◆ Chapter 5 Bagasse Energy Utilization ◆

Chapter 5 Bagasse Energy Utilization

5.1 The Use of Bagasse as an Indigenous Energy Resource

(1) Introduction

Sugar is one of the most important agricultural products in the world, with production typically in the tens of millions of tons per year, and the industry has long history in many countries. The majority of this sugar product is derived from sugar cane, and for manufacturing every unit weight of crude sugar, bagasse, a fibrous material amounting to some three times the weight of the sugar itself, is left behind as a by product. The handling, storage and disposal of this by- product is considered to be difficult for a number of reasons. Among these are its high water content (approximately 50%), its low bulk density (80-100 kg/m^3), and its susceptibility to degradation during storage, including an unfortunate tendency towards spontaneous combustion. Finally, the availability of bagasse is limited to that time of the year during which sugar cane is crushed, which is only some 4-5 months out of the entire year. All of these conditions have rendered the economic use of bagasse difficult. Projects in large sugar producing countries have been undertaken to make use of by-product bagasse material, such as manufacture of low-grade paper and fiberboard (building materials) however, few of these projects have proven successful.

In Mauritius, the markets for both paper and,fiberboard are too small to make such uses possible. Therefore, bagasse is burnt by the sugar mill itself as fuel to produce steam, which in turn, is used to produce sugar from cane.

Until the 1970s, when the price of crude oil skyrocketed during the oil crises, the value of bagasse as an energy source was not appreciated very much by outsider of sugar industry. The increase in crude oil prices resulted in an intensive review of the value of what indigenous energy resources existed in various countries, particularly in those where conventional energy resources were not available, as in the case of Mauritius. The intensive development of indigenous energy resources was (and is) considered an effective measure to reduce dependency on foreign energy supplies. This helps to avoid potential serious economic consequences which can result from violent fluctuations in international petroleum markets. Additionally, recent concerns regarding future shortages of non-renewable fossil fuel as well as the impact of greenhouse gases on the atmospheric environment have amplified the importance of renewable energy resources, such as bagasse. The Government of Mauritius has intensively promoted the use of bagasse as an energy source, with assistance from the World Bank and other international agencies.

The importance of bagasse as an energy source can be seen from the fact that, according to government statistics (supplied by the CSO) some 28.8% of total energy consumption was supplied by bagasse in 1993. A World Bank report indicates that some 37.8% of the total primary energy supply (718,000 TOE) is derived from the bagasse. This figure includes the amount of energy obtainable from the bagasse within the sugar mills themselves; if one considers the total raw energy content in the bagasse itself, the World Bank figure is correct. However, if the low conversion efficiency of bagasse to both heat and electricity is considered, the CSO figure, about 29%, is more realistic. In any case, the amount of energy derived from bagasse comprises a large proportion of the nation's energy resources, and therefore the effective use of bagasse is very important to the country.

In recent years, efforts have been concentrated on the effective use of surplus bagasse for power generation; this can be accomplished quickly, and with relatively small investment in comparison with effective use of total bagasse. Surplus bagasse is defined as the total production of bagasse minus that consumed in the operations of the sugar mill. (Surplus bagasse amounts to some 30% of the total production.) However, the effective use of bagasse energy, which is being used for the steam generation, is also very important. Take for example, the Flacq United Estate Ltd. (FUEL) sugar plant, which exports electricity to CEB; it produces 50% of its electricity from surplus bagasse, the other 50% is obtained from the use of bagasse which is consumed in steam production.

The use of bagasse for energy production is not only vital for the energy sector of the country, but is also important for improving the economic situation of the sugar mills themselves through the generation of electricity for sale as a by-product of their sugar production operations. The sugar industry in Mauritius has long been the core of her agriculture, and is responsible for some 16% of the national GNP. However, the sugar industry has faced serious international competition in recent years, and as a result, the

Government has made it a priority to improve the industry's competitive position in the international sugar trade.

The Government enacted the Sugar Industry Efficiency Act in 1988, and in cooperation with various segments of the sugar industry, the Government has promoted action plans to strengthen the cost-competitive position of the industry.

One of the principal target of these action plans was the development of the Bagasse Energy Development Project (BEDP). However, as one of the core projects of the BEDP carried out by Union St. Aubin Co. was terminated at the end of 1995. Currently, the other BEDP program are being implemented extensively.

5.2 Present Status of Bagasse Power Project

Historically, the power generation from bagasse energy was applied in many sugar mills for generating electricity required in its mill for manufacturing crude sugar from sugar cane by mean of back pressure steam turbine, which drive power generator by expansion of medium pressure steam, 15-20 bar, to the pressure required in the mill, 1.0-2.0 bar G. The recent improvement of sugar manufacturing process gradualy decreased the amount of steam & power consumption, and the amount of bagasse consumed for steam generation is also decrease. This change resulted some portion of bagasse obtained in the mill become surplus to the consumption for own requirement. After the 1970's oil crisis, the effective use of bagasse energy for generation of power to be sold to outside of mill become financially attractive.

In Mauritius, Flacq United Estates Ltd. (FUEL) started in early 1980's the business of selling sizable bagasse power to CEB, and several other sugar mills also participated to the power selling business to CEB as far as their power generation exceeded their own use.

