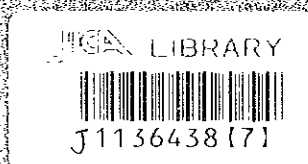


**A STUDY
ON
LONG TERM
NATIONAL ENERGY PLAN
IN
THE REPUBLIC OF MAURITIUS**

FINAL REPORT

JUNE 1997



**UNICO INTERNATIONAL CORPORATION
ELECTRIC POWER DEVELOPMENT CO., LTD.**

TOKYO, JAPAN

MPN
JR
97-131

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

**A STUDY
ON
LONG TERM
NATIONAL ENERGY PLAN
IN
THE REPUBLIC OF MAURITIUS**

FINAL REPORT

JUNE 1997

UNICO INTERNATIONAL CORPORATION
ELECTRIC POWER DEVELOPMENT CO., LTD.

TOKYO, JAPAN



1136438 [7]

Preface

In response to a request from the Government of the Republic of Mauritius, the Government of Japan decided to conduct A Study on Long Term National Energy Plan in The Republic of Mauritius and the study was implemented by the Japan International Cooperation Agency (JICA).

JICA sent a study team, led by Mr. Yoshihide Ichiki of UNICO International Corp. to the Republic of Mauritius four times from March 1996 to March 1997.

The team held discussion with the officials of the Government of the Republic of Mauritius, and conducted related field surveys. After returning to Japan, the team conducted further studies and compiled the final results in this report.

I hope this report will contribute to the promotion of the plan and to the enhancement of friendly relations between our two countries.

I wish to express my sincere appreciation to the officials concerned of the Government of the Republic of Mauritius for their close cooperation throughout the study.

June, 1997



Kimio Fujita

President

Japan International Cooperation Agency



June 1997

Mr. Kimio Fujita
President
Japan International Cooperation Agency
Tokyo, Japan

Dear Mr. Fujita

Letter of Transmittal

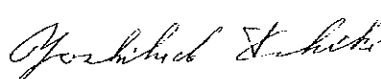
We are pleased to submit to you the report on A Study on Long Term National Energy Plan in The Republic of Mauritius. The report contains the study of the current state and prospect of energy demand, energy supply and its investment program, issues of energy policy, operations pricing and recommendations and action plans for energy development.

The Government of Mauritius is going to establish a scientific basis for national energy planning with proposals for the energy sector investment program up to 2025, and to enhance own technical capabilities in energy planning and policy analysis. The plan recommended in the report provides the basis for finalizing the energy development program, the implementation of which, we believe, will bring about substantial contribution to energy sector development in Mauritius.

Furthermore, the models for energy demand projection developed through the study could be substantially enhanced the technical capabilities of Mauritius counterparts in energy planning.

We wish to take this opportunity to express our sincere gratitude to your Agency, the Ministry of Foreign Affairs, the Ministry of International Trade and Industry and the embassy of Japan in Madagascar. We also wish to express our deep gratitude to Ministry of Local Government and Public Utilities, Central Electricity Board and other public organizations as well as private enterprises in the Republic of Mauritius for the close cooperation and assistance extended to us during our investigations and study.

Very truly yours

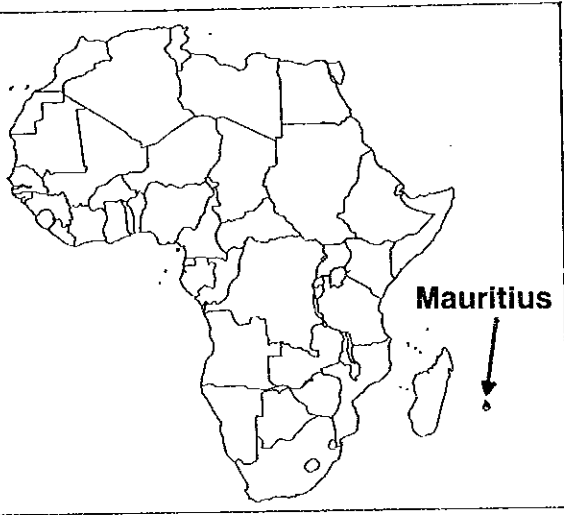


Yoshihide Ichiki
Team Leader, A Study on Long Term National
Energy Plan in The Republic of Mauritius

100

100

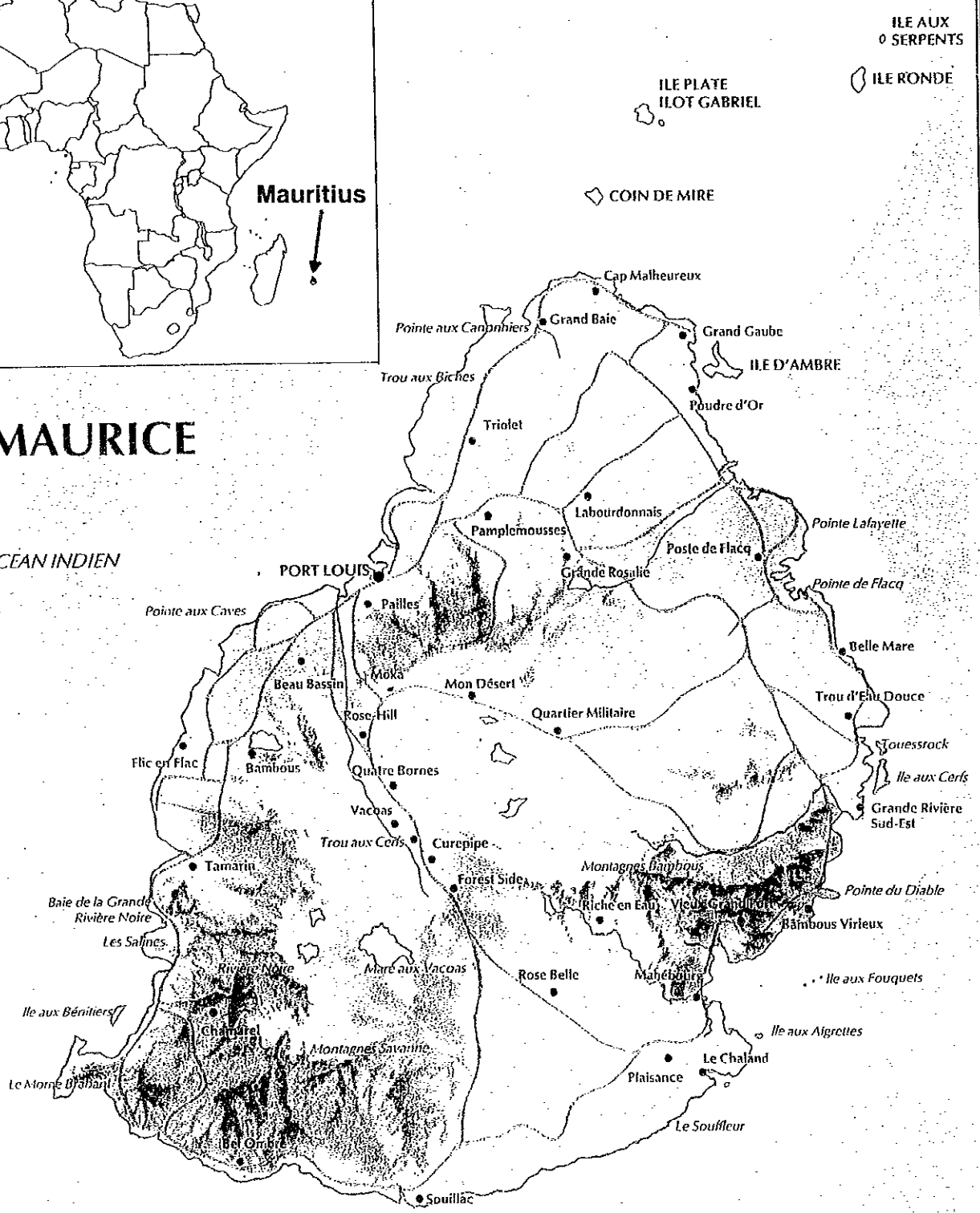
100



Mauritius

MAURICE

Océan Indien



The Republic of Mauritius



CONTENTS

	<u>Page</u>
<u>PART I INTRODUCTION</u>	
Introduction	
1. Background of the Study	- 1 -
2. Objective of the Study	- 2 -
3. Scope of the Study	- 2 -
4. Organization of the Report	- 3 -
 <u>PART II CONCLUSION & RECOMMENDATION</u>	
Chapter 1 Summary & Recommendation	
1.1 Structural Reforms of Energy Sector	1 - 1
1.1.1 Establishment of National Coordination Body for Energy Sectors	1 - 1
1.1.2 Structural Reinforcement of the MLGPU	1 - 2
1.1.3 Major Issues Related to Existing Laws and Regulations in Restructuring Energy Sector	1 - 3
1.1.4 Deregulation	1 - 9
1.1.5 Independent Power Producer Scheme	1 - 12
1.1.6 Financing	1 - 17
1.2 National Energy Security	1 - 20
1.2.1 Energy Supply Security	1 - 20
1.2.2 Recommendation on the Use of Bagasse Energy	1 - 23
1.2.3 Utilization of New Energy Sources	1 - 28
1.2.4 Diversification of Energy Sources	1 - 30
1.2.5 Strategic stockpiling	1 - 31
 Chapter 2 Action Plan Toward the Year of 2000	
2.1 Improvement of CEB*s Financial Condition	2 - 1
2.2 Energy Prices and Taxation System	2 - 4
2.3 Energy Policy and Management	2 - 9

	<u>Page</u>
2.3.1 Reformation of Legislation System and Strengthening of Institutional Set Up.....	2 - 9
2.3.2 Development of Indigenous Energy	2 - 12
2.4 Energy Sector Development and Environment Management	2 - 16
2.4.1 Establishment of Environment Monitoring System	2 - 16
2.4.2 High Priority Environment Related Action Plan	2 - 16

PART III DETAILED DISCUSSIONS

Chapter 3 Economic Development & Future Prospect

3.1 Trends of Macro Economy	3 - 1
3.1.1 Social & Political Development	3 - 1
3.1.2 Macro Economic Development.....	3 - 3
3.2 Future Development and Main Policy Issues	3 - 7
3.2.1 Mauritius Strengths	3 - 7
3.2.2 Constraints.....	3 - 8
3.3 Financial and Monetary Prospect	3 - 15
3.3.1 International Financial Market	3 - 15
3.3.2 Financial Development in Mauritius.....	3 - 19

Chapter 4 Development Process and Current State of the Energy Sector

4.1 Energy Supply and Demand Structure.....	4 - 1
4.2 Existing Electric Power Facilities.....	4 - 6
4.2.1 Electric Power Facilities	4 - 6
4.2.2 Transmission and Substation facilities	4 - 18
4.2.3 Power Facilities in Rodrigues Island.....	4 - 19
4.3 Petroleum Products and Coal Supply and Facilities.....	4 - 24
4.4 Coal and Other Energy Sector	4 - 29
4.5 Prospect of New Energy Introduction by 2025	4 - 33
4.5.1 Potential of Development of New Energy	4 - 33
4.5.2 Present situation of new energy utilization in other countries	4 - 36
4.5.3 Action plan of development of new energy	4 - 42

