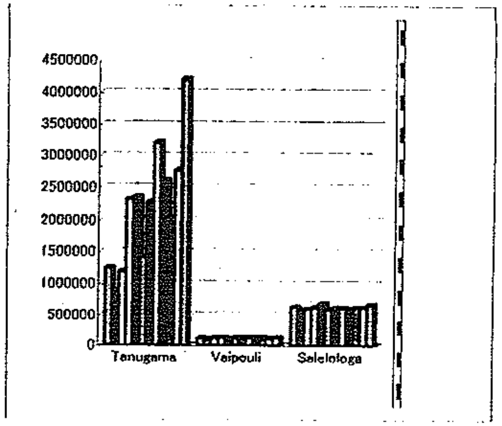
1999	Kwh Monthly Tanugam	Kwh Monthly Vaipouli	Kwh Monthly Salelolo	Fuel consumption Tanugam	Fuel consumption Salelolo	Fuel consumption Vaipou	KWh/L Tanuga	KWh/L Salelo	KWh/L Vaipo
Jan	1232960	107576	625899	3265533	201120	35750	3.8	3	3.1
Feb	873230	90538	583104	230945	184040	30940	3.8	2.9	3.2
Mar	1178364	114453	592079	321885	197790	36400	3.8	3.1	2.9
Apr	2303222	114691	623456	596219	182860	35863	3.9	3.2	3.4
May	2349816	108924	682962	635405	182900	33640	3.7	3.2	3.7
Jun	1402280	111418	596844	378636	178410	33687	3.7	3.3	3.3
Jul	2265075	113876	615714	627393	184020	37115	3.6	3.1	3.3
Aug	3203368	117812	609219	812878	182245	36200	3.9	3.2	3.3
Sep	2594601	110648	585072	677743	179235	34755	3.8	3.2	3.3
Oct	2003579	117321	618452	515012	188330	36260	3.9	3.1	3.3
Nov	2760378	102195	618056	70160	183210	33170	3.9	3.1	3.4
Dec	4201584	116029	666318	1080865	224505	35510	3.9	3.3	3
							3.8	3.1	3.3

Average

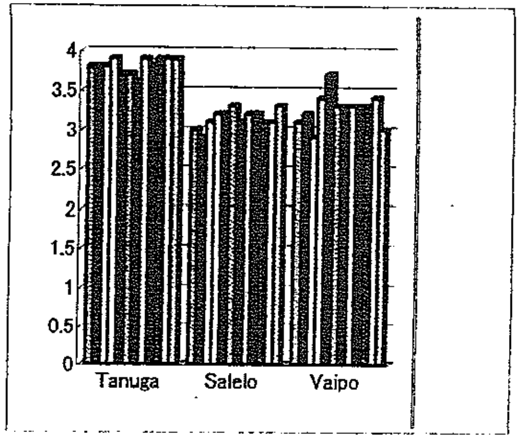
2000	Kwh Monthly Tanugam	Kwh Monthly Vaipouli	Kwh Monthly Salelolo	Fuel consumption Tanugam	Fuel consumption Salelolo	Fuel consumption Vaipou	KWh/L Tanuga	KWh/L Salelo	KWh/L Vaipo
Jan	2625780	118250	652162	686143	203615	38565	3.8	3.1	3.2
Feb	2112716	108940	609778	547250	195920	34410	3.9	3.2	3.1
Mar	2055797	65653	691070	528363	209380	20285	3.9	3.2	3.3
Apr	3077550	117337	680590	793288	218540	29840	3.9	3.9	3.1
May	2756153	116644	688547	729451	223920	38550	3.8	3	3.1
Jun	2464310	109156	651138	648868	213075	34850	3.8	3.1	3
Jul	2669742	111424	678765	696911	204080	35960	3.8	3.1	3.3
Aug	3637319	118128	695760	946799	212240	38275	3.8	3.1	3.3
Sep	3078000	114322	660590	792463	206000	38105	3.9	3	3.2
Oct	3884350	120898	687707	1039728	207982	37310	3.7	3	3.2
Nov	2557986	110008	66193	684844	209965	36515	3.7	3	3.2
Dec	217824	122184	730164	462586	228370	40513	0.5	3	3.2
							3.5	3.1	3.2

Average

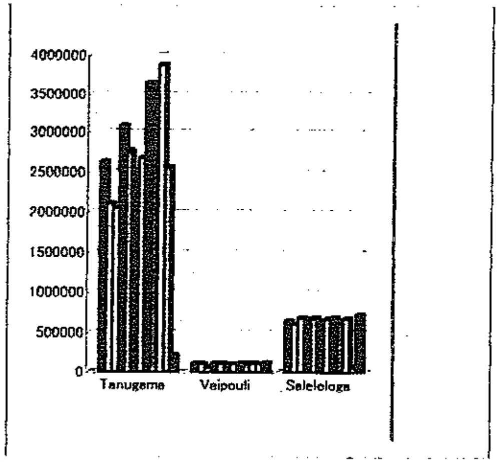
Power demand in 1999(Kwh)



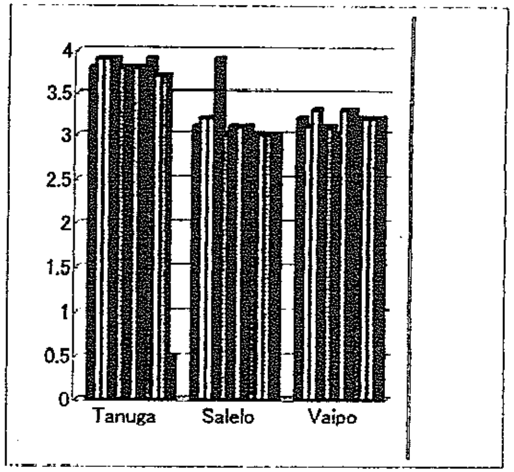
Fuel consumption in 1999 (Kwh/L)



Power demand in 2000(Kwh)



Fuel consumption in 2000 (Kwh/L)



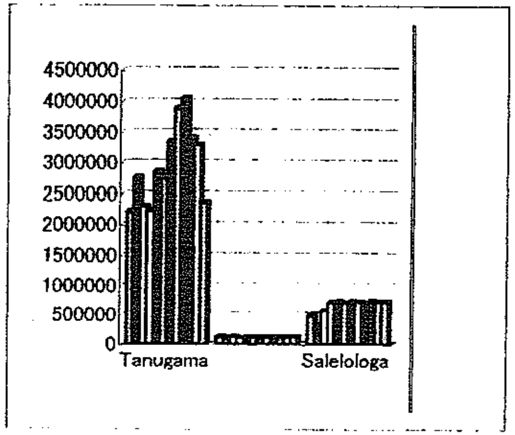
(Table No.3-1-2c)

Sheet No.3-1-2 c

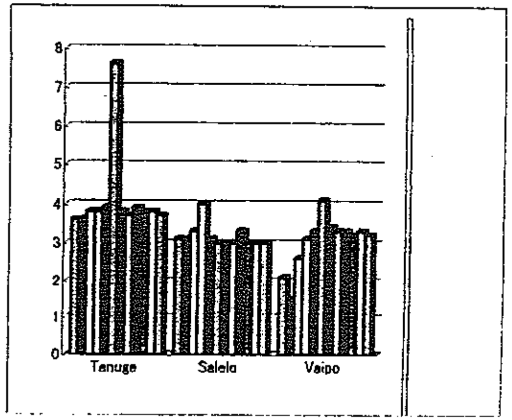
2001	Kwh Monthly Tanugam	Vaipouli	Salelolo	Fuel consumption Tanugam	Salelolo	Vaipou	KWh/L Tanuga	Salelo	Vaipo
Jan	2206690	123017	490484	681915	233060	39600	3.6	3.1	2.1
Feb	2755290	110834	308046	761976	200120	35500	3.6	3.1	1.5
Mar	2295830	123528	570786	601855	213200	36500	3.8	3.3	2.6
Apr	2219652	109114	711385	579345	229380	26805	3.8	4	3.1
May	2851200	114402	722424	721071	213200	36500	3.9	3.1	3.3
Jun	2752000	116272	711032	358344	171040	38070	7.6	3	4.1
Jul	3336764	116368	725693	863252	210670	38400	3.8	3	3.4
Aug	3884346	116129	728830	1038928	215110	38100	3.7	3	3.3
Sep	4043587	111132	685748	1032970	205520	36700	3.9	3.3	3.3
Oct	3404703	117638	733754	894898	226520	38700	3.8	3	3.2
Nov	3289939	112447	718081	852000	216280	37350	3.8	3	3.3
Dec	2355584	122974	721668	627817	224990	13265	3.7	3	3.2
							3.7	3.1	3

Average

Power demand in 2001(Kwh)