In 1995, the performance of existing bagasse power plants in the country were as follows:

Name of Sugar Mill	Nominal	Actual	Type of Operation
F.U.E.L.	21.7	18.0	Firm (Through Year) * under optimum
Mon Tresor Mon Desert	5.0	5.0	Continuous (Crop Season)
Medine	10.0	8.0	Continuous (Crop Season)
Other Mills	16.5	11.8	Intermittent (Crop Season)
Total	51.8	42.8	

Unit : MW

These capacity is equivalent to 15% of CEB effective capacity (289 MW), and the energy supplied to CEB in 1995 was 125 x 106kWh, which is equivalent to 12.5% of total power generated in the country.

Currently, following projects are being implemented under the BEDP program.

Beau Champ	12-15 MW	Firm Supply	End 1997 start
Six Sugar Mills in South	25 MW	Continuous	1998 start
Bell Vue	40-50 MW	Firm Supply	2000 start
Fuel Expansion	Expansion from 12-15 existing unit to 18-23 MW	Firm Supply	1998 start

5.3 Technical Aspects of "Bagasse Power Project"

5.3.1 Conditions for Optimization of Project Scheme

There have been several studies by MEW, the World Bank, and other parties. However, due to the complex nature of the projects, it has proven very difficult to formulate an optimum scheme for the projects. Some of the complicating factors include: the use of bagasse for power generation for internal consumption and power exports to CEB, steam use for machine drive in sugar mill and steam use for sugar mill process. In addition, the bagasse power generation, which is highly dependent on the bagasse supply from sugar mills (operable only during the 4-5 month long cropping season) and other supply factors affecting the availability of bagasse (e.g. natural disasters, such as cyclones) add further obstacles in determining an optimal project scheme.

In order to determine an ideal strategy for bagasse power generation, several fundamental issues must be clarified. The fundamental issues facing bagasse power generation are described as follows:

(a) The future operation of some of 17 comparatively small-scale sugar mills is in doubt. In the longer term, to reduce their costs of production these mills are likely to merge and then scale-up their operations are contemplated, but no reliable program is avairable.

(b) The feasibility (from both a technical and an economic standpoint) of storing and reclaiming bagasse for use during the off-cropping season is unproven. In Australia and Mauritius, while some studies have been conducted, as yet there exist no commercially proven operations.

(c) The effective use of bagasse for power generation should not be limited to the efficient utilization of surplus bagasse, which is not tied up to the sugar mill operation. The improvement of energy efficiency of bagasse burnt to produce the steam required for sugar mill operation will have significant impact to total energy efficiency of bagasse for power generation.

Therefore, the design steam pressure of the boiler both for generation of steam for sugar mill operation and for generation of steam for power generation (total condensing system) must be maintained as high as possible.

Under current technology level, the design steam pressure of the boiler for bagasse burning is limited around 60 bars.

(d) The project scheme should has his priority on stable supply to CEB through a year.

a. In a design, which places priority on the smooth operations of the sugar mill, the bagasse feed to the boiler is controlled to maintain a supply of steam to the sugar manufacturing operation. In this case steam from the boiler is sent to a generator to produce power before being used in the sugar mill process; the electrical power thus generated is used for sugar mill operations, and only if surplus power is available, it is exported to CEB.

In this design the generator is driven by an extraction steam turbine. (This design is adopted for the intermittent supply from the sugar mill.)

b. This design is engineered to produce export power at a pre-determined level by either utilizing bagasse or coal (which is used when the bagasse supply is short).

In this design, the boiler, which generates steam not only for the sugar mill's requirements, but also the steam required to produce a predetermined amount of electricity for export, and a generator driven by an extraction/condensation turbine must be installed.

This latter type of scheme is used for the continuous and firm power supply of sugar mills.

This design, (b), has been applied to the FUEL, Beau Champ and Belle Vue project as firm supply projects. However, there are still two other design strategies which should be examined.

The first approach is to upgrade all process equipment and machines to use modern technology, thereby improving the reliability of the power supply to the level of a modern power plant. This concept was applied to the old USA and Belle Vue project; the magnitude of the investment required for this design was found to be similar to that of a diesel engine generator.

The second approach is to minimize the capital investment required; this is accomplished by converting the intermittent-type power supply to a firm power supply by utilizing existing machines and equipment to their fullest extent, and, when available, second-hand equipment is also utilized.

The second approach was adopted by FUEL and will be adopted by the BEAU CHAMP project. However, the operational reliability of this type of power plant cannot be considered to be at the same level as power plants using gas-turbine and diesel engine generators. Therefore, measures to cover for service outages with this type of plant during peak demand periods must be taken by CEB. This means that there are some potential liabilities or costs to CEB associated with this type of project.

The factors discussed above are summarized in the table below:

	Type	Facility Improve	Generation during off-crop	Bagasse	Coal use
A	Intermittent supply	Not require	Not possible	Steam bagasse	Not require
B	Continuous supply	Small portion	Not possible	Total bagasse	Limited
C	Firm (High reliability)	Considerable	Possible	Total plus imported	50% or more of generation
D	Firm (Low reliability)	Minor	Possible	Total plus imported	50% of generation

Type A represents those sugar mills which intermittently export electricity to CEB. These existing plants are not an energy-efficient design, nor are they considered to be an effective use of bagasse energy.