Chapter 5 Bagasse Energy Utilization

5.1	The Use of Bagasse as an Indigenous Energy Resource	5 - 1
5.2	Present Status of Bagasse Power Project.....	5 - 4
5.3	Technical Aspects of "Bagasse Power Project".....	5 - 6
5.3.1	Conditions for Optimization of Project Scheme	5 - 6
5.3.2	Future Prospect of Bagasse Power Technology	5 - 9
5.4	Large Scale Bagasse Power Project (BEDP) and Independent Power Producer	5 - 13
5.5	Method of Tariff Setting for BEDP Project.....	5 - 18
5.6	The Utilization of Coal for Bagasse Power Project.....	5 - 21
5.7	Bagasse Power and CEB.....	5 - 23
5.7.1	Cost of CEB Spare Capacity in Relation to the Stability of Power Supply During Peak Demand Period	5 - 24
5.7.2	The Allocation of Power Supply During Low Demand Period	5 - 26
5.7.3	The Cost Increase of CEB When a New Large BEDP/IPP Commence Power Supply	5 - 27
5.7.4	Prevention of Subsidy to BEDP/IPP	5 - 29
5.7.5	The Power Generation Plant Mix in AD2000	5 - 30
5.8	New Prospect of Bagasse Power and Sugar Mills Integration	5 - 33
5.9	Future Prospect of the Bagasse Power Project	5 - 37
5.10	Recommendation on the Bagasse Power Project.....	5 - 39
5.10.1	Foreword	5 - 39
5.10.2	The Union St. Aubin Group (South Area Sugar Mills).....	5 - 40
5.10.3	BEAU CHAMP (Firm Supply).....	5 - 41
5.10.4	BELLE VUE	5 - 41

Chapter 6 Energy Policy and Institutional Framework

6.1	Current Energy Policy Framework	6 - 1
6.1.1	Outline of Energy Policy and Institutional Framework	6 - 1
6.1.2	Outline of Electricity Laws	6 - 2
6.1.3	Energy Policy and Government Organization	6 - 4

	<u>Page</u>
6.2 The Present Activity and Task of CEB.....	6 - 8
6.2.1 Financial Statement Analysis of CEB.....	6 - 8
6.2.2 Overall Position.....	6 - 16
6.2.3 Review of CEB Activities.....	6 - 17
6.3 Energy Pricing Policy.....	6 - 19
6.3.1 Pricing System and Control Organization.....	6 - 19
6.3.2 Taxation System Related to Energy Items.....	6 - 21
6.4 Electricity Tariff.....	6 - 27
6.4.1 Price Level.....	6 - 27
6.4.2 Disparities Among Final Consumers.....	6 - 27
6.4.3 Price Component.....	6 - 29
6.5 Environment Management in Mauritius and Its Impact to the Energy Sector.....	6 - 30
6.5.1 Introduction.....	6 - 30
6.5.2 Present Status of Environmental Management in Mauritius.....	6 - 32
6.5.3 Specific Environment Management Plan (Other than EIA for individual new projects).....	6 - 32
6.5.4 Future Development of Environmental Management in Mauritius and Its Impact to The Energy Sector.....	6 - 38
 Chapter 7 Energy Demand and Supply Forecast Model	
7.1 Development of Energy Demand Forecast Model.....	7 - 1
7.1.1 Structure of Model.....	7 - 1
7.1.2 Structure of Databases.....	7 - 5
7.1.3 Renewal and Expandability of Databases.....	7 - 20
7.2 Main Assumptions for Long-term Energy Demand Forecast.....	7 - 26
7.2.1 Case Scenario.....	7 - 26
7.2.2 Back-ground Explanation of Main Exogenous Valuables in Each Case.....	7 - 28
7.3 Outcomes of Economic and Energy Demand Forecast up to the Year 2025.....	7 - 44
7.4 Prospect of New Energy Development (Potential of New Energy to be commercially applicable by AD2025).....	7 - 67

	<u>Page</u>
Chapter 8 Tech-Economic Assessment of Important Issues in Energy Sector	
8.1 Comparison of Electricity Generation System	8 - 1
8.2 Inland Transportation System for Improving Energy Efficiency	8 - 11
8.2.1 General	8 - 11
8.2.2 Transport System for Petroleum Products and Coal	8 - 13
8.2.3 New Mass Transport System Between Port Louis and Curepipe	8 - 16
8.3 Energy Conservation and the Development of Related Technology	8 - 18
8.3.1 Introduction	
(The Understating of Energy Conservation in Current World)	8 - 18
8.3.2 Energy Conservation Activities in Mauritius	8 - 19
8.3.3 Impact of Technology Improvement to the Energy Use	8 - 22
8.3.4 The Bottle-neck of Energy Conservation Activities in Mauritius	
and Its Solution	8 - 36
8.3.5 Suggestion on Practical Plan for Energy Conservation	8 - 37

Chapter 9 Optimum Investment Plan

9.1 Selecting Optimum Investment Plan	9 - 1
9.2 Power Supply Plan	9 - 3
9.3 Basic Evaluation Conditions	9 - 33
9.3.1 Set Conditions	9 - 33
9.4 Calculation and Evaluation of Overall Costs	9 - 42
9.5 Scenario of Optimum Energy Supply	9 - 81
9.5.1 Evaluation of Characteristics of Energy Sources	9 - 82

APPENDIX

Appendix 1 Incentives to BEDP Power Project	A1 - 1
Appendix 2 Sample Output of Energy Demand Forecast Model	A2 - 1
Appendix 3 Sample Form for Energy Audit	A3 - 1
Appendix 4 Supplement Technical Information	A4 - 1
Appendix 5 Case Study in the Philippines Successful Privatization of	
Power Generation Business	A5 - 1

LIST OF TABLES

	<u>Page</u>
Chapter 1	
Table 1.1.1 SUMMARY OF ACTION PLAN FOR FUTURE ENERGY DEVELOPMENT	1 - 34
Chapter 2	
Table 2.1.1 CONST. COST FOR STRATEGIC STORAGE FACILITIES.....	2 - 7
Chapter 3	
Table 3.1.1 GOVERNMENT SERVICES: EMPLOYMENT BY MINISTRY, JANUARY 1996.....	3 - 3
Table 3.1.2 GROWTH RATE OF GDP.....	3 - 4
Table 3.1.3 MONEY SUPPLY AND INTEREST RATE.....	3 - 5
Table 3.1.4 BALANCE OF PAYMENT	3 - 6
Table 3.2.1 WORK PERMITS ISSUED TO FOREIGNERS.....	3 - 12
Table 3.3.1 AGGREGATE NET LONG-TERM RESOURCE FLOWS TO DEVELOPING COUNTRIES, 1990-95.....	3 - 17
Table 3.3.3 MAURITIUS MONETARY AGGREGATE	3 - 21
Table 3.3.4 MAURITIUS INTEREST RATE (%).....	3 - 22
Table 3.3.5 FOREIGN EXCHANGE RATE.....	3 - 23
Chapter 4	
Table 4.1.1 1995 MAURITIUS ENERGY BALANCE	4 - 2
Table 4.1.2 PER CAPITA ENERGY CONSUMPTION IN 1991.....	4 - 4
Table 4.1.3 TPES AND GDP GROWTH RATES FOR 1980-91	4 - 5
Table 4.2.1 SALES OF ELECTRICITY IN THE PAST 10 YEARS (GWh)	4 - 7
Table 4.2.2 ENERGY PRODUCTION IN THE PAST 10 YEARS (GWh).....	4 - 7
Table 4.2.3 MAXIMUM POWER SUPPLY IN THE PAST 10 YEARS (MW).....	4 - 9
Table 4.2.4 INSTALLED CAPACITY IN THE PAST 10 YEARS (MW).....	4 - 12
Table 4.2.5 CAPACITY OF EACH STATION AS OF END 1996 (MW).....	4 - 13
Table 4.2.6 EXISTING TRANSMISSION LINES	4 - 21

	<u>Page</u>
Table 4.2.7 TRANSMISSION LOSS	4 - 21
Table 4.2.8 MAJOR EXISTING SUBSTATION.....	4 - 21
Table 4.4.1 1983/1995 Wood and Related Product (M3·Round Wood)	4 - 30
Table 4.5.1 MEAN SUNSHINE DURATION	4 - 34
Table 4.5.2 WIND DATA COLLECTED BY UNDP	4 - 35
Table 4.5.3 SITUATION OF WIND POWER IN USA.....	4 - 41

Chapter 5

Table 5.4.1(A) MAURITIUS BAGASSE POWER PROFITABILITY ASSESSMENT. 5 - 16	
Table 5.4.1(B) MAURITIUS BAGASSE POWER PROFITABILITY ASSESSMENT. 5 - 17	
Table 5.10.1 CURRENT AVAILABILITY OF BAGASSE BY SUGAR FACTORY, 5 - 43	
Table 5.10.2 CRUSHING PERIOD (1995).....	5 - 44

Chapter 6

Table 6.2.1 CEB BALANCE SHEETS	6 - 9
Table 6.2.2 CEB INCOME STATEMENT	6 - 10
Table 6.2.3 CEB CASH FLOW.....	6 - 11
Table 6.2.4 FINANCIAL STATEMENT ANALYSIS.....	6 - 16
Table 6.3.1 TAX RATE ON PETROLEUM PRODUCTS AND COAL.....	6 - 21
Table 6.3.2 PRICE STRUCTURE OF PETROLEUM PRODUCTS.....	6 - 23
Table 6.5.1 ENERGY CONSUMPTION/CAPT. (1991).....	6 - 31
Table 6.5.2 EMISSION STANDARD (WITHOUT SOPHISTICAL TREATMENT FACILITIES).....	6 - 35
Table 6.5.3 ENVIRONMENTAL STANDARD (AVERAGE).....	6 - 35
Table 6.5.4 ENVIRONMENTAL WATER QUALITY STANDARD	6 - 42
Table 6.5.5 ENVIRONMENTAL WATER QUALITY STANDARD (JAPAN) LIVING ENVIRONMENT STANDARD (DAILY AVERAGE) (JAPAN)	6 - 43
Table 6.5.6 NOIZE STANDARD (MAURITIUS) (JAPAN).....	6 - 44