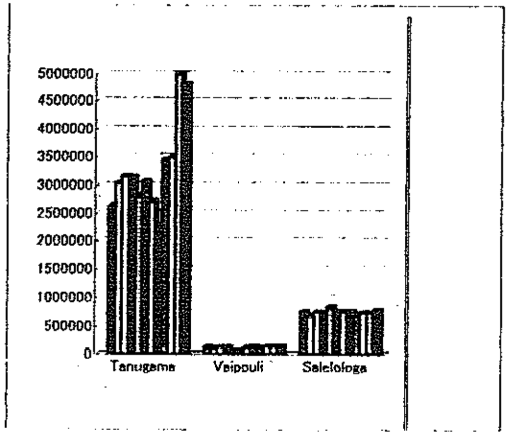
Fuel consumption in 2001 (Kwh/L)



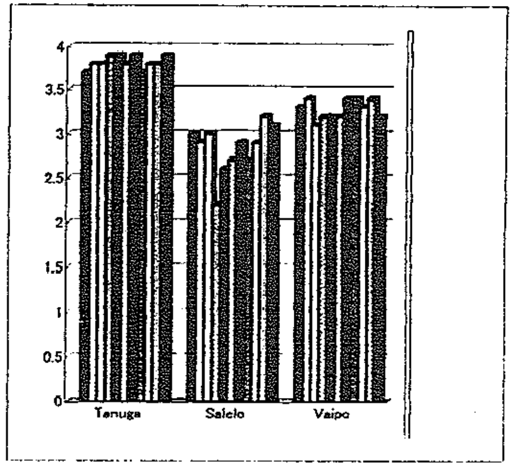
2002	Kwh Monthly Tanugam	Vaipouli	Salelolo	Fuel consumption Tanugam	Salelolo	Vaipou	KWh/L Tanuga	Salelo	Vaipo
Jan	2618760	117890	739701	697498	223100	39295	3.7	3	3.3
Feb	3017686	104488	670996	796602	192820	35710	3.8	2.9	3.4
Mar	3156642	120997	741532	826550	235460	40500	3.8	3	3.1
Apr	3131893	121480	721970	783147	226580	35150	4	3.5	3.2
May	2796345	49886	821474	717475	255850	22460	3.9	2.2	3.2
Jun	3059323	63120	753452	777856	238060	24200	3.9	2.6	3.2
Jul	2699754	122946	747220	703623	228685	45535	3.8	2.7	3.2
Aug	2252713	128052	755130	579795	219310	44200	3.9	2.9	3.4
Sep	3436437	122139	708430	916709	206800	44150	3.7	2.7	3.4
Oct	3474802	133076	725886	905481	214910	46590	3.8	2.9	3.3
Nov	4989145	136509	731499	1294481	215094	42756	3.8	3.2	3.4
Dec	4811985	126506	782058	1237087	246522	40531	3.9	3.1	3.2
							3.7	2.9	3.3

Averagre

Power demand in 2002(Kwh)

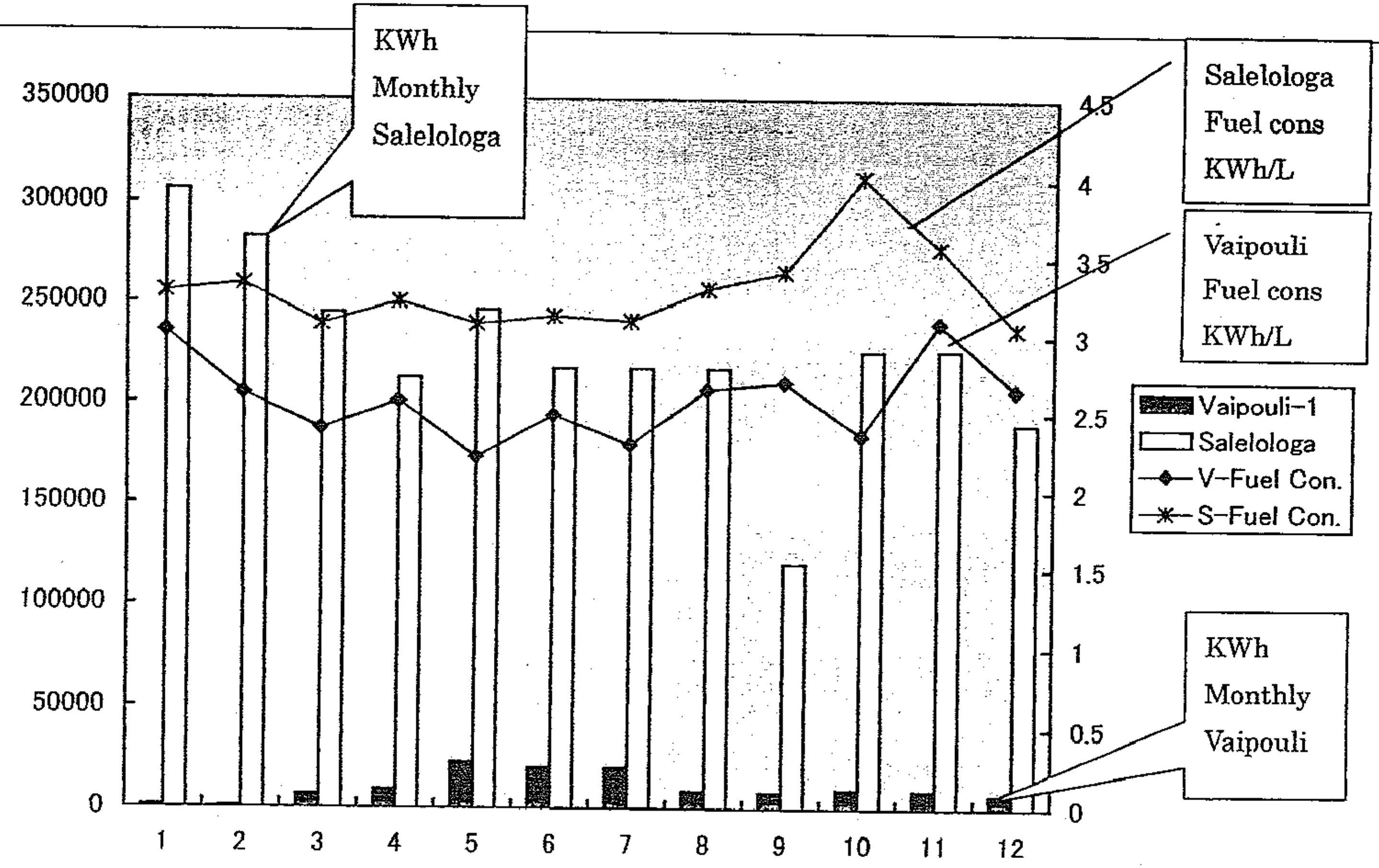


Fuel consumption in 2002 (Kwh/L)



SAVAII MONTHLY PRODUCTION(2002) COMPARISON TABLE (Table:3-1-3)

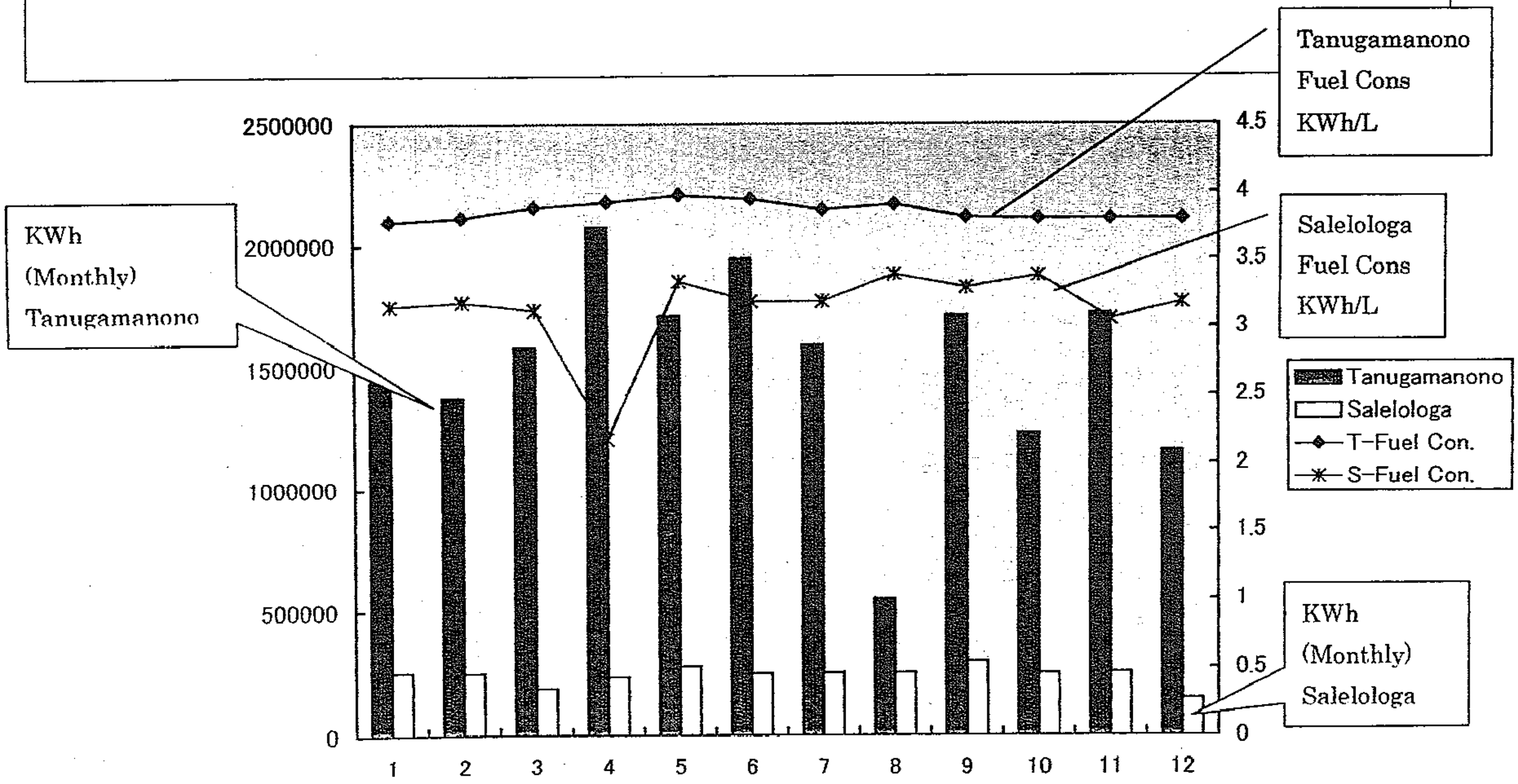
Vaipouli 130KW and Salelologa 800KW Fuel Consmption