Type B is represented by the MEDINE project, which is equipped with an extraction-condensation turbine; efficiency is reasonable as the combustion of bagasse generates medium steam pressure, at around 30 bars. However, power supply is limited during the cropping season. Therefore, the plant capacity can not be considered to form part of the power grid's peak load capacity in December and January.

The operation of types C and D during the cropping season are similar to that of type B, but even during the cropping season, when bagasse is not produced sufficiently by the sugar mill; the power supply to CEB is continued by means of burning coal. This concept is identical to all firm supply Bagasse Power Project.

The existing FUEL project as well as the newly-implemented BEAU CHAMP project belong to the D type. The investment for electricity export to CEB on a firm supply basis is minimized due to a number of factors, including process simplification by minimizing stand-by equipment, making maximum use of existing sugar mill plant and equipment, and utilization of second-hand boilers and generators. These methods are suitable for reducing generation costs, however, both the reliability and energy efficiency of the plant are somewhat sacrificed.

The Belle Vue project is expected to build the power generation plant with high reliability. This means the project will have comparatively high investment cost, which is the typical case of Type C project.

The estimated investment for one kW (unit capacity) increased up to about U.S.Dollar 2,000, and therefore the project viability is questioned by the concerned experts. In order to overcome high investment cost problem the increase of plant capacity, which is normally results lowering the cost for unit capacity by the scale merit and the adjustment of tariff in accordance with actual plant cost are being considered.

5.3.2 Future Prospect of Bagasse Power Technology

The most fundamental conditions out of miscellaneous conditions mentioned in previous paragraph are following two.

The first one is the co-ordination of modernization/rationalization of sugar industry of Mauritius and future bagasse power project in future, and the other one is the co-ordination of BEDP projects and other power generaiton projects to be implemented either by CEB or the IPP projects to achieve over-all system optimization.

<u>Coordination of BEDP and Modernization/Rationalization of Sugar Mill</u>

If we assume the continuation of all the existing sugar mills in near future, and all the bagasse available to each mill will be used evenly the amount will be about 100,000 ton/one season in average. The size of power plant to use this amount in one cropping season, about 150 days, will be about 10 MW (28 ton/hr bagasse).(Reference: Table 5.10.1)

As it is well awared by the people concerned, this size of steam cycle power plant does not reach economic scale as the investment of this type of plant, which will have very high investment for one kW base. The future, at around AD2015, power plant in Mauritius to be built by CEB & IPP will have 100-150 MW, the merit of scale for the cost of unit capacity of such large plant will make it difficult for the small size BEDP project to compete financially even the bagasse cost is kept very low. As the results, the future BEDP project must have the capacity more than 30 MW as the case of old U.S.A. project of which the project scheme was changed during the feasibility study from 20 MW to 36 MW.

When the size of power plant increase to 30 MW, the plant must have bagasse about 300,000 ton per season. This means some of sugar mill must give up the power generation for export, and to give their bagasse to the mill building a large power plant.

Further, the plant who give all the surplus bagasse to other party will find difficulty to invest significant monetary to improve energy efficiency for the bagasse burning to supply steam and electricity for his own consumption because of small scale demerit of the plant. This will results low efficiency bagasse energy use in these small mills. The transportation cost of surplus bagasse from small size mill to a large mill will be additional cost for bagasse energy utilization.

Now, we see the clear advantage of a large power plant built at the large scale sugar mill, where bagasse will be produced at the level of 300,000 ton per one crop season.

Since the modernization of sugar mills in Mauritius is intending the scale up of the size of a mill by the merge of a few small mills, the future BEDP projects must be built at the adjecent area of such a large sugar mill to utilize the scale merit for cost reduction of unit power.

In this case the investment to improve energy efficiency for use of not only surplus bagasse but also the bagasse to be burn for production of steam & power for their sugar manufacturing process will be justified because of the scale merit. In addition, the cost of bagasse transportation between mills will be avoided by this scheme. In this way nation wide effective bagasse energy utilization will be achieved in parallel to the effective modernization of the sugar industry of the country.

Note: The merit and demerit of coal use for "Bagasse Power Project" will be described in paragraph 5.10.

Integration of BEDP Project Into National Power Generation System

When the above mentioned scale up of the BEDP power generation project is realized, the additional investment to improve reliability of bagasse power supply to the similer level of other power generation plants will be possible because the cost competitivity of the BEDP with other project will not be spoiled by such additional cost because the economy of scale of the project improve the cost competitivity. Therefore, the BEDP supply capacity in future will be considered as the part of peak load supply capacity of total power generation system.

In order to realize above mentioned desirable BEDP development, the Government must take positive role to draw a blue print, which show the long term plan for the future BEDP development and the power generation system development with obtaining positive co-operation from sugar sector and energy sector.

The early consensus in relation to the location where future large scale sugar mills and bagasse power plants will be built and how coordination of future program of electricity transmission and distribution system will be made. The long term plan to accommodate the participation of future BEDP project to the national electrical system, without difficulty, must be prepared by CEB and other related parties.