Chapter 7

Table 7.2.1 GDP Growth Rate by Sector (Base Case)	7 - 28
---	--------

	<u>Page</u>
Table 7.2.2 LOCAL LABOUR FORCES AND ACTIVITY RATE.....	7 - 30
Table 7.2.3 FOREIGN WORKERS.....	7 - 30
Table 7.2.4 SECTORAL LABOUR INPUT.....	7 - 32
Table 7.2.5 SECTORAL CHANGE OF LABOUR INPUT VOLUME.....	7 - 33
Table 7.2.6 SECTORAL COMPONENT RATIO OF EMPLOYMENT.....	7 - 34
Table 7.2.7 LABOUR MARKET	7 - 35
Table 7.2.8 G5 INFLATION	7 - 35
Table 7.2.9 ECONOMIC FORECAST OF SOUTH AFRICA.....	7 - 36
Table 7.2.10 INFLATION ASSUMPTION IN SOUTH AFRICA.....	7 - 36
Table 7.2.11 ENERGY PRICE FORECAST BY THE WORLD BANK.....	7 - 37
Table 7.2.12 FORECASTS OF THE WORLD ECONOMY BY IEA	7 - 37
Table 7.2.13 WORLD ENERGY DEMAND FORECASTS BY IEA.....	7 - 38
Table 7.2.14 WORLD ELECTRICITY FORECAST BY IEA.....	7 - 39
Table 7.2.15 ENERGY PRICE FORECASTS BY IEA	7 - 39
Table 7.2.16 OIL CONSUMPTION	7 - 40
Table 7.2.17 OPEC CRUDE OIL PRODUCTION AND QUOTAS.....	7 - 40
Table 7.2.18 NON-OPEC OIL SUPPLY	7 - 41
Table 7.2.19 ENERGY PRICE ASSUMPTION.....	7 - 41
Table 7.2.20 ASSUMPTION OF ENERGY INTENSITY.....	7 - 42
Table 7.2.21 EFFECTIVENESS OF ELECTRICITY.....	7 - 43
Table 7.3.1 GDP GROWTH RATE BY SECTOR.....	7 - 48
Table 7.3.2 INVESTMENT RATIO BY PUBLIC AND PRIVATE SECTOR	7 - 49
Table 7.3.3 GOVERNMENT FINANCE	7 - 50
Table 7.3.4 TRADE BALANCE	7 - 51
Table 7.3.5 LABOUR PRODUCTIVITY BY INDUSTRIAL SECTOR.....	7 - 52
Table 7.3.6 CPI AND GDP DEFLATOR.....	7 - 53
Table 7.3.7 TOTAL ENERGY DEMAND BY SECTOR.....	7 - 54
Table 7.3.8 INLAND ENERGY DEMAND BY SOURCES.....	7 - 55
Table 7.3.9 ENERGY INTENSITY AND PER CAPITA CONSUMPTION	7 - 56
Table 7.3.10 INCOME ELASTICITY BY SECTOR.....	7 - 57
Table 7.3.11 PEAK ELECTRICITY DEMAND.....	7 - 59
Table 7.3.12 ENERGY BALANCE TABLE IN TOE.....	7 - 60

Chapter 8

Table 8.1.1	COMPARISON OF GENERATION COST OF GT	8 - 3
Table 8.1.2	COMPARISON OF GENERATION COST OF CCGT.....	8 - 4
Table 8.1.3	COMPARISON OF GENERATION COST OF DIESEL.....	8 - 5
Table 8.1.4	COMPARISON OF GENERATION COST OF COAL.....	8 - 6
Table 8.1.5	CEB'S PERCHASING PRICES AS OF 21, DEC., 1996.....	8 - 7
Table 8.3.1	TRANSITION OF ENERGY INTENSITY.....	8 - 27
Table 8.3.2	ENERGY CONSUMPTION PER 1000m2 TEXTILES.....	8 - 28
Table 8.3.3	TECHNOLOGY LEVEL ASSESSMENT	8 - 29
Table 8.3.4	1995 DATA	8 - 33

Chapter 9

Table 9.2.1	ELECTRICITY PEAK DEMAND FORECAST.....	9 - 8
Table 9.2.2	CONDITION OF POWER GENERATION FACILITIES	9 - 9
Table 9.2.3	RETIREMENT PROGRAM.....	9 - 10
Table 9.2.4	POWER DEVELOPMENT PLAN (BASE CASE-1).....	9 - 11
Table 9.2.5	POWER DEVELOPMENT PLAN (BASE CASE-2)	9 - 12
Table 9.2.6	POWER DEVELOPMENT PLAN (BASE CASE-3)	9 - 13
Table 9.2.7	POWER DEVELOPMENT PLAN (HIGH CASE-1).....	9 - 14
Table 9.2.8	POWER DEVELOPMENT PLAN (HIGH CASE-2).....	9 - 15
Table 9.2.9	POWER DEVELOPMENTPLAN (HIGH CASE-3).....	9 - 16
Table 9.2.10	POWER DEMAND AND SUPPLY IN 1996 (BASE CASE REFERENCE).....	9 - 17
Table 9.2.11	POWER DEMAND AND SUPPLY IN 1997 (BASE CASE).....	9 - 18
Table 9.2.12	POWER DEMAND AND SUPPLY IN 1998 (BASE CASE).....	9 - 19
Table 9.2.13	POWER DEMAND AND SUPPLY IN 1999 (BASE CASE)	9 - 20
Table 9.2.14	POWER DEMAND AND SUPPLY IN 2000 (BASE CASE).....	9 - 21
Table 9.2.15	SHORT TERM TRANSMISSION PLANNING.....	9 - 22
Table 9.2.16	DISTRIBUTED FORECAST OF EVENING PEAK LOADS, 1995-1999	9 - 23
Table 9.2.17	EXPANSION PLAN OF TRANSMISSIONS AND SUBSTATIONS....	9 - 24
Table 9.2.18	BULK SUPPLY POINT TRANSFORMERS (MVA)	9 - 25

	<u>Page</u>
Table 9.2.19	DISTRIBUTED FORECAST OF EVENING PEAK LOADS..... 9 - 26
Table 9.2.20	DISTRIBUTED FORECAST OF EVENING PEAK LOADS, 2000-2015 9 - 27
Table 9.3.1	ASSUMPTION FOR POWER DEMAND FORECAST 9 - 33
Table 9.3.2	ALTERNATIVE CASE..... 9 - 33
Table 9.3.3	CONSTRUCTION COST (INCLUDING I.D.C. AND PREOPERATIONAL EXPENSES)..... 9 - 38
Table 9.3.4	FUEL TABLE..... 9 - 39
Table 9.3.5	OTHER VARIABLE COSTS..... 9 - 40
Table 9.3.6	FIXED COST..... 9 - 40
Table 9.3.7	ADJUSTED FUEL COST 9 - 41
Table 9.3.8	ADJUSTED VARIABLE COST 9 - 41
Table 9.3.9	ADJUSTED FIXED COST 9 - 41
Table 9.4.1	BASE CASE I-1 (FINANCIAL) 9 - 44
Table 9.4.2	BASE CASE I-1 (ECONOMIC) 9 - 47
Table 9.4.3	BASE CASE II-1 (FINANCIAL)..... 9 - 50
Table 9.4.4	BASE CASE II-1 (ECONOMIC)..... 9 - 53
Table 9.4.5	BASE CASE III-1 (FINANCIAL)..... 9 - 56
Table 9.4.6	BASE CASE III-1 (ECONOMIC)..... 9 - 59
Table 9.4.7	HIGH CASE I-2 (FINANCIAL) 9 - 62
Table 9.4.8	HIGH CASE I-2 (ECONOMIC)..... 9 - 64
Table 9.4.9	HIGH CASE II-2 (FINANCIAL)..... 9 - 66
Table 9.4.10	HIGH CASE II-2 (ECONOMIC) 9 - 68
Table 9.4.11	HIGH CASE III-2 (FINANCIAL)..... 9 - 70
Table 9.4.12	HIGH CASE III-2 (ECONOMIC)..... 9 - 72
Table 9.4.13	ANALYTICAL STUDY ON THE PRESENT VALUE OF TOTAL COST OF THE CASES 9 - 74
Table 9.4.14	RESULT OF SENSITIVITY ANALYSIS 9 - 75
Table 9.5.1	ESTIMATED TOTAL PRIMARY ENERGY SUPPLY..... 9 - 85

LIST OF FIGURES

	<u>Page</u>
Chapter 3	
Figure 3.3.1 TREND OF LIBOR	3 - 16
Figure 3.3.2 DEVELOPING COUNTRIES* SHARE IN GLOBAL FDI	3 - 18
 Chapter 4	
Figure 4.1.1 GROWTH OF PRIMARY ENERGY CONSUMPTION.....	4 - 3
Figure 4.2.1 ELECTRICITY CONSUMPTION.....	4 - 8
Figure 4.2.2 MONTHLY PEAK LOAD CURVE.....	4 - 10
Figure 4.2.3 DAILY LOAD CURVE.....	4 - 11
Figure 4.2.4 ELECTRICITY CONSUMPTION (RODRIGUES).....	4 - 22
Figure 4.2.5 EXISTING MAIN TRANSMISSION LINE AND SUBSTATION	4 - 23
Figure 4.5.1 TREND OF GENERATION COST OF WIND POWER.....	4 - 44
Figure 4.5.2 TREND OF GENERATION COST OF PHOTOVOLTAIC CELL.....	4 - 44
Figure 4.5.3 REVERSE FLOW SYSTEM.....	4 - 45
Figure 4.5.4 PHOTOVOLTAIC POWER GENERATION SYSTEM (a).....	4 - 46
Figure 4.5.5 PHOTOVOLTAIC POWER GENERATION SYTEM (b).....	4 - 47
Figure 4.5.6 FLOW CHART OF PLANNING OF WASTE POWER GENERATION PLANT	4 - 48
 Chapter 5	
Figure 5.4.1 (A) PROFITABILITY OF BAGASSE POWER	5 - 16
Figure 5.4.2 (A) ROI : KWH COST.....	5 - 16
Figure 5.4.1 (B) PROFITABILITY OF BAGASSE POWER.....	5 - 17
Figure 5.4.2 (B) ROI : KWH COST.....	5 - 17
Figure 5.7.1 ANNUAL LOAD DURATION CURVE	5 - 32
Figure 5.10.1 BAGASSE PRODUCTION.....	5 - 45
Figure 5.10.2 SURPLUS BAGASSE (Exclude Existing Power Use)	5 - 46
 Chapter 6	
Figure 6.1.1 MINISTRY OF LOCAL GOVERNMENT AND PUBLIC UTILITIES. 6 - 7	6 - 7

	<u>Page</u>
Figure 6.2.1 FINANCIAL STATEMENT ANALYSIS.....	6 - 17
Figure 6.3.1 TRENDS IN PETROLEUM PRICES (RETAIL PRICES).....	6 - 24
Figure 6.3.2 COMPARISON OF PREMIUM GASOLINE PRICES	6 - 25
Figure 6.3.3 PRICE COMPARISON OF FUEL OIL (1989).....	6 - 26
Figure 6.3.4 GASOLINE PRICES AND TAXES (US DOLLARS/LITER) THIRD UARTER 1995	6 - 26
Figure 6.4.1 COMPARISON OF COST AND PRICE (per kWh).....	6 - 27
Figure 6.4.2 ELECTRICITY PRICE	6 - 28
Figure 6.4.3 COST AND PRICING STRUCTURE.....	6 - 29
 Chapter 7	
Figure 7.1.1 STRUCTURE OF DATABASE FILE (1).....	7 - 22
Figure 7.1.2 STRUCTURE OF DATABASE FILE (2).....	7 - 23
Figure 7.1.3 LAYER STRUCTURE OF FILE AND SIZE	7 - 24
Figure 7.1.4 INTERFACE AND STRUCTURE OF ENERGY DATABASE SYSTEM.....	7 - 25
Figure 7.3.1 ENERGY DEMAND BY TYPE OF ENERGY	7 - 64
 Chapter 8	
Figure 8.1.1 COMPARISON OF CONSTRUCTION COST	8 - 8
Figure 8.1.2 COMPARISON OF GENERATION COST (FINANCIAL).....	8 - 9
Figure 8.1.3 COMPARISON OF GENERATION COST (ECONOMIC)	8 - 10
Figure 8.3.1 PROGRESS OF ENERGY SAVING IN HOUSEHOLD ELECTRICAL APPLIANCES	8 - 34
Figure 8.3.2 ENERGY INTENSITY (1880=100).....	8 - 35
 Chapter 9	
Figure 9.2.1 FORECASTED TYPICAL OPERATION PATTERN OF MAIN EQUIPMENTS ON MAXIMUM LOAD DAY IN 2025	9 - 28
Figure 9.2.2 EXISTING TRANSMISSION LINE & PROPOSED NEW TRANSMISSION LINE (2000)	9 - 29