(Table 3-1-4)

SAVAII and TANUGANONO MONTHLY PRODUCTION(2002)COMPARISON TABLE

Salelologa 1000KW and Tanuganono 4200KW Fuel Cons.



(Table No.3-1-5)

Specifications and performances of 4 Cycle Diesel Engines for Power plant

Item	Speed Rpm / Unit	300～500 Low speed Engine	500～1000 Middle speed Engine	1000～1800 High speed Engine
Piston speed	m/s	4～5	4.5～10.5	5.3～10.8
Compression ratio	-----	11～15	8～16.5	12～23
Maximum pressure	Kgf/cm²	50～150	50～147	60～147
Fuel consumption	g/ps・h	124～171	132～211	151～218
	g /kwh	168～232	179～287	205～296
	Kwh/L	5.0～3.67	4.68～2.94	4.32～2.82
Thermal efficiency	%	37～51	30～48	29～42
Machine efficiency	%	75～95	75～95	75～92
Fuel oil type	------	Heavy oil A,B or C	Heavy oil, or A,B or C	Light oil or Heavy oil A
Output range	KW	600～21.000	100～11.000	100～4.600
Major application	-----	Normal use	Normal use	For emergency

Fuel consumption assumed to be proper (in case of 600Rpm・1.500Rpm)

High speed (kwh/L)				3.7～3.5 (1.500Rpm)
Middle speed			3.9～3.6 (800 Rpm)	
Low speed (kwh/L)		4.0～3.8 (600Rpm)		

Tanugamanono P/S Accident Breakdown record (Table No.3-2-4)

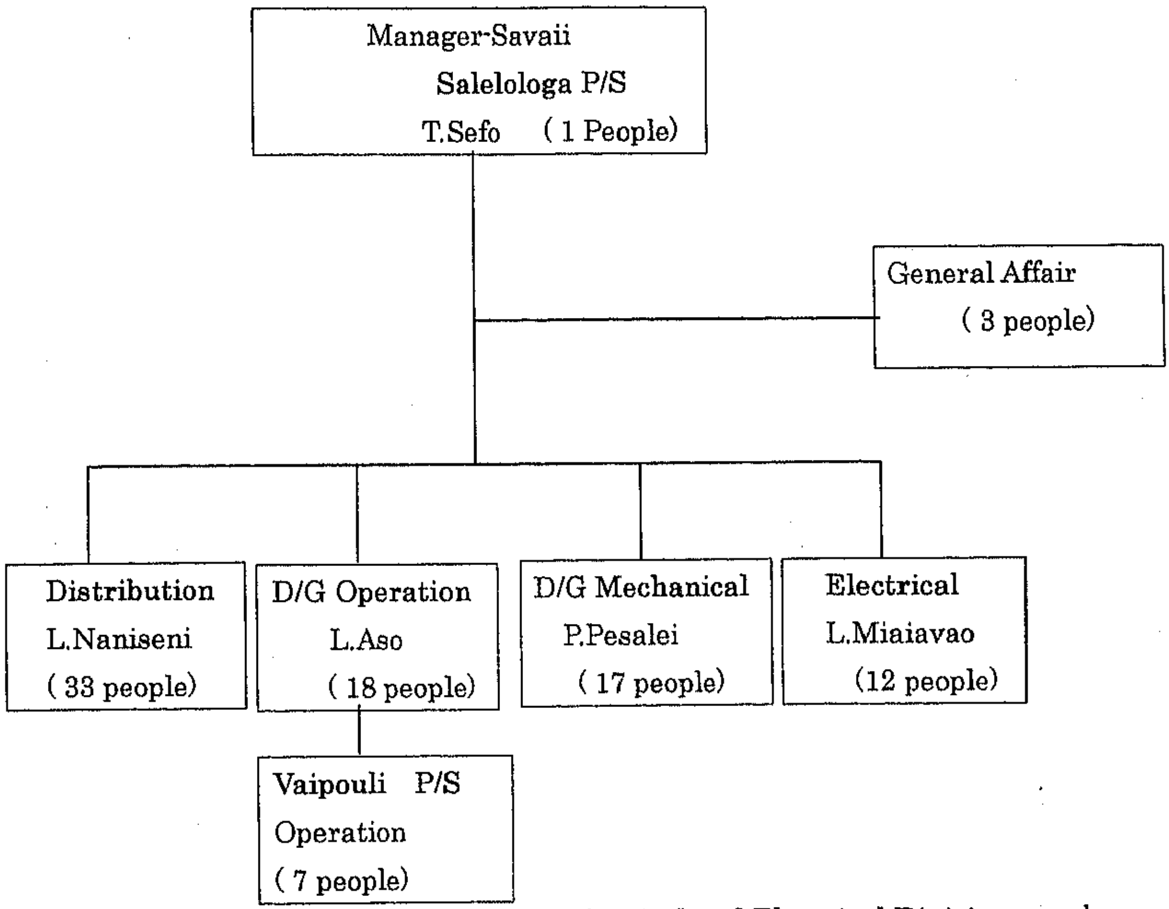
(The content of the under mentioned breakdown is information from 2001.)

Check at Feb/03

Unit No.	Date	Locating fault (Accident cause)	Content
# 4A	02/01 07/02 10/02	 Rocker arm Leaking	Major overhaul at 17000 running hours 1)Change the broken rocker arm of cylinder #1 2)Fuel pump of cylinder #7 is leaking
# 5A	12/02	Rocker arm Governor Fuel pump Injection pump	1)Change the broken rocker arm of cylinder #2 2)Replace actuator of 5A with governor 3)Replace Fuel pump o 4)Install the injection pump replacement of cylinder #8
# 7B	05/02 05/02 03/02 01/02 08/01 06/01	Water leak Over speed Rocker arm Crankpin	1) No.8 cylinder head water leak problem 2) To change bearing of turbocharger of no.7B 3)Reinstall the LFI bowl for No.7B generator 4)Eng.No.7B Over speed 5) Change the broken rocker arm stud 6)-Crankpin Damage
# 9A	11/02	Rocker arm	1) Change the broken rocker arm of cylinder #6 2) Cooling water for local control is blocked 3) Injector of cyl#7 is different please
#12	12/02 01/03	Sleeve Sleeve	Major overhaul was done at 22248 running hours 1) Eng, sleeve replacement for #6 cylinder (2,2 "crack from the top of the sleeve) 2) Eng, sleeve replacement for #3 cylinder (2,5 "crack from the top of the sleeve)
# 8		Not Run Supercharger	 1) broken supercharger

(Table No.3-2-1(4))

EPC Organizational Chart (SAVAII)