It is estimated that by AD2000 the firm bagasse power capacity will reach 80 MW, and the long future 190 MW bagasse power capacity is possible by use of the total bagasse avairable in Mauritius, about 1.8 million ton/year to be produced in the country.

5.4 Large Scale Bagasse Power Project (BEDP) and Independent Power Producer

The Government of Mauritius has provided several financial and taxation incentives for the development of the bagasse power projects up to now, which is a effective measure both for strengthening of international cost competitivity of the sugar industry and for development of utilization of indigenous renewable energy resource. (Ref. A1-1)

This policy itself is considered very reasonable up to now, but recent Government policy in relation to the encouraging the participation of the private sector into the power generation sector of the country as Independent Power Producer (IPP) may creates potential difficulty for next stage development of BEDP and IPP.

The potential problem is the ambiguity of the definition of the current & future BEDP and IPP. The BEDP project in the past was interpreted as the power generation and its export to CEB using bagasse energy.

It is well known that the first firm power supply by the FUEL project was including the coal burning during off-crop season to continue power supply to CEB. However, the coal burning is considered as supplemental.

On the contrary, the recent BEDP project is intending to use coal extensively for enjoy the scale merit of the power plant, boiler/alternator. This means the capacity of the near future BEDP power plant may be determined without the consideration of the availability of bagasse.

Take for example, the estimated bagasse available to one large mill, which also import surplus bagasse from the adjacent sugar mill, will be about 300,000 tons/one season. When this amount of bagasse is used for firm power supply during cropping season, about 150 days, the average bagasse available for one hour will be about 83 tons.

When 18.5% of bagasse energy can be converted to one kW power to be fed to national grid, the maximum power supply to the grid will be 33.2 MW. The recent Bagasse cum

Coal project are intending to have capacity exceeding 33 MW. This means until the time scale up of individual mills by the integration of other mills are realized, the near future Bagasse cum Coal project seems to require burning of coal even during cropping season.

The financial incentives provided up to now for the BEDP project can make possible to make the advanced investment for the construction of large scale sugar mill/power plant at very low cost based on the long future prospect. This case, the bagasse use for the power generation become the supplement of coal fuel.

When we assume the integration of sugar mill is proceed, by AD2010 the size of one sugar mill increase to tree times of current average size. This means the available bagasse in a year will be 300,000 ton and the economic size of the power plant will be 30 MW or so.

This means that until the time the scale up of individual sugar mill progress up to the level, the bagasse available to each mill increase to about 300,000 tons in one season, the most of Bagasse cum Coal power project with economic size plant, say 30 MW, will have significant shortage of bagasse supply even during the cropping season.

In such case, the power supplied from the Bagasse cum Coal plant will heavily depend on coal instead of bagasse.

This implies the characteristics of the project of the future BEDP project changed from bagasse energy utilization to the coal base power generation project.

There is another aspect of the coal dependent power generation under current scheme BEDP. The profitability assessment of bagasse cum coal projects (Ref. Table 5.4.1 (A) (B), Figure 5.4.1 (A) (B), Figure 5.4.2 (A) (B)), indicates the higher return on investment to the large plant because the unit price of power sold to CEB is determined regardless the size of the power plant (total sales volume of power) but the avoided cost of CEB for the Fort George unit. Now, the potential conflict between the future BEDP and IPP, which is to be encouraged by the Government, is become reality. Take for an example, in case a entrepreneur propose BEDP project based on 90% coal fuel and 10% bagasse fuel, and the other entrepreneur proposed 100% petroleum or coal fuel IPP project, the same financial incentives should be given to the party of BEDP and the IPP or the treatment in different way will be questioned.

Table 5.4.1 (A) MAURITIUS BAGASSE POWER PROFITABILITY ASSESSMENT

CASE	I	II	III	IV	V	VI	VII	VIII	IX	X
PLANT SIZE	MW 20	MW 20	MW 40	MW40	MW 60	MW 60	MW 20L	MW 20L	MW 40L	MW 60L
FUEL	BAGA	BAG/COA	BAGA	BAG/COA	BAG/COA	BAG/COA	BAGA	BAG/COA	BAG/COA	BAG/COA
ANNUAL HOURS	3600	7200	3600	7200	7200	7200	3600	7200	7200	7200
HOURS BAGASS	3600	3600	3600	3600	3600	0	3600	3600	3600	3600
HOURS COAL	0	3600	0	3600	3600	7200	0	3600	3600	3600
EFFICI BAGA	0.195	0.195	0.195	0.195	0.195	0.195	0.172	0.172	0.172	0.172
EFFICI COAL	0.225	0.225	0.225	0.225	0.225	0.225		0.2	0.2	0.2
BAG AMOUT	171428	171428	342857	342857	342858	0	188571	188571	384000	384000
COAL AMOUNT	0	43636	0	87272	174545	261816	0	48872	97745	195490
FUEL COST BA	7	7	7	7	7		7	7	7	7
FUEL COST CO		65		65	65	65		65	65	65
ANNU COST BA	1199996	1199996	2399999	2399999	2400006	0	1319997	1319997	2688000	2688000
ANNU COST CO	0	2836340	0	5672680	11345425	17018040	0	3176680	6353425	12706850
INVESTMENT	33600000	42000000	56400000	70500000	95700000	95700000	16800000	21000000	28200000	47850000
CAPITAL RECO	4032000	5040000	6768000	8460000	11484000	11484000	2016000	2520000	3384000	5742000
FIXED COST	1000000	1400000	1700000	1700000	2400000	2400000	700000	1000000	1400000	1700000
VARIAV COST	35999.88	121090.08	71999.97	242180.37	412362.93	510541.2	39599.91	134900.31	271242.75	461845.5
ANNU COST	6267995.9	10597426	10939999	18474859	28041794	31412581	4075596.9	8151577.3	14096668	23298696
SALE HOUR $	1500	1500	3000	3000	4500	4500	1500	1500	3000	4500
ANNUAL SALE	5400000	10800000	10800000	21600000	32400000	32400000	5400000	10800000	21600000	32400000
ANNUAL PROF	-867995.9	202573.92	-139999	3125140.6	4358206.1	987418.8	1324403.1	2648422.7	7503332.3	9101304.5
RETURN ON INV	-.0258	.0048	-.0025	.0443	.0455	.0103	.0788	.1261	.2661	.1902
KWH COST	.0871	.0368	.0760	.0641	.0649	.0727	.0566	.0566	.0489	.0539