	<u>Page</u>
Figure 9.2.3 EXISTING TRANSMISSION LINE & PROPOSED NEW TRANSMISSION LINE (2005).....	9 - 30
Figure 9.2.4 EXISTING TRANSMISSION LINE & PROPOSED NEW TRANSMISSION LINE (2010).....	9 - 31
Figure 9.2.5 EXISTING TRANSMISSION LINE & PROPOSED NEW TRANSMISSION LINE (2015).....	9 - 32
Figure 9.4.1 COMPARISON OF CALUCULATED PRESENT VALUE - BASE CASE FINANCIAL	9 - 77
Figure 9.4.2 COMPARISON OF CALUCULATED PRESENT VALUE - BASE CASE ECONOMIC.....	9 - 78
Figure 9.4.3 COMPARISON OF CALUCULATED PRESENT VALUE - HIGH CASE FINANCIAL.....	9 - 79
Figure 9.4.4 COMPARISON OF CALUCULATED PRESENT VALUE - HIGH CASE ECONOMIC.....	9 - 80
Figure 9.5.1 CONCEPTUAL WORK FLOW FOR MAKING AN OPTIMUM ENERGY SUPPLY SCENARIO.....	9 - 86



ABBREVIATIONS AND ACRONYMS

ACP	African, Caribbean and Pacific Group of Countries to the Lome Convention
AMB	Agricultural Marketing Board
BEDP	Bagasse Energy Development Programme
BOM	Bank of Mauritius
BOO	Build Operate Own
BOT	Build Operate Transfer
BTU	British Thermal Unit
CEB	Central Electricity Board
CIF	Cost, Insurance, Freight
COMESA	Common Market for Eastern and Southern Africa
CSO	Central Statistical Office
CST	Centistoke (viscosity unit)
CWA	Central Water Authority
DBM	Development Bank of Mauritius
DSM	Demand Side Management
EEC	European Economic Community
EPZ	Export Processing Zone
EPZDA	Export Processing Zone Development Authority
ESMAP	Energy Sector Management and Assistance Program
FARC	Food and Agricultural Research Council
FOB	Free on Board
FSC	Farmers Service Corporation
FSC's	Farmer's Service Centre
FY	Financial Year
GATT	General Agreement on Tariffs and Trade
GDFCF	Gross Domestic Fixed Capital Formation
GDP	Gross Domestic Product
GDP _{fc}	Gross Domestic Product at factor cost
GDP _{mp}	Gross Domestic Product at market prices
GNP	Gross National Product
GOM	Government of Mauritius
GRR	Gross Reproduction Rate
GWh	Gigawatt hour
ha	hectare
HFO	Heavy Fuel Oil
HSFO	High-Sulfur-Fuel Oil
HV	High Voltage
IOC	Indian Ocean Commission
IPP	Independent Power Producer
IVTB	Industrial and Vocational Training Board
kcal	kilocalories
kgoe	kilogram of oil equivalent

km	kilometer
kV	kilovolt (1,000 volts)
kW	kilowatt (1,000 watts)
kWh	kilowatt hour
l	liter
LFPR	Labour Force Participation Rate
LIBOR	London Interbank Offered Rate
LRM	The Long-Run Model
LNG	Liquefied Natural Gas
LPG	Liquefied Petroleum Gas
LSFO	Low-Sulfur-Fuel Oil
LV	Low Voltage
m	meter
M3	cubic meter
MANR	Ministry of Agriculture and Natural Resources
MCCI	Mauritius Chamber of Commerce and Industry
MEDIA	Mauritius Export Processing Zone Association
MEF	Mauritius Employer's Federation
MEPITT	Ministry of Economic Planning, International Trade & Telecommunications
MEPZA	Mauritius Export Processing Zone Association
MEST	Ministry of Education, Science & Technology
MFA	Mauritius Freeport Authority
mg	Milli Gram (1/000 gram)
MHC	Mauritius Housing Company Ltd.
MIC	Ministry of Industry & Commerce
MIE	Mauritius Institute of Education
MJ	Megajoule
MLC	Mauritius Leasing Company Ltd.
MLGPU	Ministry of Local Government & Public Utilities
MMA	Mauritius Marine Authority
MOBAA	Mauritius Offshore Business Activities Authority
MOF	Ministry of Finance
MOGAS	Motor Gasoline
MRC	Mauritius Research Council
MSA	Mauritius Sugar Authority
MSB	Mauritius Standard Bureau
MSIRI	Mauritius Sugar Industry Research Institute
MT	Metric Ton
MTPA	Mauritius Tourist Promotion Authority
MW	Megawatt
MWh	Megawatt hour (1,000 kWh)
NGO's	Non-Government Organizations
NIC's	Newly Industrialising Countries
NLTPS	National Long-Term Perspective Study

NOX	Nitrogen Oxide
NPDP	National Physical Development Plan
OECD	Organization for Economic Co-operation and Development
pa	per annum
PDP	Power Development Plan
PMSM	Revised Minimum Standard Model
PPA	Power Purchase Agreement
ppm	Part per million
PSIP	Public Sector Investment Programme
PTA	Preferential Trade Area
RON	Research Octane Number
SADC	Southern African Development Community
SADCC	Southern African Development Coordination Conference
SAM	Social Accounting Matrix
SEM	Stock Exchange of Mauritius
SIC	State Investment Corporation
SIPO	Small-Scale Industrial Development Organization
SOX	Sulphur Oxide
SRMI	The Short-Run Model
STC	State Trading Corporation
TOE	Ton of Oil Equivalent
TPES	Total Primary Energy Supply
tpy	metric tonne per year
UAPTA	Unit of Account for the PTA
μ g	micro gram (1/1000 mg)

Currency Exchange Rates

US\$1 =	Rs 20.50 (1996)
	Rs 17.91 (1995)
	Rs 17.96 (1994)
	Rs 17.65 (1993)
	Rs 15.56 (1992)
	Rs 15.65 (1991)
	Rs 14.86 (1990)



PART I INTRODUCTION

◆ *Introduction* ◆

Introduction

This is the Final Report for the Study on Long Term National Energy Plan in the Republic of Mauritius.

The Study was commenced in March 1996, on the basis of the Scope of the Study and the Minutes of Meeting signed between the Ministry of Energy, Water Resources, Postal Services, Scientific Research and Technology (MEWPSRT, the present MLGPU) and Japan International Cooperation Agency (JICA) on December 7, 1995. The Final Report is presented as the main result of four local surveys and home-office analysis work.

1. Background of the Study

The Economy of Mauritius has undergone rapid growth during the past decade as a result of the government's industrial policy, that seeks to change the economic structure from a mono-culture dependent upon sugar cane production to be a more diverse one. This rapid economic development, however, has created a new theme for Mauritius, which does not have much indigenous energy resources, i.e., how should the energy sector be developed to ensure economic development in the future.

At present, the Ministry of Local Government and Public Utilities (MLGPU), being responsible for comprehensive energy policy making, is now working on a new long-term energy development plan that sets forth the security of future stable energy supply as a major policy objective. For this purpose, MLGPU intends to introduce long-term demand forecast techniques that reflect market principles and other relevant factors, for the purpose of evaluating the long term energy planning made in the past and to establish a new plan.

On October 10, 1994, the Government of Mauritius requested the Government of Japan to conduct a study on long-term national energy planning as part of the above efforts. In response, JICA sent to Mauritius a study team discussed with representatives of the MEWPSRT (the present MLGPU) and other government agencies. On December 7, 1995, JICA and the MEWPSRT signed the Scope of Work and the Minutes of Meeting on the proposed study.

2. Objective of the Study

The objectives of the Study are to establish a scientific basis for national energy planning with proposals for the energy sector investment program over the period 1996-2025, and to enhance the technical capabilities of Mauritius counterparts in energy planning and policy analysis.

3. Scope of the Study

The Study was conducted in three phases in accordance with the Scope of Work. It was agreed thus the following four issues, and their related tasks would be emphasized in the Study.

(1) Energy Demand Analysis

- To carry out an analysis of 1984-1994 trends in energy demand, and supply, and investments in the electricity, solid and liquid fuels sub-sectors.
- To establish an energy data base including annual energy balance tables.
- To develop an energy demand forecast model.
- To make projections of energy demand for the periods 1996-2000, 2001-2010 and inductively for the period 2011-2025 based on econometric tools and realistic and consistent scenarios of macroeconomics and sectoral growth, population trends and energy conservation.

(2) Energy Supply Studies and Investment Requirements

- To identify the least-cost investment programme that meets the energy requirements under each economic growth and policy scenario.
- To make an assessment of the costs, benefits, finance and risks of the proposed energy investment program and fuel supply system.
- To establish a priority ranking of investment and policy measures consistent with (a) least-cost expansion of energy supplies and (b) optimal reliability of supplies.

(3) Energy Policy, Operations and Pricing

- To review the policy measures and institutional framework.

- To review the current energy sector legislation and to make appropriate recommendations to keep pace with development in the sector.
- To study the potential and measures for energy conservation.
- To assess the impact of environmental management on the energy plan.

(4) Technology Transfer

- To train the Mauritian counterparts in energy planning and policy analysis and in the application of the analytical tools developed in the Study.
- To assist the Mauritian counterparts in developing monitoring techniques for the implementation of policy measures and projects.

4. Organization of the Report

This report consists of three volumes, Summary, Main Report and Appendix.

The main reports divided into Introduction, Conclusion and Recommendations, and Detailed Discussion. The Introduction describes the objective, background, and scope of the study. Conclusion and Recommendations, as a result of the total survey effort, discusses recommendations for the major task in energy sector, and proposes the action plans which shall be taken immediately toward the year of 2000. Detailed Discussions presents the details of evaluation and analysis as the basis of conclusion and detailed data according to each subject of the Study.



PART II CONCLUSION & RECOMMENDATION

◆ **Chapter 1 Summary & Recommendation** ◆

Chapter 1 Summary & Recommendation

1.1 Structural Reforms of Energy Sector

1.1.1 Establishment of National Coordination Body for Energy Sectors

Energy Policy Making and its Implementation

As a national economy develops, energy related issues become increasingly complex and more closely interrelated to the many elements of social and natural environments of the country, as well reflected in the current international consensus on the importance of “sustainable development”.

The need for harmonization of appropriate environment preservation with desirable economic development is considered as the foundation of the concept. Energy issues are always closely related to economic development of any country, where an increase in energy consumption in the transportation sector, industries and other sectors are inseparably associated with economic growth and development. At the same time, the increase in energy consumption resulting from economic development has the high potential to cause deterioration of the natural and social environments.

In order to achieve the desired economic development without a negative impact on the national environment, the establishment of a national level coordination body for making and implementation of policy related to energy, economic development and environmental management is an essential step to optimize the future development of Mauritius.

Energy experts are well aware that there is no way to separate energy issues from a broad range of economic policy issues, and energy related issues always involves to both domestic and foreign concerns. In addition energy policy needs to be harmonized with other national politics, some of which may have serious conflict with it. A typical example of this is seen when in the electricity tariff is raised, which always create financial conflict between the electricity sector and the industries and households.