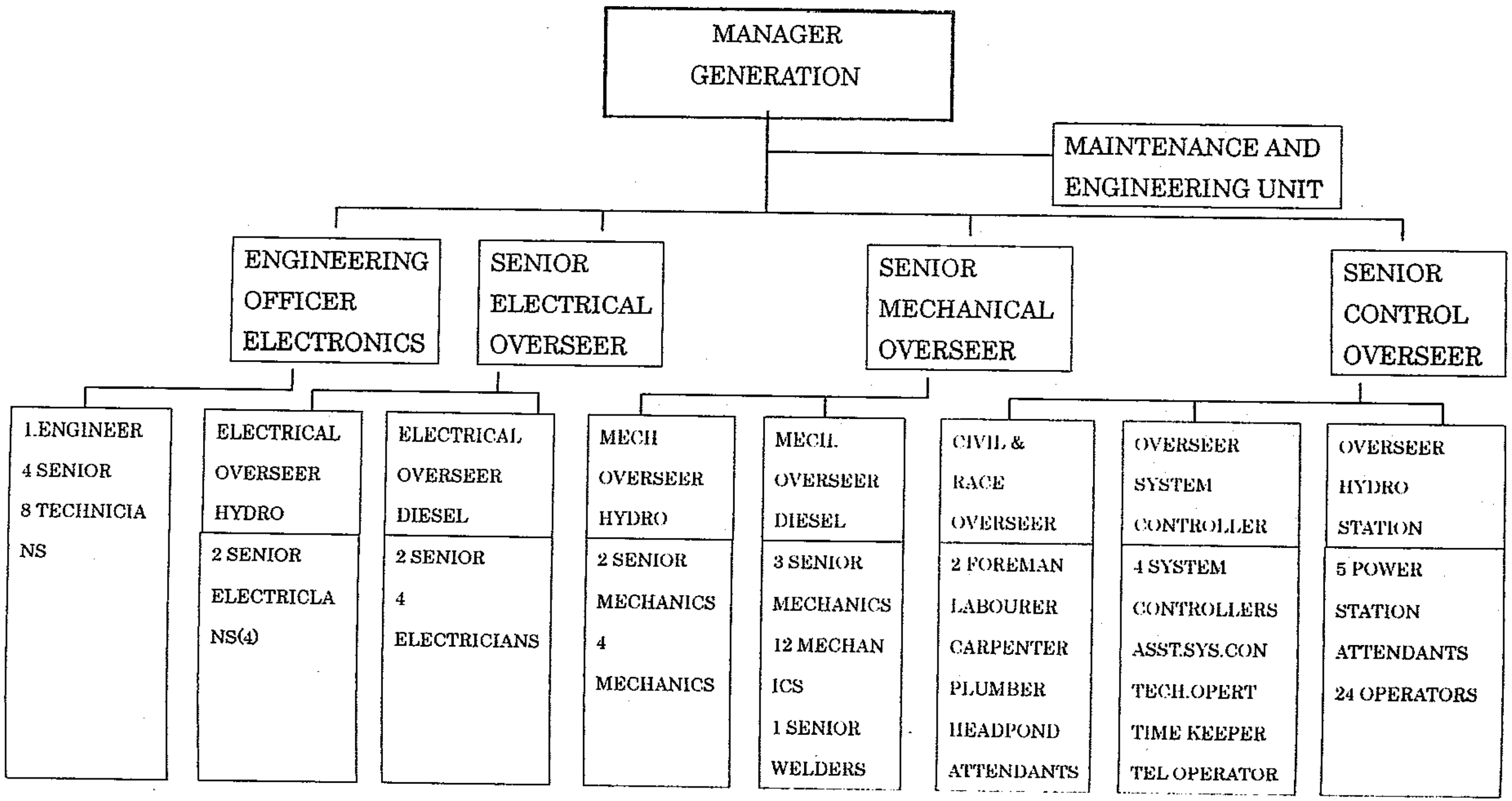


D/G Mechanical and Electrical Division members

* Manager-- 1 Person
* D/G Mechanical Engineer------------------ 0 Person
* Electric Engineer------------------------------ 0 Person
* 20 Years or more experience Mechanical worker------------ 2 Person
* 10 Years or more experience Mechanical worker------------ 3 Person
* 5 Years or more experience Mechanical worker------------ 4 Person
* 20 Years or more experience Electrical worker--------- ----- 1 Person
* 10 Years or more experience Electrical worker--------------- 1 Person
* 5 Years or more experience Electrical worker--------------- 4 Person
* Others worker (Driver/Welder/Store man / Apprentice) -- 9 Person

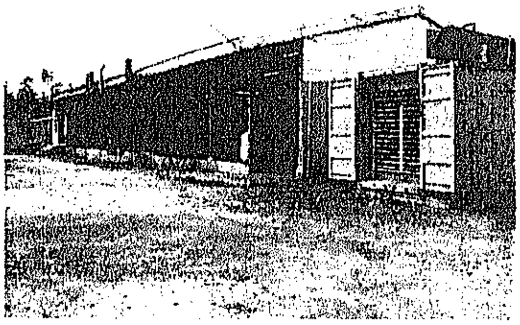
Table No 3-2-1 (5)

EPC Organizational Chart (UPOLU)P/S

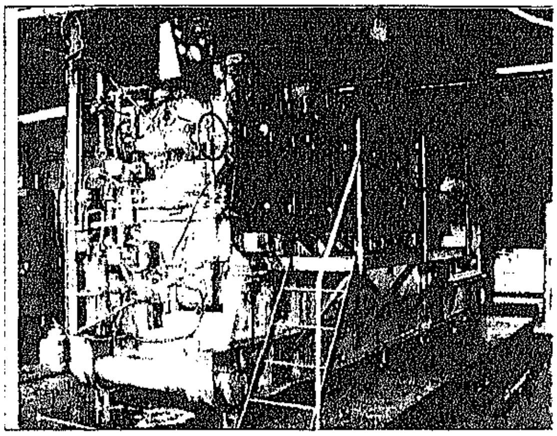


Savaii Salelologa D/G P/S

Inspection
Date:Feb/08/03
(Table No. 3-b-1)

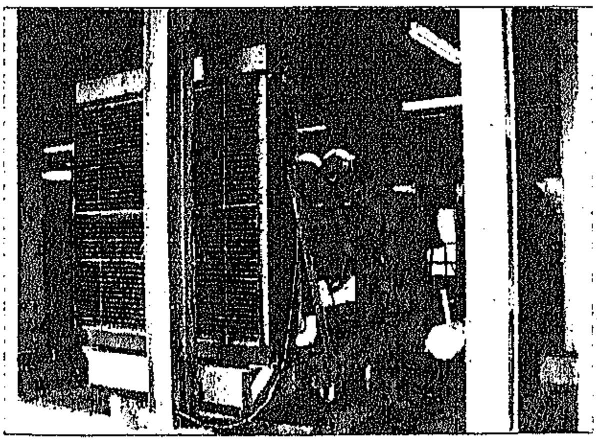


Power Plant General View



EPC No. # 7 GEN. (STOPPED)

1) Gen. Output--------1000 KW
2) Installed ------------1997
3) Date of Mfg---------1980
4) O/p Time -----------24510 h
5) Eng. Maker---------Blackstone
6) Eng. Model----------ESL8M
7) Situation of Generator STOPPED
8) Situations of replenishment parts.
not possible to repair
9) Cause of accident : Camshaft
bearing damage
10) Use for 7 years

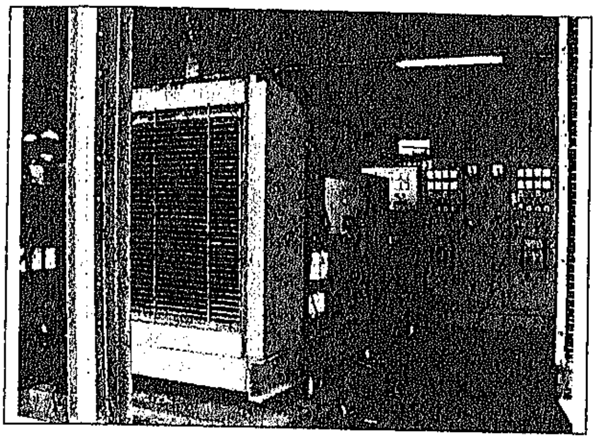


EPC No. # 1 GEN.

1) Gen. Output---------800 KW
2) Installed -------------2001/Jan
3) Date of Mfg ---------JUL/94
4) O/p Time -------------5573 h
5) Eng. Maker ----------Commins
6) Eng. Model------------KTA38
7) Situation of Generator --RUN
8) Situations of replenishment parts

Consume parts only

9) Use for 8.5 years



EPC No. # 2 GEN.

1) Gen. Output.-------400 KW
2) Installed ------------1994
3) Date of Mfg---------11/94
4) O/p Time ------------5101.2/ h
5) Eng, Maker ---------Commins
6) Eng. Model ----------KTTA19G2
7) Situation of Generator: RUN
8) Situations of replenishment parts

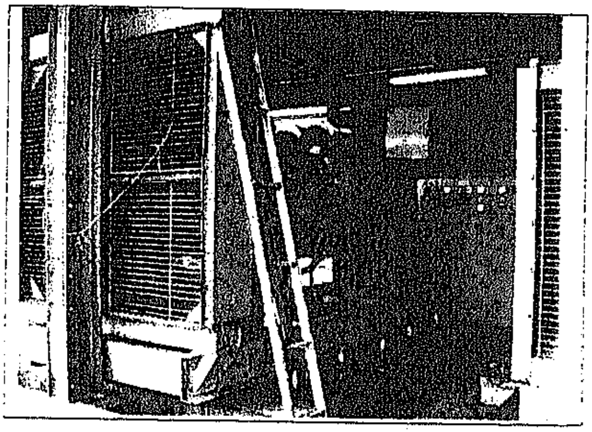
Consume parts

only

9) Cause of accident : AVR damage

Synchronized operation is difficult.