PLANT COST '42 MILLION US$ 20MW '(CAPACITY/20)^0.75 EFFICIENCY=NET POWER TO GRID

CAPITAL RECO =12% OF INVESTMENT

MAXIMUM BAGASSE SUPPLY IS CONSIDERED AS 342857 TON/YEAR VARIABLE COST 3% OF FUEL COST

CASE VI AND X 75% OF POWER FROM COAL TARIFF =0.075 US$

CASE VII...X LOW COST LOW TECHNOLOGY CASE INVESTMENT 50% OF HIGH TECH PLANT BUT 12% ENERGY IS LOSS 40MW CASE 1.2 MILLION $/Y

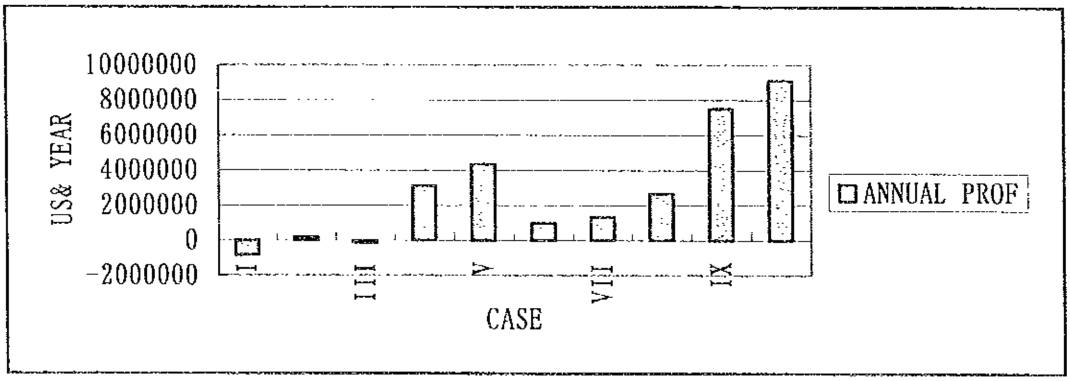

Figure 5.4.1 (A) PROFITABILITY OF BAGASSE POWER

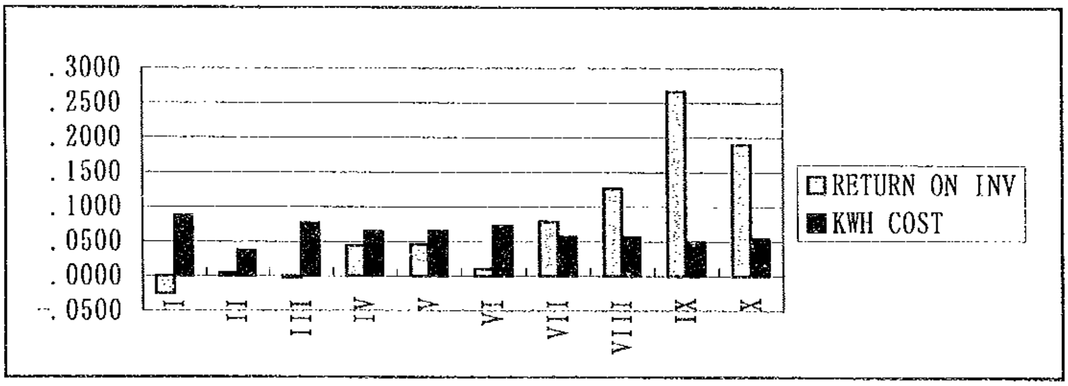

Figure 5.4.2 (A) ROI : KWH COST

Table 5.4.1 (B) MAURITIUS BAGASSE POWER PROFITABILITY ASSESSMENT

CASE	I	II	III	IV	V	VI	VII	VIII	IX	X
PLANT SIZE	MW 20	MW 20	MW 40	MW40	MW 60	MW 60	MW 20L	MW 20L	MW 40L	MW 60L
FUEL	BAGA	BAG/COA	BAGA	BAG/COA	BAG/COA	BAG/COA	BAGA	BAG/COA	BAG/COA	BAG/COA
ANNUAL HOURS	3600	7200	3600	7200	7200	7200	3600	7200	7200	7200
HOURS BAGASS	3600	3600	3600	3600	3600	0	3600	3600	3600	3600
HOURS COAL	0	3600	0	3600	3600	7200	0	3600	3600	3600
EFFICI BAGA	0.195	0.195	0.195	0.195	0.195	0.195	0.172	0.172	0.172	0.172
EFFICI COAL	0.225	0.225	0.225	0.225	0.225	0.225		0.2	0.2	0.2
BAG AMOUT	171428	171428	342857	342857	342858	0	188571	188571	384000	384000
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FUEL COST BA	7	7	12	12	12		7	7	12	12
FUEL COST CO		65		65	65	65		65	65	65
ANNU COST BA	1199996	1199996	4114284	4114284	4114296	0	1319997	1319997	4608000	4608000
ANNU COST CO	0	2836340	0	5672680	11345425	17018040	0	3176680	6353425	12706850
INVESTMENT	42000000	42000000	70500000	70500000	95700000	95700000	21000000	21000000	35250000	47850000