It is observed by the study team that the MLGPU has the responsibility for formulating and implementing national energy policy, but at present there is the lack of linkage with other executing bodies which have primarily control over important elements of energy policy such as energy pricing, fuel management of the transportation sector, etc., preventing effective national coordination.

One weakness in the current energy policy making and its implementation in the country is the absence of a single executive body that can lead energy sector management.

As the first step of national energy policy coordination ,the strengthening of the energy group of MLGPU is recommended to ensure that it can take leadership in relation to the following activities;

- 1) Assessment of the current institutional framework of the government in relation to energy policy making and implementation with a view to preparing a comprehensive plan for establishing a high level executive agency, similar to the Department of Energy of the United States;
- 2) Continuous updating of the long term national energy sector development plan, which includes the existing energy sector and new energy development ; and
- 3) Build-up of expertise required to improve the ability to formulate and implement a comprehensive long term national energy plan.

1.1.2 Structural Reinforcement of the MLGPU

It is recommended in paragraph 1.1.1 that a core organization be established for policy making and administration at the national level for long term energy planning and administration, by integrating of the activities of all related ministries and government agencies.

In addition, the strengthening of the MLGPU is strongly desirable in relation to energy information gathering and data processing for continuous updating of the long term energy demand and supply forecast and promotion of nationwide energy conservation activities.

Presently, energy related information such as on fuel imports, fuel consumption by each sector, electricity generation and consumption, are collected by CSO/MLGPU, but the current way of data collection from diverse sources is not adequate for accurate assessment of the energy use efficiency, to evaluate interchanability of energy types, to estimate the current and future of energy use and to use as the basis of energy policy formulation. In order to facilitate the collection of reliable data relating to the activities of multiple ministries/corporations for planning of the national energy policy, procedures for data collection compilation from different sources must be reviewed by the core organization of MLGPU. In addition, the MLGPU once collected basic data for long term planning of energy conservation by means of energy audit of a few sectors, which has not been continued in subsequent years. Clearly consistent energy auditing of every sector is very important to improve the accuracy of the long term forecast model prepared by MLGPU and the JICA team this time.

Consistent data collection and long term supply and demand forecast by MLGPU, as the basis of national energy policy making and its administration, will be very helpful not only for the national plan but also the planning and administration of energy related activities under individual ministries/corporations. It is expected that effective cooperation between the energy data/information center of MLGPU and the senior staff of every ministry and corporation will reduce work load of the senior staff in data collection and assessment of the effect of policies.

Personnel with the ability to organize the energy data gathering system and to assess data collection for policy making should be assigned as the core team of the MLGPU energy development department to realize the above functions.

1.1.3 Major Issues Related to Existing Laws and Regulations in Restructuring Energy Sector

(1) Major issues in present laws and regulations

As seen in many countries including Japan, the electricity business in Mauritius originated in private initiatives to supply electricity to large cities and industrial areas on a pure commercial basis. In the process, the government was required to devise appropriate

measures to maintain public safety, such as the prevention of public hazards peculiar to the electricity business and the control of negative impacts of electrical installations on communication facilities. Various laws and regulations were effectuated with the primary purpose of ensuring safety control related to the electricity business by the government. This intention is clearly seen in the Electricity Business Act (AD1939). In the next stage, as the use of electricity was proliferated into the entire country, it was widely recognized that electricity was essential in improving national standards of living as well as industrial development. The electricity business, previously considered on a pure commercial basis, was required to serve public interest. For the commercial business, it is not viable to supply high quality electricity to an area with low population density and lagged industrial development, and at a low cost. During this stage of development, competition exerts full force and multiple electricity suppliers strive to serve an area with large demand where the price is kept at a reasonably low level by the competition. At the same time, duplication of investment occurs in transmission and distribution facilities for urban area. Naturally oversupply and excessive competition had took place.

The situation calls for the emphasis on public aspects of electricity (electricity supply to remote areas) and public control on the business to prevent undue competition. As the public increasingly demand stable electricity supply at low cost, the government grants a selected enterprise exclusive rights to supply electricity to a certain area while obliging it to extend the same service to an area for which supply is not commercially feasible. Then, as electricity charge is considered to be a financial burden on low-income households and the electricity cost is viewed as a key factor in determining the industry's international competitiveness in the country, electricity sales price falls below electricity reproduction cost to deprive the business of commercial viability, and the government takes over to manage it as a state-owned monopoly.

This was the time when Mauritius enacted the CEB Act, which laid the groundwork for the monopolistic electricity business which also prevails in many countries and is managed by a public organization or a special entity which is authorized by law to have monopolistic control of the business.

In recent years, privatization of public utilities including electricity is promoted in the U.K.,

the U.S., and EU countries. The move has been driven by public consensus that electricity price can be lowered by introducing competition into the industry that leads to cost reduction, together with the world political trend toward the small government. It should be noted here that the reduction in electricity supply cost is sometimes realized by transfer of infrastructure, which is not bring profit directly, constructed by low cost public money to the privatized entity at a very low cost. This implies that, when a new energy source, which is not profitable in short term, is to be developed at a cost of the private sector, special policy consideration is required to ensure recovery of the cost. In this connection, it is important to recognize the differences between middle-income countries and industrialized countries (especially the U.S. and U.K.) in the situation surrounding privatization of electricity business. This means, most of middle-income countries have investment requirements for public infrastructure including electricity to meet fast growing demand, which exceed each country's ability to meet financial requirements.

Under the current world economic conditions, the World Bank recommends the countries to privatize electricity and other public utilities in an attempt to encourage free flow of investment funds worldwide, so that they can build infrastructure required for adequate economic development while keeping (direct) financial obligation of each government at a controllable level.

In this context, it is important to realize that modernization of electricity business related laws, which MLGPU is mandated by the Mauritius government, intends to pave the way for infrastructure development in that direction. More precisely, the current Electricity Business Act and the CEB Act need to be entirely amended so as not to prevent private enterprises (both domestic and foreign) from entering the electricity business in the country by using their own funds, or a new law must be enacted to promote privatization of electricity business. One of impediments to privatization is found in the current laws that authorize CEB to monopolize the electricity business, which can effectively be used as a legal ground for blocking the entry of private enterprises as competitors (see Articles 4, 5, 6, 10 of the Electricity Business Act, and Article 3 of the CEB Act).

(2) Recommended amendments of the Electricity Business Act and the CEB Act in Mauritius

Introduction

Legal reforms for the electricity sector required for the country should start from the recognition that existing laws and regulations related to the electricity business primarily aims at ensuring stable, safe and low-cost provision of public utilities to every person and industrial sector, while leaving profitability of the business as the secondary goal, thereby justifying monopolistic control of the business with explicit or implicit assumption of financial dependence on government subsidy. The reforms therefore should aim to depart from the generation-old legal structure and establish a new electricity business law that can serve as the foundation of the national energy policy addressing the current needs.

New electricity business act

To achieve the above objective, the new electricity business law should incorporate the following elements:

- 1) Declaration of Policies
 - (a) to ensure reliability, security, and affordability of power supply
 - (b) to promote competition and accountability of industry participants to achieve greater operational and economic efficiency
 - (c) to enhance inflow of private capital and broader ownership base of power generator, subsectors, and minimize movement financial and risk exposure
 - (d) to rationalize and make electricity price competitive and affordable, and when warranted to provide transparent subsidies to unviable areas to assure socially and environmentally compatible energy sources and infrastructure

2) Definition of the Organization of the Power

Define the organization, the transition from the present to desired competitive structure, and responsibility of the various agencies and private entities during and after the restructuring process.

Generation of electric power shall be market-based and shall include but will not be limited to the participants.

- (a) Independent Power Producers (IPPs)
- (b) Electric Utilities (New CEB) Owing Generation Plants
- (c) Other state owned national generating authority for multi-purpose hydro etc.

The planning, construction and centralized operation of high-voltage transmission system not acquired by electric utilities shall be the responsibility of New CEB. New CEB shall assist Department of Electricity (Energy) in integrating expansion plans of generation and electric utilities, and shall provide access to the transmission system by all power producers and users through fair and transparent wheeling operations.

3) Tariff Setting

Tariff shall be cost reflective and set a level which allows companies to cover all reasonable costs including a reasonable return on their investment with the aim of achieving safe and reliable electricity supply and development of the system over the long term.

New CEB shall purchase that power needed to serve its anticipated demand (including reasonable reserve requirement) at rates that shall not be more than their "Avoided Cost".

"Avoided Cost" as herein defined shall mean incremental cost that an national electric utility (New CEB Generation) would incur toward meeting its anticipated power demand, if such utility does not buy power from a IPP.

Rate for purchase shall be just and reasonable to the customer of New CEB and in the public interest.

Be in accordance with guidelines set by the regulatory body, under Energy Ministry, on this matter where full and/or excess energy production shall be sold to the system of concerned parties.

An acceptable competitive scheme (e.g.bidding) is one means of setting avoided cost as well as reasonable purchase rates.

The regulatory body in consultation with related parties shall formulate and adopt a standard methodology for calculation of New CEB and other utilities avoided cost.

Criteria for competitive procurement scheme (e.g.bidding) shall also be formulated to define acceptable means of solicitation that can also provide the basis for determining an national electric utility's avoided costs and reasonable purchase rates.

- 4) The regulatory body, under Energy Ministry/D.O.E.
 - (a) Enforce technical performance standards for all generation facilities.
 - (b) Enforce performance standards for the transmission company (New CEB) including financial management, system losses, and reliability standards, including a system of incentives, fines and penalties to be consolidated by the regulatory body in a transmission code.

- 5) Restructuring

The existing CEB shall be restructured to separate its generation and transmission function and other allied undertaking. CEB shall reorganize and divest itself of its generation assets to ensure competition, supply reliability and efficiency. New CEB will retain control and responsibility over transmission functions.

- 6) Privatization

Privatization may be pursued through any or combination of the following.

 - (a) Sales of share of stocks to institutional or investors in domestic, and, if warranted in the international market
 - (b) A strategic partner
 - (c) Employee stock option plan
 - (d) Others

- 7) In addition to the above new elements, it is important to maintain safety management elements which are contained in the current law and continued to be imperative (e.g., Articles 19, 20, 21, 22, 46, and 47), and portions of the new CEB Act to specify CEB's responsibility and authority as a public utility need to be incorporated.

Establishment of the new basic energy act

It should be noted that the new law represents minimum required amendments of the present law to promote early privatization of the power generation business. In

addition, the study team believes that a law governing the entire energy sector should be enacted to enable the establishment of Department of Energy in order to ensure formulation of national energy policy and effective coordination and management of policy implementation.

As discussed in the beginning of this report, the basic law hereby proposed should contains laws and regulations which clearly define the purpose of establishing DOE and functions required for it (see Appendix 5 No.7638 Republic Act of Philippines). Furthermore, the development of a comprehensive law is imperative as part of modernization of the electricity business law, consisting of laws and regulations required for implementation of policy related to the entire energy sector, particularly fossil fuels, implementation of energy conservation projects including the development of new energy sources, a framework for public administration related to the entire energy sector and the environment, and implementation of pricing policy for public utilities including electricity and fuels.

1.1.4 Deregulation

(1) Concept of Deregulation

While the restructuring of CEB and private investment are urgent tasks for the power industry, the deregulation issue should be approached from a long term viewpoint. Since the revision of the relationship between the CEB will be dealt with first, the discussion on deregulation should be addressed second.