10) Use for 8.5 years



EPC No. # 3 GEN.

1) Gen. Output.-------800 KW
2) Installed ------------2001/Jan
3) Date of Mfg --------JUL/94
4) O/p Time ------------2.574 / h
5) Eng. Maker ---------Commins
6) Eng. Model ----------KTA38-G3
7) Situation of Generator: RUN
8) Situations of replenishment parts

Consume parts only

9) Use for 8.5 years

EPC No. # 4 GEN.

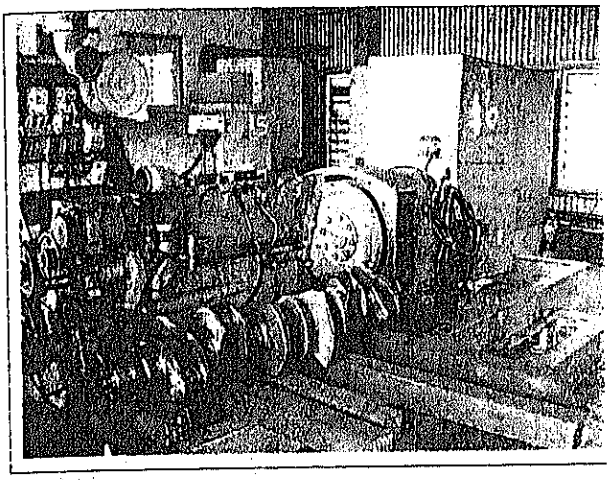
1) Gen. Output. : 400 KW
2) Installed : SIFT to

VAIPOULI

3) Date of Mfg :
4) O/p Time :
5) Eng. Maker : Commins
6) Eng. Model :

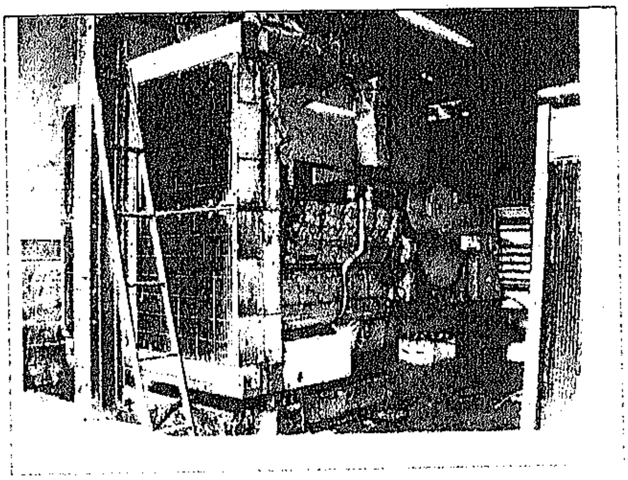
7) Situation of Generator : None

8) Cause of accident : Dynamo damage



EPC No. # 6 GEN.(STOPPED)

1) Gen. Output. --------400 KW
2) Installed---------------1996
3) Date of Mfg----------11/94
4) O/p Time -------------6429.6h(1/10)
5) Eng, Maker---------- Commins
6) Eng. Model :
7) Situation of Generator: ----Stopped
8) Situations of replenishment parts
9) Cause of accident: Stops the Eng, by overload of the feeder accident.

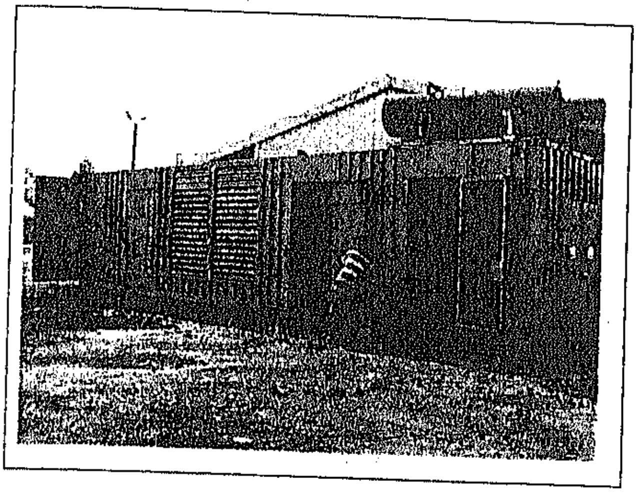


EPC No. # 5 GEN.

1) Gen. Output.--------1000 KW
2) Installed -------------1999
3) Date of Mfg ---------Dec/93
4) O/p Time -------------23538.68 h
5) Eng, Maker ---------Caterpillar
6) Eng. Model :
7) Situation of Generator : RUN
8) Situations of replenishment parts

Consume parts only

9) Use for 9.0 years

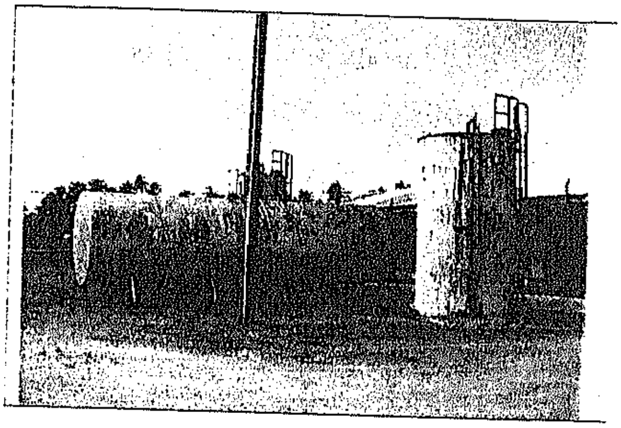


EPC No. # 8 GEN.

1) Gen. Output.---------1400 KW
2) Installed --------------2002/Dec
3) Date of Mfg ----------1993
4) O/p Time --------------3031 h
5) Eng, Maker ----------Caterpillar
6) Eng. Model -----------3516TA
7) Situation of Generator: RUN
8) Situations of replenishment parts

Consume parts only

9) Use for 9.0 years



* Fuel and Oil Tank

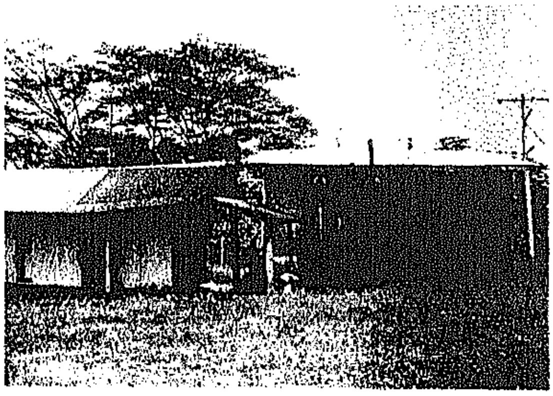
* Fuel tank capacity (50,000 L)
* (Excluding the lubricant tank)

Tank of the Vertical type is not possible to use.

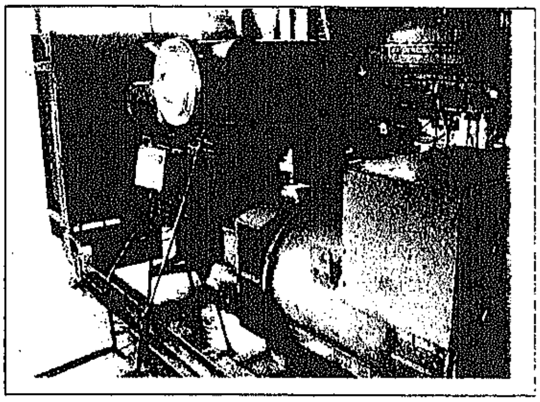
Savaii Vaipouli D/G P/S

Inspection Date:Feb/17/03

(Sheet No.3-a-1)

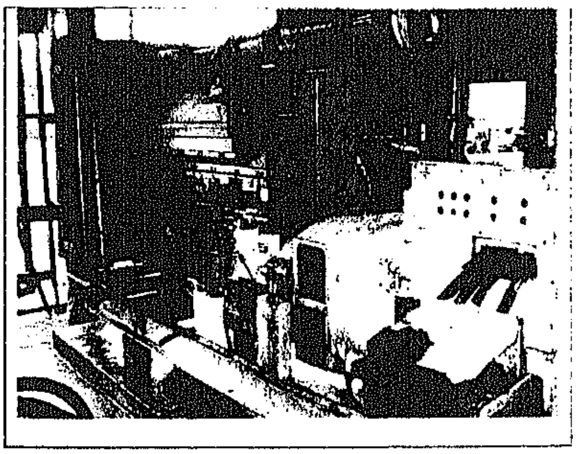


Power Plant General View



EPC No. # 2 GEN (GENERATED)

1) Gen. Output.---------200 KW
2) Installed --------------1989
3) Date of Mfg
4) O/p Time --------------47113.0 h
5) Eng, Maker ----------Commins
6) Eng. Model------------NT855-G6
7) Situation of Generator : RUN
8) Situations of replenishment parts No Parts
9) Cause of accident Gen, Exchanged and Exciter Damage
10) Use for 14 years