CAPITAL RECO	5040000	5040000	8460000	8460000	11484000	11484000	2520000	2520000	4230000	5742000
FIXED COST	1000000	1400000	1700000	1700000	2400000	2400000	700000	1000000	1400000	1700000
VARIAV COST	35999.88	121090.08	123428.52	293608.92	463791.63	510541.2	39599.91	134900.31	328842.75	519445.5
ANNU COST	7275995.9	10597426	14397713	20240573	29807513	31412581	4579596.9	8151577.3	16920268	25276296
SALE HOUR $	1500	1500	3000	3000	4500	4500	1500	1500	3000	4500
ANNUAL SALE	5400000	10800000	10800000	21600000	32400000	32400000	5400000	10800000	21600000	32400000
ANNUAL PROF	-1875996	202573.92	-3597713	1359427.1	2592487.4	987418.8	820403.09	2648422.7	4679732.3	7123704.5
RETUN ON INV	-.0447	.0048	-.0510	.0193	.0271	.0103	.0391	.1261	.1328	.1489
KWH COST	.1011	.0736	.1000	.0703	.0690	.0727	.0636	.0566	.0588	.0585

PLANT COST `42 MILLION US$ 20MW `(CAPACITY/20)^0.75 EFFICIENCY=NET POWER TO GRID

CAPITAL RECO =12% OF INVESTMENT

MAXIMUM BAGASSE SUPPLY IS CONSIDERED AS 342857 TON/YEAR VARIABLE COST 3% OF FUEL COST

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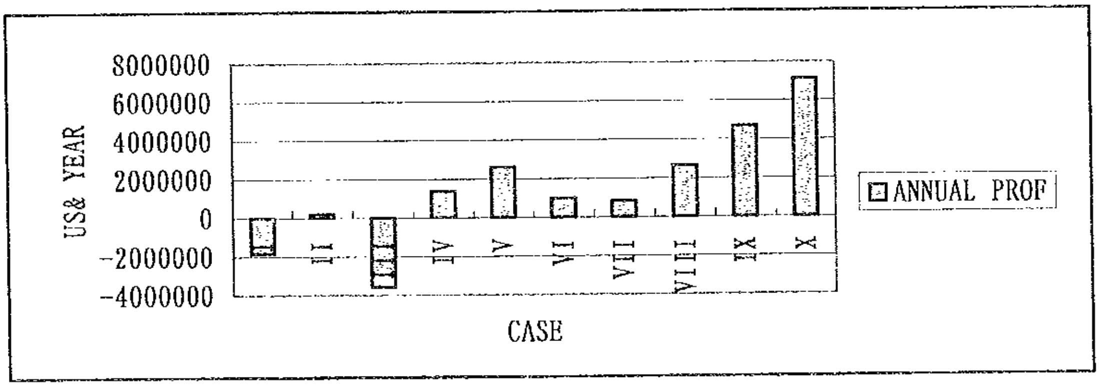


Figure 5.4.1 (B) PROFITABILITY OF BAGASSE POWER

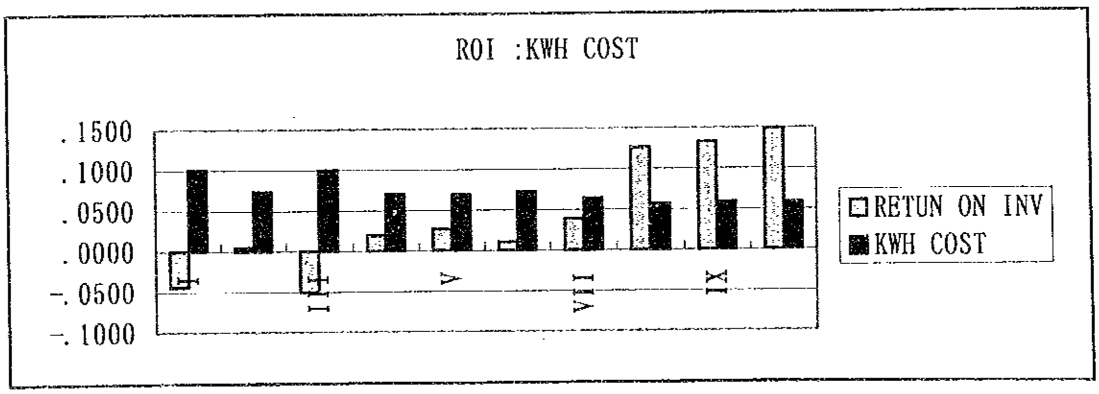


Figure 5.4.2 (B) ROI : KWH COST

5.5 Method of Tariff Setting for BEDP Project

Currently, the purchase price of power from firm supply BEDP project, is being set on the concept of avoided cost of CEB, which had developed in the course of implementation of the Union St. Aubin project.