The general concept of deregulation is classified into the following eight elements;

- 1) Entry regulation
- 2) Operation and maintenance management
- 3) Diversification regulation (e.g., new business activities)
- 4) Investment planning (e.g., for new projects)
- 5) Work force management (e.g., appointments, promotions, salaries, etc.)
- 6) Financial management (e.g., procurement of funds)
- 7) Price regulation
- 8) Ownership

In the power industry, the first priority to be achieved among should be given entry regulation. Because of the CEB's capital constraints and fast growth of electricity demand, induced private investment is one of the most promising answers as it allows "off-balance (sheet)" transactions.

Further deregulation should be discussed thoroughly among the government, private sector and academic institutions. Empirically a drastic structural change is not always the best solution. For instance, the price charged by the privatized power industry in the Philippines is widely complained by consumers. Also environmental issues are easily neglected especially in the developing countries.

(2) Action plans for forming a competitive market

The time schedule and major targets to be achieved during the specific periods are discussed in this section.

The schedule can be divided into two phases: short term (next five or six years) and long term.

Phase I : 1997-2002

(Short term tasks)

- Improvement of CEB operations
- Further promotion of private sector participation, and legal reforms for the relevant licensing system
- Establishment of a committee for deregulation planning

Phase II : 2003-

(Long term prospects)

- Preparation for the transition process
- Deregulation of the electric power industry
- Privatization

CEB restructuring and private investment promotion are central issues in Phase I. Deregulation cannot be achieved without regaining management efficiency and profitability of the CEB. Revenue growth, especially by adjusting the electricity tariff, is one of the most important issues. Phase I also serves as preparatory period for deregulation, and a committee to plan deregulation should be established.

Phase II, the deregulation period, will follow confirmation of management efficiency of the CEB and the maturity of the power industry. The profitable nature of CEB will have been enhanced through the partial deregulation such as promoted competition with other independent power producers and the restructuring. This way, the CEB will be able to seek and face further deregulation. Again, the transition period may be required, during which such measures as favorable tax treatment and access to government loans are provided.

(3) Private Sector Investment

Concept of private sector investment

There are basically two objectives in inducing private investment. One is to bring in foreign direct investment. The other is to stimulate competition in the power industry. The reduction of the government intervention is also an indirect objective.

The encouragement of private investment for the industry will require the following preparations in the legal system.

- Licensing system for private investment
- Energy pricing system
 - Avoided cost
 - Bidding system
 - Negotiation system
- Obligation of producers (e.g. quantity, quality, etc.)
- Obligation of purchaser
 - Purchasing conditions
 - Open access to the transmission system

- Exemption from existing energy laws and regulations
- Favorable status for independent power producers, if any

Investors seek to minimize risks involved in their investments including foreign exchange, political, contract, and financial. For this reason, the government may be required to provide a transparent system for purchasing electricity.

1.1.5 Independent Power Producer Scheme

Independent power producers have been increasing in number as well as importance in both developed and developing countries. This section makes recommendations on nurturing of independence power producers based on the concept for deregulation of the Mauritius power sector.

(1) Action plans

Private sector investment in the power generation industry in Mauritius is to be promoted through the following action plans.

Step I : Preparatory Works

- Revision of laws such as Investment Act, Electricity Act and CEB Act
- Drafting of technical performance standards
- Establishment of power development plan for the new producers

Step II : Invitation/Selection of Investors

- Preparation/issuance of request for proposals for power purchases
- Pre-qualification of bidders, if necessary
- Evaluation of proposals
- Award of contract

Step III : Power Purchase Agreement

The power purchase agreement would include the following stipulations.

- Required facilities
- Connection condition

- Payment
- Quality of supply
- Minimum take
- Fuel purchase agreement
- Duration of agreement
- Contract milestones
- Default and termination
- Security and liquidated damages
- Force majeure
- Dispute resolution
- Limitation of liability
- Confidentiality
- Miscellaneous provisions

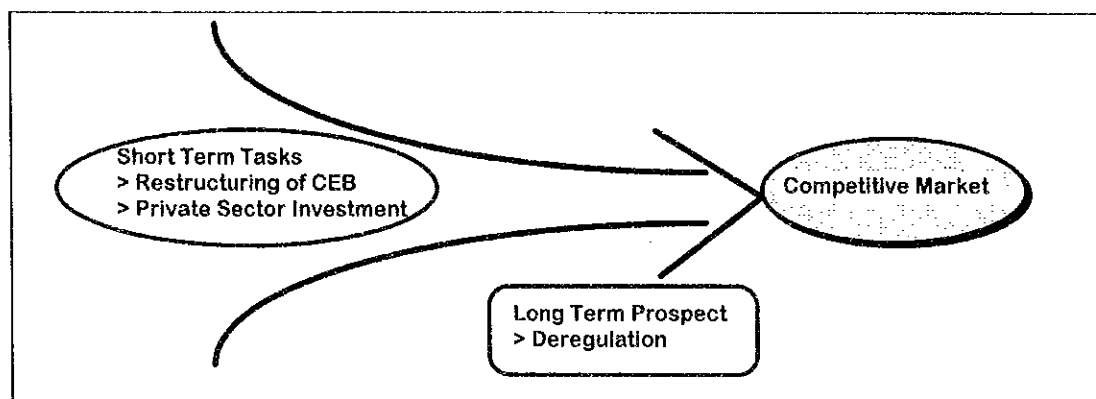
(2) Role of CEB

Frameworks for Restructuring CEB and the Electric Power Industry

The fundamental purpose of restructuring the CEB and the power industry is to spur the competitiveness and hence economic efficiency through deregulation. The underlying concept is to shift towards a competitive market in the industry and efficient regulation of the monopoly system, thereby providing consumers with more efficient services. Additionally, the concept enables CEB to mobilize alternative sources to finance future projects and to enhance the motivation of employees to improve their performance. The competitive market allows each party of the industry to achieve the following:

- Efficient regulation of the monopoly system
- Maximization of efficiency of public services for consumers
- Effective operation of the CEB

The basic concept for achieving this is illustrated as follows.



The three vehicles, namely 1) restructuring of CEB, 2) private sector investment, 3) deregulation, are discussed in the subsequent sections.

The CEB needs to enhance its organizational strength through the improvement of managerial, operational, and financial efficiencies.

(a) Improvement of management/organization efficiency

Senior managers should play the key roles in establishing long term strategy for the CEB and reconstructing organizational efficiency. In the process, CEB may face the following challenges.

- Need to establish clear, long term corporate strategy, especially development and financial planning
- Increase in managerial autonomy of the CEB
- Empowerment of management officers, especially financial managers

(b) Improvement of operational efficiency

While the CEB is committed to the continuous improvement of operational efficiency, it may be worthwhile again to reengineer each place of work and to review each procedure of tasks in order to eliminate redundancy and to rationalize operations. CEB might be able to look at the following items.

- Increase of employee productivity
- Efficiency in fuel procurement
- Review of staff allocation and outsourcing
- Decommissioning of outmoded power plant facilities, and standardization of operation and facilities

(3) Privatization of the CEB

The efficient supply of electricity can be achieved through a competitive market. While the CEB has been a parastatal body, the restructuring of its organization will be required to shift it towards a competitive company and hence one that can meet the needs of consumers. Therefore, it is recommended to reform the CEB from the current organization to a corporation whose shares are primarily owned by the government initially and separated into two bodies, one in charge of power production and the other for transmission and distribution. The electricity production industry will be privatized and participation of independent producers will be encouraged. The power generation sector of the old CEB will continue to maintain existing power plants and participate in the bidding for power development if its financial condition so allows. On the other hand, the transmission and distribution company will remain a largely-state-owned monopoly because of the small size of the system and the need for secure supply of electricity. Additionally, the further privatization of the two corporations might be sought by public offering of its shares. However, before the privatization is implemented, a more in-depth study should be carried out to evaluate the validity of the privatization issue.

The role of the government after privatization will be to ensure stable and efficient supply of electricity from the viewpoint of public utility rather than that of market regulation. The government also should encourage continuing private investment and oversee electricity pricing. Preparation and enforcement of technical performance standards for independent producers will remain one of the most important roles of the government.

(4) Improvement of the Financial Position of the CEB

The CEB is currently facing financial difficulties. CEB should consider the following possibilities.

- Revenue growth/revision of energy tariff
- Diversification of revenue sources
- Debt control

(a) Revenue growth/revision of energy tariff

Since supply of electricity is practically the sole business activity of the CEB, the electricity tariff plays a crucial role in the financial base. While the current tariff system is based on the prime cost principle and has been applied for a long period of time there are various elements to be re-assessed and reviewed as follows;

- Establishment of clear and transparent procedures for price revision
- The revision of electricity tariff should reflect the fluctuation of prime cost such as fuel cost, personnel expenses, and indirect costs. For example, the tariff could be revised every year, reflecting the actual variation of fuel price. The process of price revision must be clear and transparent.
- Determination of appropriate profit for CEB from a long term perspective
- Elimination of the discriminatory tariff system for some end users
- The discriminatory aspect in the electricity tariff system should be eliminated.
- Consideration to low income users
- Reasonable allocation of costs to the pricing system <Demand and running charge for each level and category of consumer>
- Introduction of time-of-day rate (discriminatory pricing)

(b) Diversification

Diversification of revenue centers for CEB would help improve its financial position as well as create new job opportunities. The examples of potential diversification may be sought in the following areas;

- Development of a new communication system
- Production and/or marketing of electrical appliances
- Industrial area development and real estate development

- Cable TV
- Management of power plant operation at a sugar mill
- Consultancy services

(c) Debt problem

Given the current accumulated debt level for the CEB, it is difficult to continue investing in new power plant development. Therefore, the CEB may want to seek an alternative financing scheme to cover the required cost for new projects. IPP can help solve this problem through introducing private funding necessary for new projects. We also recommend that the CEB establish a long-term repayment schedule for the accumulated debt along with the long-term development plan.

1.1.6 Financing

In the fund procurement plan for the energy development and supply project in Mauritius, it is important to consider how to secure the foreign currencies required for importing energy products while giving adequate consideration to the international balance of payments. As evident from the energy demand forecast in the present study, energy demand in Mauritius will continue to grow rapidly. Therefore, the securing of the required funds on a long-term basis, including the effective utilization of private capital in electric power projects, is a major challenge to the government.

The funds required for energy supply in Mauritius include those for securing the primary energy sources--foreign currencies for importing petroleum products, coal, etc. and domestic currency for purchasing bagasse; those for providing facilities for supplying energy (power generation and transmission facilities, energy product storage facilities, energy transportation facilities, new energy development facilities, etc.); those for investment in new energy development (foreign and domestic currencies); and those for providing various services relating to energy supply (operation and maintenance of facilities).

Of the above funds, those for securing the primary sources of energy and operating the

energy supply facilities are short term in nature, requiring a procurement plan based on the relationship between corporate finance and domestic financial institutions. On the other hand, the funds relating to the development of energy supply facilities are long term in nature, which, in view of the financial situation in Mauritius, need to be procured from foreign banking institutions, international cooperation agencies, etc.