EPC No. # 4 GEN(GENERATED)

1) Gen. Output.------300 KW
2) Installed -----------1989/ 1992
3) Date of Mfg -------11/94
4) O/p Time ----------43323.05 h
5) Eng, Maker -------Commins
6) Eng. Model --------KTTA19G2
7) Situation of Generator : RUN
8) Situations of replenishment parts No Parts

9) Cause of accident Gen, Exchanged

10) Use for14 years

EPC No. # 1 GEN(GENERATED)

1) Gen. Output.-------130 KW
2) Installed-------------1989
3) Date of Mfg ---------07/1989
4) O/p Time -------------25468.71 h
5) Eng. Maker ----------Commins
6) Eng. Model-----------6CTA8.3G
7) Situation of Generator : RUN
8) Situations of replenishment parts No

Parts

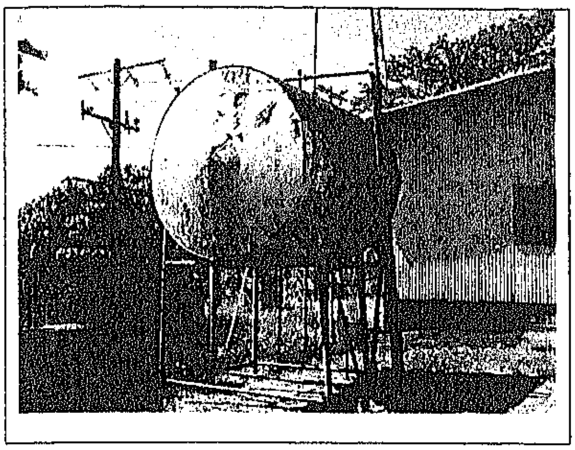
9) Cause of accident

10) Use for14 years

EPC No. # 3 GEN (STOPPED)

1) Gen. Output.-------300 KW
2) Installed-------------1997
3) Date of Mfg :
4) O/p Time ------------05872.4h
5) Eng. Maker ---------Detroit D/G
6) Eng. Model ---------V71
7) Situation of Generator : STOPPED
8) Situations of replenishment parts: NO

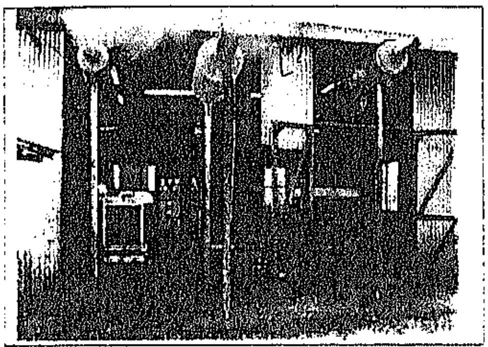
9) Cause of accident Gen. Damaging

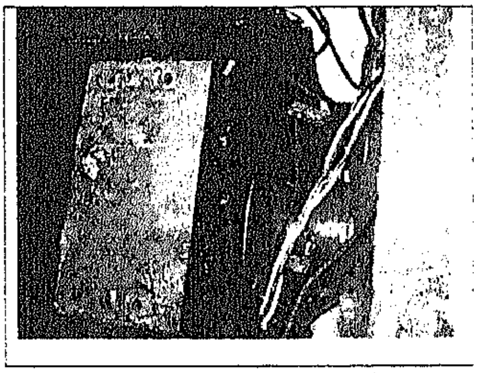


＊Fuel and Oil Tank

＊Fuel tank capacity (10,000 L)

＊ (Excluding the lubricant tank)





Vaipouli D/G Exhaust Gas
(Black smoke exhaust gas)

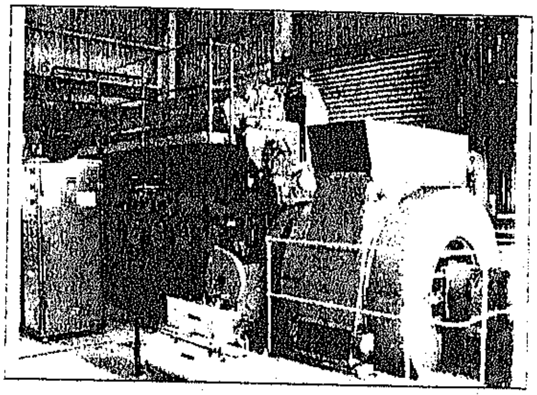
Vaipouli D/G Generator Damaged
(Damage of Stator coil)

TANUGAMANONO D/G P/S

Inspection Date:Feb/03

(Table No.3-C-1)

Power Plant General View

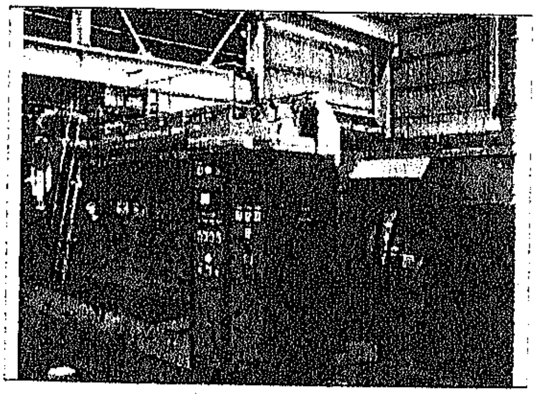


EPC No.#12 ENG.(RUN)

1) Gen. Output ------3500KW
2) Installed -----------1992
3) Date of Mfg.-------1992
4) O/P Time-----------48190/h
5) Eng. Maker--------BLKS
6) Eng. Model---------
7) Situation of Generator --RUN
8) Situations of replenishment parts

Consume parts only

9) Use for 11 Years

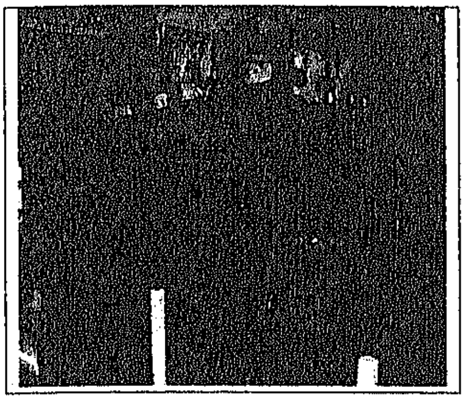


EPC No.# 9A ENG.(RUN)

1) Gen. Output ------4200KW
2) Installed -----------2002
3) Date of Mfg.-------2001
4) O/P Time-----------2706/h
5) Eng. Maker--------BLKS
6) Eng. Model---------
7) Situation of Generator --RUN
8) Situations of replenishment parts

Consume parts only

9) Use for 1 Years

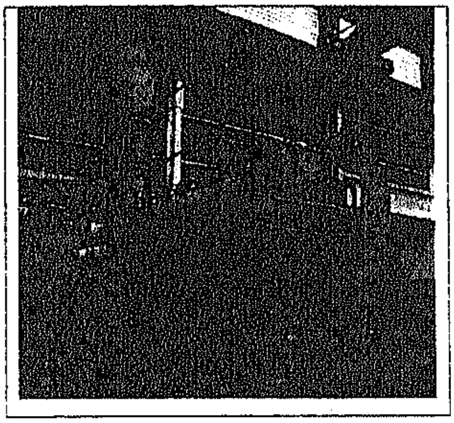


EPC No.# 8 ENG.(STOPPED)

1) Gen. Output ------2000KW
2) Installed -----------1978
3) Date of Mfg.-------1978
4) O/P Time-----------
5) Eng. Maker--------NIGATA
6) Eng. Model---------
7) Situation of Generator --**STOPPD**
8) Situations of replenishment parts

Repair measures are uncertain.

9) Use for **24** Years

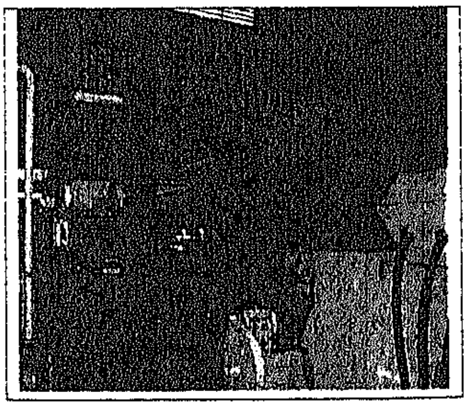


EPC No.# 7AENG.(RUN)

1) Gen. Output ------4200KW
2) Installed -----------1999
3) Date of Mfg.-------1999
4) O/P Time-----------16496/h
5) Eng. Maker--------BLKS
6) Eng. Model---------
7) Situation of Generator --RUN
8) Situations of replenishment parts

Consume parts only

9) Use for 3 Years

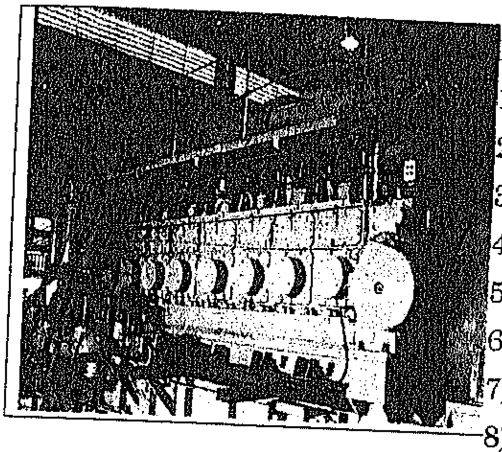


EPC No.# 5AENG.(RUN)

1) Gen. Output ------4200KW
2) Installed -----------2001
3) Date of Mfg.-------2001
4) O/P Time-----------9801/h
5) Eng. Maker--------BLKS
6) Eng. Model---------
7) Situation of Generator --RUN
8) Situations of replenishment parts

Consume parts only

9) Use for **2** Years



EPC No.# 4AENG.(RUN)

1) Gen. Output ------2200KW

2) Installed -----------1996

3) Date of Mfg.--------1968

4) O/P Time-----------020537/h

5) Eng. Maker--------BLKS

6) Eng. Model---------

7) Situation of Generator --RUN

8) Situations of replenishment parts

Consume parts only

9) Cause of accident—Gen.