The avoided cost is determined by the additional capital cost and additional running cost of additional unit of the Fort George Power Plant of CEB, which will be required by CEB to produce same amount of power, when U.S.A. will not supply the electricity to CEB.

Therefore, the purchase price of power from the project is consider as constant regardless the size of plant, total purchase amount, the cost of power generation by BEDP.

The avoided cost was considered to be able to provide reasonable return to the investment by U.S.A. This method of determination of purchase price is reasonable provided the following conditions are fulfilled:-

1) The BEDP supply can replace a portion of base load power supply through the year.
2) BEDP participation to the total CEB power supply system will not create any additional cost to CEB, which may require for the additional stand-by capacity to prepare the failure of BEDP power during peak demand.

This additional cost of CEB includes the arrangement of securing the peak load capacity even the case the delay of the completion of BEDP project is happened.

Practically, when the total demand of electricity increase and additional generation capacity is added by BEDP/IPP or CEB, the stand-by capacity of total system must be increased, the cost of such additional stand-by capacity is considered as the CEB cost up to now. The penaly imposed on failure of supply can not cover the total cost of CEB for such stand-by.

Take for an example, the BEDP's power supply amount is assured by CEB at full capacity from the time of commencement of operation, therefore the CEB supply amount will be reduced up to the time the increase of total demand of power catch up the increase of supply capacity by the participation of a new BEDP project. (The cost saving by the difference between purchase price from BEDP and the real cost of CEB power generation will not cover the reduction of CEB income by reduced of generation amount.)

The financial loss of CEB caused by the reduction of power generation during the time the demand increase can not catch up additional base load generation capacity will not be significant when the newly installed capacity is comparatively small compared with total generation capacity. (In case of unrealized U.S.A. the additional capacity was about 10% of total.)

However, the capacity of newly built unit by BEDP/IPP exceeds 20-30% of total base load capacity, the impact to CEB financial position will be significant.

In future, when the participation of the IPP to the Power Generation Sector is increased, the purchase price of power by CEB must take into consideration the financial loss of CEB as negative avoided cost resulted by the participation of a new project or such cost should be added to the distribution side cost of CEB. Further, the avoided cost of CEB must be estimated based on the cost of alternative power generation system, which CEB can adopt at the time new BEDP/IPP project will come into operation. In another word, the capital and operation cost of Fort George Power Plant was considered as the basis of avoided cost in the past, but in the near infuture the additional capacity of CEB can be a more economical large scale GTCC plant. This mean the purchase price of power from BEDP/IPP must be determined on the basis of such advanced system. Accordingly, the avoided cost of CEB must be estimated based on the envisaged type of plant, generation amount in near future and reasonable capital recovery rate, which should be same standard to that of entrepreneur of BEDP/IPP.

In case, the unit tariff is determined without consideration of plant size/project life generation amount the large plant have better return on investment than small one because of scale merit of the power plant.

In order to maintain the fair competion among potential BEDP/IPP entrepreneurs, Government/CEB (or a newly set-up regulatory body) should introduce "Competitive Bidding" for selection of the contractor for electricity supply to the national grid in future. CEB must publicate practical avoided cost of electricity supply of CEB for incremental demand during contracted period, say minimum ten years.

The avoided cost of CEB must include adequate capital recovery cost for the facilities to be constructed for the supply of incremental power demand in the same way as international contractor will require.

The I.P.P. including B.E.D.P. entrepreneur will permit to submit their bid for the supply of electricity during indicated contracted period with contracted supply conditions. The contractor's bid price must not exceed the avoided cost publicated by CEB. In case, CEB is already privatized, the bid will be managed by the regulatory body, and CEB will be included as one of bidders.

In order to conduct above mentioned competitive bid, the incentive to encourage bagasse energy use in the country should be reviewed carefully to avoid the conflict between I.P.P. bidder based on fossil fuel and I.P.P. based on Bagasse cum Coal scheme.

5.6 The Utilization of Coal for Bagasse Power Project

The first commercial bagasse power project, Flacq United Estates Limited (FUEL) project, and the succeeding other firm power supply projects, such as Beau Champ and Belle Vue, are all adopting the coal burning for power generation during the time bagasse production is scarce. (Firm Power Supply Contract)

The other type of bagasse power project either continuous & intermittent type supply power to CEB only the time their sugar mills are producing bagasse. This means, CEB must have power generation capacity to fulfill the supply capacity lowering of these continuous/intermittent during the off-cropping season unless the power supply from hydro-power plant can provide additional generation to fulfill this lowering. At present, the spare capacity to supplement the bagasse power during off-crop season is provided by the thermal power plant one way or others.