The short-term funds, whether they are foreign or domestic currency, are procured on a routine basis, and the risk involved in procurement is relatively easy to predict. By contrast, the long-term funds for investment in energy supply facilities involve risks inherent in long-term funds. Concerning plant and equipment investment in power generation projects in Mauritius in the future, the following problems are pointed out and proper responses to them are called for.

- a) In order to meet the growing electricity demand for, it is necessary to implement plant and equipment investment on a continual basis. According to the plan for investment in power supply facilities shown in Chapter 9 of this report, financial demand is also expected to increase very rapidly.
- b) Because of the financial burden imposed by long term debt, the CEB lacks sufficient credit standing to implement the above plant and equipment investment on a continual basis.
- c) As the rupee-US dollar exchange rate indicates, the value of rupee in the international money market has declined continually. Thus, in terms of the exchange rate, both the CEB and private enterprises represent a high risk in introducing long-term foreign funds.
- d) The rate of inflation is markedly high and domestic interest rates are relatively high, and these conditions driving production costs high.
- e) Though privatization of the power generation business is expected, it is difficult to be realized since incentives for private investment (BOT, BOO, etc.) have not been sufficiently institutionalized by legislation.

- f) The industrial sector strongly resists a reasonable raise in power rates, making it difficult for the power generation business to be commercially viable.

1.2 National Energy Security

1.2.1 Energy Supply Security

Repeated regional conflicts in the Middle East, especially after the oil embargo to European countries in 1967, it have made countries recognize the importance of storage of petroleum for energy security. Prior to that, OECD issued a recommendation in 1962, to its member countries to have stockpiles of petroleum equivalent to 60 days consumption. Then, the first oil crisis occurred in 1973 and caused serious confusion and damage on the world economy. Responding to this experience, the IEA (International Energy Agency), which was organized as a subordinate of OECD, obliged its member countries to have oil stocks equivalent to 60 days' quantity of importation, which was raised to 90 days by 1980. IEA established detailed procedures to be followed in an emergency such as mutual accommodation of shortage and control of demand. And IEA decided to promote international cooperation in development of energy conservation technology and alternative energy for lowering dependency on petroleum. The second oil crisis, in 1978, caused Middle East crude oil prices to rise to 10 times the level of the early 1970s. It reconfirmed the importance of energy conservation, diversification of energy sources, purchasing from multiple sources and strategic stockpiling.

In response to the price increase of crude oil, developed countries endeavored to develop energy conservation technology and to increase recovery from existing oil fields. As a result of these efforts, although the growth rate of oil demand in developing countries was high, world consumption growth has been decelerated, due to slow down in developed countries. Regarding supply and demand of petroleum, the reserves to production rate (R/P) rose up to 40 years because of further growth of proven reserves (R) against production. The increase in proven reserves is the result of discovering new oil fields and increase in proved recoverable reserves. Recently, however, growth of proven reserves is increasing by enhancement of recovery rate while discovery of new oil reserve is decreasing.

Increased production in non-OPEC countries resulted in shrinkage of OPEC countries' production share to 30% (52% of world exports) in 1985, which went up again to the level of 42% at present. Due to the peaked production in big fields of non-OPEC countries and

increased oil demand in developing countries caused by motorization, increased dependency on OPEC countries is expected, especially on Middle East producers which have huge oil reserves but face uncertain geopolitical conditions. Crude oil produced in the Middle East accounted for 38% of the world total, and 54% (87% of export) of OPEC countries at 1st oil crisis.

Under these circumstances, and as consumption of petroleum products in Mauritius accounts for 85% of total primary energy, it is clear that an interruption or drastic cut in oil supply will cause serious damage to the economy and population. For stable continuation of economic development, which has been supported by investment from foreign countries, secure and stable supply of energy is one of the essential conditions, and accordingly national energy security must be maintained.

Strategic stockpiling is the most common measures of assuring stable energy supply, but a tremendous amount is needed to secure energy supply for a long period of time. Accordingly, efforts to reduce dependency on petroleum, in view of its uncertainty of stable supply, must be made in parallel to a stockpiling program. The government is required to promote the following measures by providing incentives and taking account the benefit of lowering both the probable risk of supply shortage and the cost burden of strategic stockpiling.

(a) Utilization of Indigenous Energy (refer to Sections 4.5 and 5)

Hydropower, bagasse, and new energies such as wind, solar heat and photovoltaics are available or have commercial potential. Among them hydropower has been developed with no additional development being expected. There is considerable potential remaining for bagasse and it is required to utilize it for public energy with higher efficiency all the year round. As for new energy sources, Mauritius has recognized importance of their utilization and has introduced a semi-commercial scale wind power plant for testing. The solar water heater is also introduced in these years in effort to reduce energy imports. As a result of technological development, the economic viability of these new sources against traditional ones are being improved. Therefore the development of those energy sources as well as bagasse should be accelerated from now on as

one of measures for national energy security.

(b) Energy Conservation (refer to Para. 8.4)

Improvement of energy efficiency decreases dependency on imported energy and serves as a safeguard for the national economy against supply interruption. In addition, energy conservation gives favorable economical effects on the country and the company. Conservation should be promoted also from the viewpoint of global and national environment preservation. See to Para. 8.4 Energy Conservation and the Development of Related Technology for detailed discussion.

(c) Diversification from Petroleum to Alternative Fuels

At present, Mauritius imports most of primary energy in the form of petroleum products. This means that the national economy and people life can be disturbed directly by worldwide supply shortages or a significant price hike. To minimize such risk, dependency on imported petroleum energy needs to be reduced by means of diversification from petroleum. The basic requirements for alternative energy sources are presence of large reserves, wide distribution in the world, and low prices, major candidates include coal, natural gas, and oil sand. In Mauritius, natural gas and nuclear power are excluded from consideration because of relatively small energy demand and large investment required.

Coal reserves are huge and distributed world wide, and therefore its supply is assured. Coal is expected to become more important as oil-alternative. Considerations may be required in promotion of coal utilization in industries, e.g., the provision of a low-cost handling and transportation system, effective pollution control measures, and dispersal or utilization of ash.

Considering the practical use of coal as an alternative fuel in various sector, in addition to apply various measures to reduce dependency on petroleum, demand forecast was performed in the study. This fuel mix may cope with energy supply emergency with minimum effect on the national economy.

To control the increase in CO₂ emission that is caused by utilization of coal or Orimulsion, such measures as the improvement of energy conversion efficiency, energy conservation, are required. The government is required to establish and determine the national target for introduction of alternative energies and promotion plan including the provision of financial incentives.

(d) Establishment of Cooperative Relationship with Oil Suppliers

Oil companies working in Mauritius have attained stable oil supply capability by utilizing their international network from field production through refining. The establishment of a long term supply contract with such oil companies could be of benefit for both parties. At present suppliers of petroleum products, except for CEB use, are selected through international bidding every year. From the viewpoint of energy security, considerable portions of oil imports should be made through inter-government deals and major oil companies by establishing cooperative relationship under the long term contract with oil companies and oil producing countries in long term bases.

Agreements within neighboring countries is also be useful to meet emergency requirements by cooperation of member countries.

1.2.2 Recommendation on the Use of Bagasse Energy

(1) Long term planning of the "Bagasse Energy Development Project"

The Bagasse Energy Development Project (BEDP) has been promoted as an effective program both for improvement of economic competitiveness of the sugar industry and the effective use of bagasse energy. It is our understanding that the modernization program of the sugar industry includes the integration of sugar mills by merging a few small mills is contemplated in the near future.

The current BEDP has already sizable capacity as a portion of the CEB power supply system by use of not only bagasse also a large amount of coal as its fuel. As the result, the impact of BEDP program on the whole electricity generation system of the country become significant, and therefore the implementation of future BEDP project must be

taken into consideration the long term power generation plan for the whole country.

The future BEDP power plant must be maintained at the technological level of other power plants in Mauritius, which is required to be considered as the reliable supply capacity during the peak demand period. The additional investment to improve reliability of the plant and the necessary cost for mitigating pollution of air and water by the plant, will necessitate to construct a large (above 30MW) unit to enjoy economy of scale, and thereby to secure the financial viability of the project.

The prospect for future capacity expansion of sugar mills and the need for increasing the scale of the power generation plants for cost reduction indicate that the future Bagasse power projects may adopt a project scheme which adopt the plant of 30MW or more, without consideration to the limitation of availability of Bagasse for the project. This will result the future large BEDP power generation projects heavily depending on coal burning.

At present, it is difficult to advocate that the power generation system of Mauritius, which is isolated from neighboring countries and has a comparatively small total generation capacity, should have a very large modern power plant, in the 200-300MW range, using liquefied natural gas or coal, even though it is considered as the most economical power generation scheme under current international conditions. For this reason, the large slow-speed diesel-engine power generation, 25-30MW per unit, consists the major part of the power generation system of Mauritius and the medium scale plants, 10-30MW hydro power plants, bagasse power plant, and gas turbine single cycle plants are supplementing the diesel plants.

Nevertheless, the continuation of economic development and the improvement of the living standards of the country will be accompanied by a rapid increase in electricity demand, and the conditions justifying a large modern power plant, which will help achieve stable supply of low cost electricity to support economic development and daily life, will be fulfilled within 15-25 years. The introduction of a large modern coal base power plant in around 2015-2020 is considered the most economical way to meet the additional electricity demand.

Until such a large modern coal base power generation plant is constructed, coal-based power generation by BEDP will be an adequate project as the necessary means to develop bagasse power projects which can save 200,000 TOE energy imports. In addition, the use of coal in a Bagasse cum Coal project in the near future is an effective way to diversify energy sources (see Chapter 5.6).

However, after a modern coal-burning power plant is constructed, coal consumption by the Bagasse cum Coal power plant should be reviewed in response to the new circumstances in consideration to the low energy efficiency of the latter, 50% more energy consumption per kWh than the modern plant, and possible reduction of the impact on the environment by the coal burning through the mitigation process applied in the modern coal power plant.

In order to realize such a desirable transition from the Bagasse cum Coal power plant to the exclusive use of coal in a new large scale modern coal-burning plant, a comprehensive long term plan, which includes the coordination of the future coal power plant construction and the operation of the Bagasse cum Coal power projects in the coming years must be prepared. Also the agreement between future BEDP and CEB must be made with consideration of such long term prospects. It is also necessary that the procedures for coordination among CEB, the current and future BEDP and IPP, including coordination regarding the possible development of new energy and solid waste power generation projects, must be established as part of the long term power generation plan.

(2) Standardization of the Bagasse Power Plant

As discussed in Chapter 5, the design of bagasse-burning power generation plant is closely integrated with the sugar manufacturing plant, and the arrangement of coal related facilities including ash treatment and waste water treatment can have wide variations, and the concept of stand-by equipment installation in the power plant may be different among parties.

On the other hand, the purchase price of electricity from the Bagasse cum Coal plant will be determined by avoided cost of CEB. In such case, the party who builds a very low cost plant with low reliability of electricity supply during a peak demand period can have very

high profit compared with the party who spends a larger sum of money to improve quality of the plant.

In order to avoid such a situation the CEB must impose on the future BEDP applicant the requirements to conform to minimum design standards for their power generation facilities.

When such standards are established as the basis of plant design, the purchase price of power from difference BEDP projects can be standardized in a fair manner.

At the same time, time and effort by the MLGPU and CEB for the contracting BEDP projects could be reduced very much.