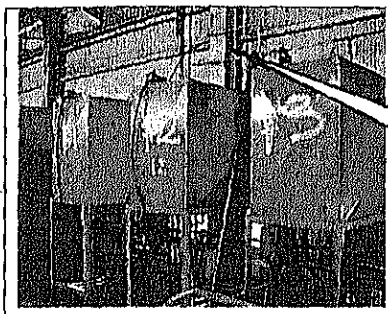
10) Use for **6** Years

SALELOLOGA D/G P/S (Table No.6－1)

Storage of fuel oil and lubrication oil equipment

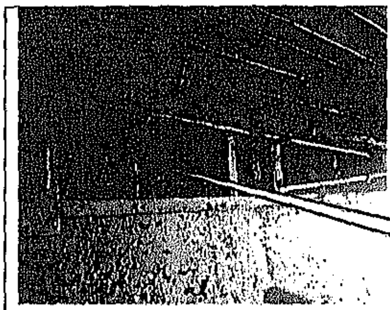
Check by Feb/03

The under mentioned photograph should immediately take the storage facility and the collection treatment from environmental pollution and the safety aspect with the wasted oil confirmed in the Salelologa power plant and the Vaipouli power plant



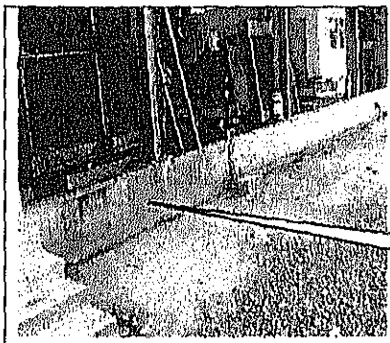
Leaked Fuel oil from Fuel Sub tank of Engine

Fuel over flow Leak



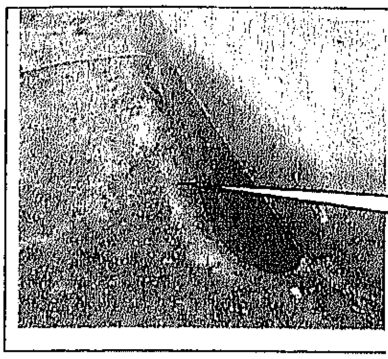
Oil pollution in power plant pit

Wasted oil in pit

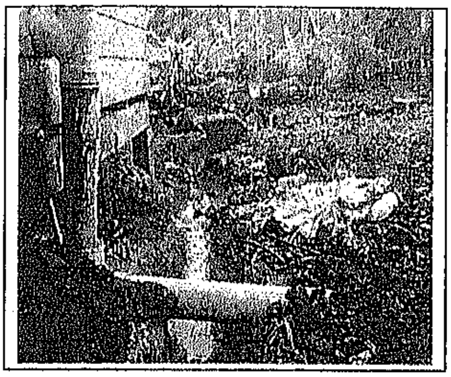


Wasted oil situation around powerplant base

Wasted oil



Wasted oil around power plant base

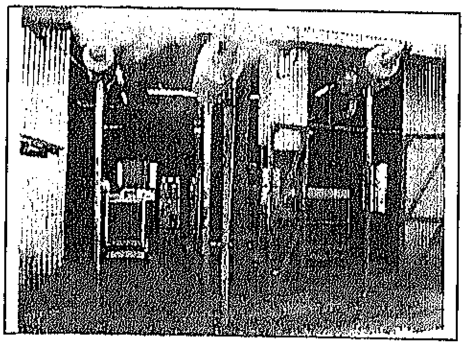


Wasted oil flows from the power plant to the hole.

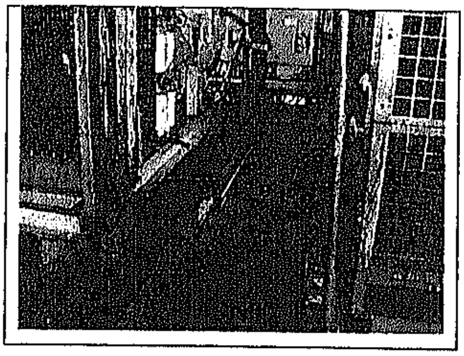
Wasted oil throwing away place in power plant

ELCTRIC POWER S/T (Vaipouli)
Storage of fuel oil and lubrication oil

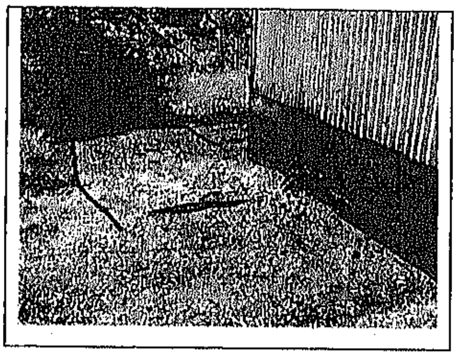
Check by Feb/ 1 7



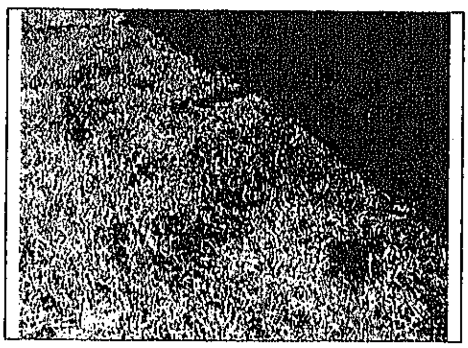
Exhaust gas situation (bad)



Oil leak from surrounding of diesel eng,

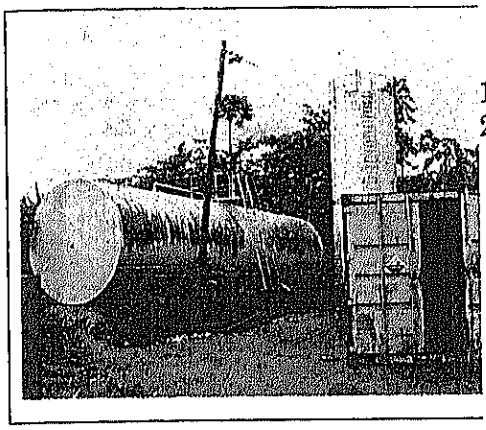


Wasted oil leakage from building of dynamo (pit)
(There is no oil processing system)



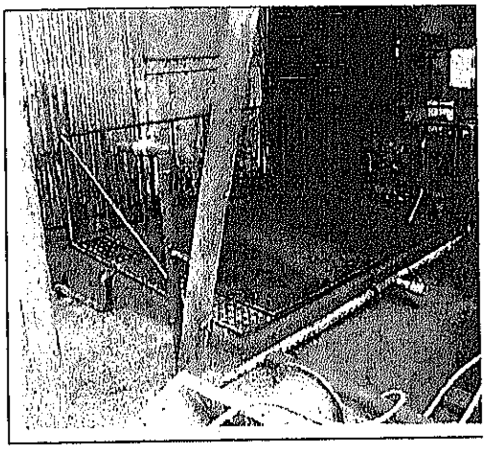
Exchanged oil on ground

ELCTRIC POWER S/T (Tanugamanono)
Storage of fuel oil Tank (Table No. 6 – 2)

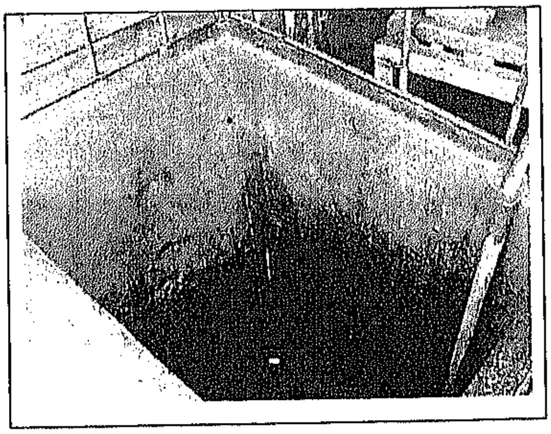


1) 165.000 (L) Fuel tank
2) 180.000 (L) Fuel tank

(Excluding the lubricant tank and no treatment for the oil spill)