Note that the design standards must be prepared separately for the base load plant, middle load plant and peak load plant. It is expected that in the near future, the private sector will be invited to bidding for IPP contracts. A design standard similar to that of the BEDP projects will be required to ensure the equitable basis of cost estimation for all the bidders. Otherwise, the evaluation of bid prices for the power supply will be very complicated.

(3) Development of New Technology for Efficient Use of Bagasse as Fuel

Research projects on the improvement of the quality, sugar content and fiber content of sugar cane by genetic technology, the improvement of storage/transportation properties of bagasse by balling, and other research work, is under way in Mauritius and other sugar producing countries.

The development of technology which enables the continuous supply of bagasse to power generation throughout the year is strongly needed to improve the economy of any bagasse power project.

* Expanding the cropping season. (Long-range future target)

If the cropping season of sugar cane is extended by genetic engineering from the current five months to 9-10 months in a year, it will be possible to realize a bagasse power project without coal use, and the project will be a very environment-friendly project using the really renewable indigenous energy source. The capital cost and operating cost of the project will be significantly reduced by eliminating coal and coal ash related costs.

* Research and development of technology for bagasse storing.

It is observed that the technology conceived and tested in the past for storing bagasse and use of the stored bagasse during the off-cropping season proved to be unsuitable for large scale commercial operation.

The study team aware that "the Bio-Coal Technology", which use bagasse as a supplemental component of a coal base fuel for domestic use, is being developed internationally as the mitigation of air pollution for coal burning in small boilers/stoves. (Reference Appendix 4-C)

It is considered that if a low cost combustible materials such as coal pitch/petroleum pitch has an excellent compounding effect on bagasse, when it is added as an compounding agent, the bagasse-pitch mixture may have good storage properties including the improvement of handling properties,

However, extensive technology development will be required to establish economic and environment friendly technology for use of such fuel on a commercial scale.

(4) Technology for integration of bagasse and solid waste power project

As described in Chapter 4.5, incineration of solid urban and industrial waste disposal will be a important project in Mauritius. It is expected that the burning of bagasse together with high calorie solid wastes will be an economic scheme for waste heat recovery power generation because waste power generation facilities include much the same equipment as those of bagasse power. It is recommended that technology required for bagasse use and that for solid waste power generation should be developed together.

(5) Development of a high-efficiency boiler for bagasse burning

The present bagasse cum coal power plant uses a very traditional stoker type boiler and the steam generation pressure is around 40-60 bar because the high-moisture, low-caloric value of bagasse make it difficult to use a more energy efficient system. The coal burning

process during the off-cropping season of bagasse uses the same boiler to minimize investment, and the energy efficiency of coal remains around 22-23% (net). This low efficiency make it difficult to economically justify the burning of coal for power generation after a coal base modern energy efficient power plant comes on stream. However, if new technical innovation to improve energy efficiency of the Bagasse cum Coal power plant is realized, the future of such projects will be very bright.

For an example, the use of a fluidized bed combustor for low calorie solid waste burning or coal/bagasse gasfication, which uses the technology to eliminate potassium migration problem, may have good potential to improve efficiency of bagasse energy use.

It is necessary that the MLGPU take leadership in urgent development of such important technology by obtaining the co-operation of the sugar industry and CEB.

1.2.3 Utilization of New Energy Sources

Mauritius is a small island nation which has poor energy resources. 60% of the nation's energy is supplied by imported petroleum. Hydro-power and bagasse are the only available domestic energy resources.

Considering the issues related to the development of domestic energy resources, the needs for reducing dependency on imported petroleum and providing for the security of energy, the development of new energy, such as solar energy and wind power, are very important.

For the global environmental concerns, the development of new energy is indispensable for solving problems such as the earth greenhouse effect caused by CO₂ generated by fossil fuel combustion, acid rain and destruction of the ozone layer.

In Mauritius, the development of new energy was started in 1980 but presently, only solar thermal equipment for water heating, and wind power generation in Rodrigues are in practical use.

Considering the potential of new energy, Mauritius has rich sunshine and its location is

ideal for solar energy utilization. With the presence of the southeastern trade winds Mauritius is ideally located for wind power generation. There is great potential in these energy resources.

On the other hand, the utilization of new energy in various countries is seen to concentrate on photovoltaic power generation, while wind power generation and waste power generation and the use of other new energy resources are still in the R&D stage.

Furthermore, demand for solar thermal water heaters is expected to increase. The economic performance of photovoltaic power generation is expected to improve as solar cell costs become substantially lower. Moreover, the basic research on the potential of the usable winds was already conducted. Regarding waste power generation, although there is no experience with this in Mauritius, it should be positively promoted for the purposes of waste disposal and energy supply.

From these reasons, as in various other countries, the development of three types of new energy, namely solar energy (solar thermal utilization and photovoltaic power generation), wind power generation, and waste power generation, should be promoted. However, in view of the present meager use of new energy, action plans for new energy development promotion and the formulation and introduction of legal incentives by the government are indispensable. In particular the following plans are conceivable:

- 1) The establishment of a supply target for development of new energy in future;
- 2) The introduction of a compulsory system for the purchase, either by power companies or the government, of power generated by new energy sources (this system under purchase cost is higher than the avoided cost);
- 3) The provision of the government subsidy system for those introducing residential photovoltaic power generation systems;
- 4) The possible introduction of the so-called reverse power flow systems wherein photovoltaic power generators sell their generated power to power companies during the daytime, and buy power from power companies during the night time;
- 5) The introduction of tax credits and low interest loan systems for wind power generation developers;

- 6) The introduction of waste power generation systems under governmental leadership;
- 7) Public education and advertisement to promote new energy;

1.2.4 Diversification of Energy Sources

This aims at reducing dependency on petroleum products which have a 85% share in primary energy, and at improving protection against risks related to supply cut and price hike as may be caused by an international dispute. Realistic alternative fuels to be introduced to Mauritius in the near future are coal and Orimulsion as explained below.

To promote diversification, the government is required to build infrastructure such as storage and distribution facilities and to provide incentives to make it possible for users to have access to available supporting technology, with special consideration to applicable environmental standards.

First of all, the government is obliged to establish a concrete program for promoting diversification including technical and financial support.

Widely adopted substitutes for petroleum fuel are coal, natural gas, nuclear and oilsand. Among those, natural gas and nuclear power are not relevant for Mauritius because of the small scale of energy demand and high initial investment required for facilities. In the future, however, it will be possible to utilize LNG if a cooperation program with neighboring countries can be established.

Coal reserves are huge and distributed widely all over the world, and supply security is expected to be very high. The major advantage of coal is its price and a future coal-fired power plant in this country will be located on the seacoast to receive coal directly from ocean-going ships. In connection with small industrial users located inland, a major concern in promotion of diversification is the establishment of an economical distribution system. In addition, small users require governmental support to comply with environmental regulations, including disposal of ash.

Oil sand is commercially available as Orimulsion which is water emulsified oil bitumen, produced in Venezuela. Orimulsion was developed to utilize natural bitumen as liquid fuel.

The scale of recoverable reserves of natural bitumen in the Orinoco Belt is comparable to coal in South Africa and crude oil in Saudi Arabia. This fuel is outside OPEC production quotas due to its specification and is being utilized at commercial power plants in Japan, Europe and North America. According to the supplying company, the price of this fuel was set so as to be competitive against coal in general: however the price to Mauritius may be slightly more expensive than South African coal because of a longer distance of shipment and rather small demand. However, Orimulsion has such advantages as the ease in handling and transportation and less ash content. Therefore this fuel will be convenient for small industrial boilers.

1.2.5 Strategic stockpiling

The IEA requirement for strategic stockpiling by OECD members is equivalent to minimum 90 days of consumption. This figure includes the running stock and excludes the amount for imported petroleum reexportation. Generally, the running stock is 45 days and storage facilities of oil companies in Mauritius have 45-55 days storage capacities at present. The 90 days stock is based on the perceived need to control internal consumption according to the level of supply cut down.

CEB has changed its standard on storage capacity and has already increased storage capacity from 28 days to 90 days. Considering the fact that economic development in the country is dependent on foreign investment and international tourism, the security of stable energy supply is an essential requirement for further development. Accordingly, the 90 days storage, which is the same capacity as CEB already decided, will be the minimum requirement for both public and industrial sectors. This means an additional 45 days stock is required as strategic stockpiling. For electric power generation, IPP shall adopt the same standard as CEB for their fuel oil storage.

Laws to control internal supply smoothly in an emergency situation are required to support effective utilization of the stockpiling. This may need to cover such items as detailed procedure for control of demand according to the shortage of supply and expected duration of the shortage, when and how to release the emergency stock, and procedures to control electric power supply.

(1) Strategic Stockpiling Facilities

The petroleum products requiring strategic stockpiling are gasoline, diesel and heavy fuel oil. Bunker oil and jet fuel are excluded because of reexport. Kerosene consumption other than electric power generation is only 15% of airplane use, and diversion of airplane use will be possible to eliminate an additional storage. The supply sources of LPG are widely dispersed and less risk in supply cut-down is expected.

Costs relating to strategic stockpiling, such as investment cost for storage facilities and inventory cost of petroleum product, and maintenance cost, should be born by entire population as a cost for national energy security. Considering that this storage is non-commercial use and needs a large investment, the government is required to provide sufficient financial measures.

There are two ways to build storage facilities.

- (a) The government builds the facilities independent of oil companies' normal operation.
 - (b) The government requests oil companies to build and maintain the facilities with the 90-day capacity based on last year's sales quantity. Additional cost for expanded facilities and oil will be borne by the government and oil companies will be responsible to maintain stock of 45 days quantity.
- (a) will be recommended from the viewpoint of possible efficient utilization of limited land and due to small domestic demand. (a) has the additional advantage of easy control of supply (where and how much) according to the government policy.

Based on the demand forecast, the following storage tanks are required to achieve the above mentioned strategic stockpiling capacity.

<u>Year</u>	<u>Gasoline</u>	<u>Diesel Oil</u>	<u>Fuel Oil</u>
2000	7000 kl x 3	7000 kl x 3	7000 kl x 2
2005	7000 kl x 1	7000 kl x 1	-----
2010	7000 kl x 1	-----	7000 kl x 1
2015	7000 kl x 1	-----	7000 kl x 1
2020	7000 kl x 1	7000 kl x 1	7000 kl x 1
2025	7000 kl x 1	7000 kl x 1	7000 kl x 3

The location for storage facilities will be an area allocated for new oil facilities in Mer Rouge of Port Louis port. This area is convenient for the following reasons.

- (a) Existing infrastructure can be utilized.
- (b) Adjoining oil companies' facilities saves construction cost (connections for receiving and releasing of oil, etc.)/
- (c) Maintenance will be contracted to oil company to minimize cost.

According to MMA, an additional area can be developed by reclamation to the west of the preset allocated area, to allow for future expansion. However, concentration of a large quantity of oil at the entrance of the sole international port of Mauritius presents a major risk to the nation. To avoid it, future strategic stockpiling should preferably be built in the energy center in Mmahebourg area as proposed in Sec. 4.3 and 8.2.

(2) Maintenance of Storage Facilities

Even though the facilities are simple, adequate maintenance is the key to safety. In practice, the work should be contracted to oil companies who are doing the same activity. The work will include distribution of released oil to consumers through their facilities in an emergency situation.

Table 1.1.1 SUMMARY OF ACTION PLAN FOR FURTHER ENERGY DEVELOPMENT