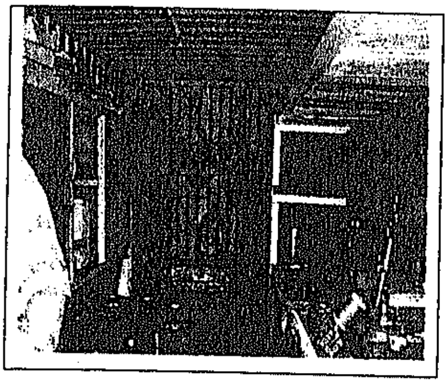
Wasted oil
Storage facility



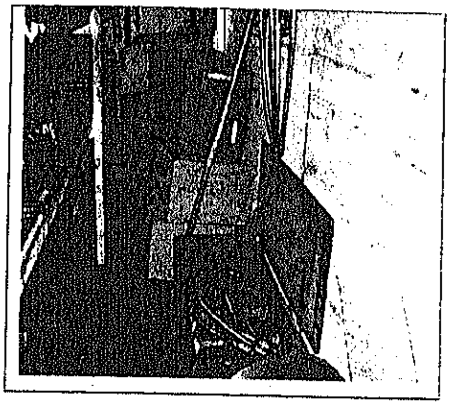
Wasted oil
Storage facility
(in the pit)

EPC. TANUGAMANONO P/L TOOLS

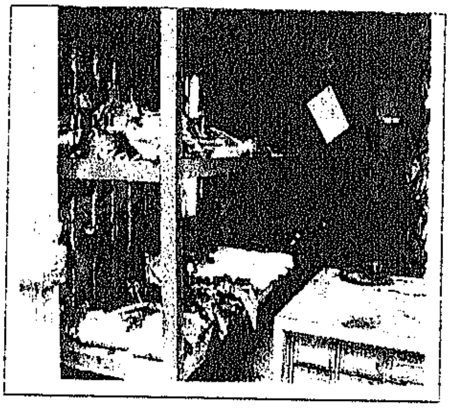
Check by Feb/03
(Table No.6-2-2)



Maintenance tools(for mechanical)



Eng. Special Tools

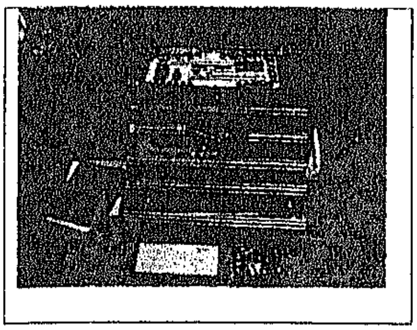


Eng. Special Tools

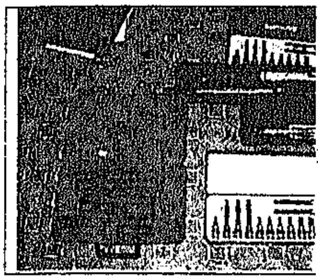
EPC SALELOLOGA P/L TOOLS

Check by Feb/03

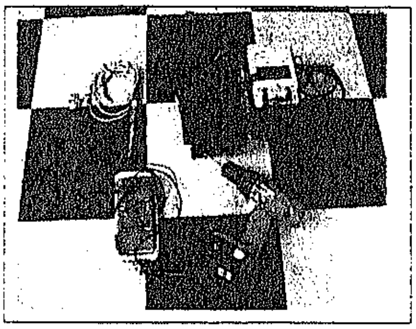
(Table No.6-2-1)



Maintenance tools (for mechanical)
Supply by(JICA)

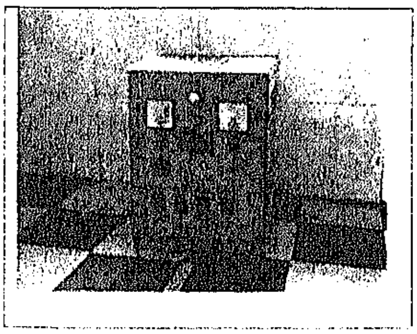


Maintenance tools (for mechanical)Supply by(JICA)



Electric tools (for electric)

1) Electric drill	1 SET
2)Multi meter tester	1 SET
3)Insulation tester	1 SET



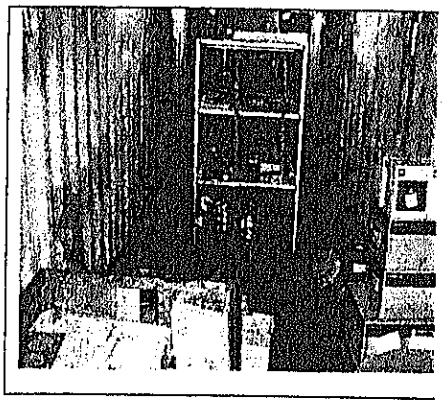
Electric tools (For electric)

1)Battery charger 1SET

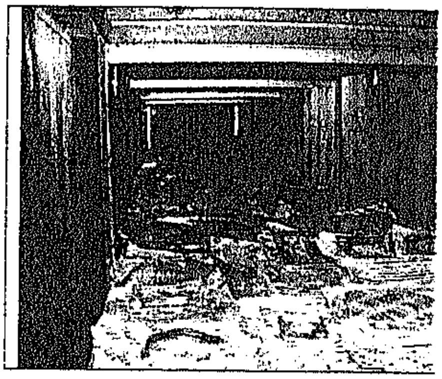
ELCTRIC POWER S/T (TANUGAMANONO) SPARE PARTS

Check by Feb/03

(Table No.6-2-4)



Replenishment parts in container



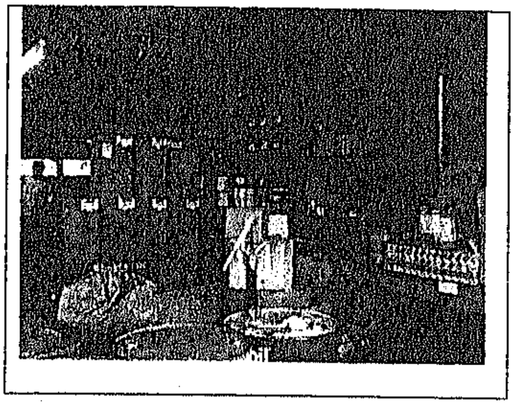
Eng. Gasket and O-ring Parts
(Consume Parts only)

Eng. Gasket and O-ring Parts
(Consume Parts only)

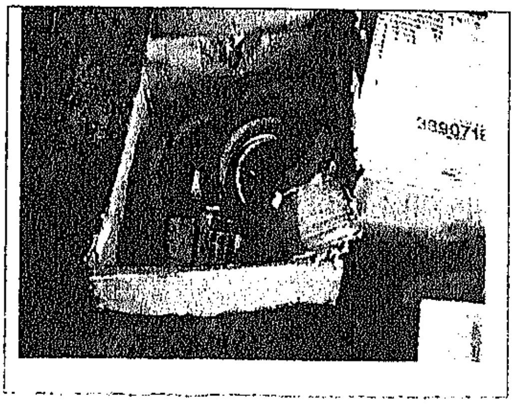
ELCTRIC POWER S/T (SALELOLOGA ./ VAIPOULI) SPARE PARTS

Check by Feb/03

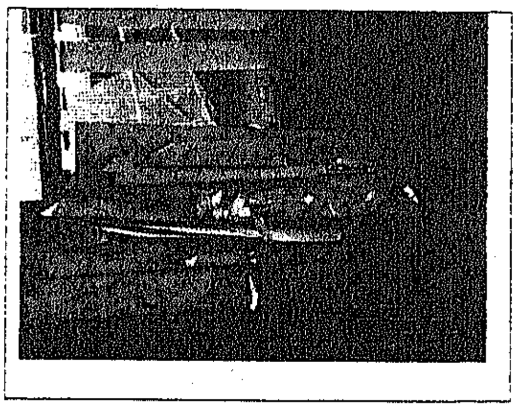
(Table No. 6-2-3)



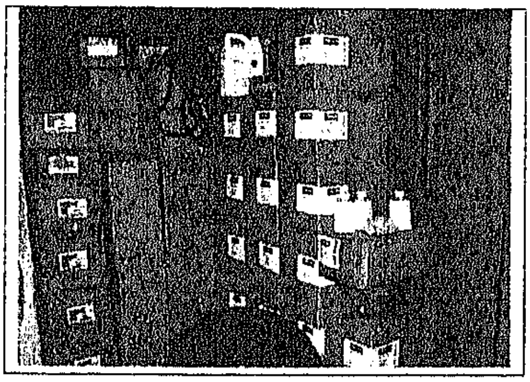
Replenishment parts in warehouse



Turbocharger (1Assy)



Gasket parts



Air, fuel, and lubricant filter
(Consume parts)