The use of coal during off-cropping season is intending to avoid the problem of intermission of power supply to CEB even the time the bagasse supply is scarce. In stead of using coal during off-crop season, use of bagasse, which is stored during cropping season, during off-crop season is contemplated in Mauritius and another sugar producing country. However, the storing of bagasse as it is has potential problem of spontaneous ignition and biological degradation, and therefore presently there is no commercial power plant which continue the power generation through a year based on bagasse fuel.

The use of coal by the bagasse power plant is intending to supply power constantly through a year and to bear the peak load demand of the country. In order to improve stability of power supply during peak demand period, the technology level of such Bagasse cum Coal plant must be equivalent to the modern power generation plant. This means the technology standard, which have been applied to the steam boiler/alternator of conventional sugar mill, are considered not satisfactory. The investment required to built a reliable Bagasse cum Coal power plant per kW become equivalent to the diesel engine plant unless the plant capacity is increased above 50-60 MW. The financial viability of the bagasse power project is very much depend on the way of reduction of investment per kW. The scheme of Bell Vue and the unrealized U.S.A. adopted high technology plant but large scale, and Beau Champ/Fuel adopted low investment plant by maximum use of second hand equipment. It is expected that there will be some difference on the supply stability between high technology plant and low cost plant.

In case of high technology plant, the additional cost per kW is reduced by adopting large scale plant. Because of limitation of the amount of bagasse to be collected economically by the large plant, the amount of coal to be used is tend to increase.

Naturaly the coal power generation is performed by the same plant of bagasse power generation, the energy efficiency of coal burning power generation by Bagasse cum Coal plant can not exceed 22-23% (net) because of the pressure limitation about 60 Bar, of the boiler for bagasse fuel. To the contrary, the modern large coal power generation, which apply "Super-Critical Pressure", steam pressure 240 Bar, or "Sub-Critical Pressure", steam pressure 160 Bar, can achieve about 35~40% energy efficiency.

In short, the future Bagasse cum Coal plant, which is to supply power constantly through the year require high investment per kW, and therefore a large scale plant 50-100 MW will be contemplated to maintain financial viability at satisfactory level.

This tendency indicates that future bagasse power project must be implemented together with the scale up of sugar mills by the integration of some of existing small/medium size sugar mills.

5.7 Bagasse Power and CEB

Foreword

The basis of the operation of CEB up to now is considered to be responsible to secure the economic and stable supply of electricity, which is crucial utility of the society for improving living standard of the nation and for supporting the development of industries in the country.

The construction of facilities required for generation, transmission and distribution of electricity and their operation and maintenance have been executed as a public sector corporation, which is not orienting profit generation.

This means that the financial soundness of the operation of CEB is not considered essential, because the fund for construction of a new facilities is provided by the Government and the operational loss is written off as required by the Government arrangement. In addition, the sales price of the electricity of CEB usually determined by the Government from the point of view of social security and a incentive for encouraging the entrepreneurs to invest in industrial and commercial sector of the country.

Therefore, the capital recovery from electricity sales could not generate necessary fund for new investment, and the increase of capital cost of old investment, which was used for the facilities constructed in the past, by the deterioration of exchange rate of Mauritius Rupee with the currency borrowed for the past investment caused significant financial loss in these year.

Further, the importance of development of bagasse energy utilization in the country, miscellaneous additional cost of CEB in relation to the implementation of BEDP projects tends to be absorbed by CEB as a Government agencies.

However, the recent international concern on the market orienting economy consider that the public sector operation neglecting financial soundness is disastrous to the national economy in the long term. This concept is adopted by the Government of Mauritius, and reforming of public sector operation are proceeding. In the long term prospect, the privatization of not only generation of electricity but also transmission & distribution of electricity is contemplated by the Government. In order to make possible such the transformation, the financial structure of CEB must be reformed. (Reference Chapter 1.1.4)

As the short term, the introduction of IPP to the power generation sector is envisaged. The relationship between CEB and BEDP has many identical relationship between CEB and IPP, and therefore the power supply from BEDP/IPP to CEB increase to the similar capacity of CEB the extra financial burden to CEB for the implementation of BEDP/IPP should not be absorbed by CEB. The adequate cost assessment must be conducted to prepare necessary arrangement to share the necessary cost among CEB generation sector, BEDP/IPP and CEB transmission/distribution sector.

The financial impact of BEDP/IPP implementation to CEB total system is described in the following paragraph. The following aspect must be taken into consideration in future before setting purchase price of electricity from BEDP/IPP.

(1) Cost of CEB spare capacity in relation to secure the stability of total supply system.
(2) Sharing of power supply during low demand period.
(3) The contract arrangement for operation load of large scale power project during the time the base load generation capacity exceeds the base load demand.
(4) The assurance of cost reduction of total system by introduction of BEDP/IPP.

5.7.1 Cost of CEB Spare Capacity in Relation to the Stability of Power Supply During Peak Demand Period

The current CEB investment plan is made to maintain, the power generation capacity to secure the power supply capacity to meet the peak demand, which normally appears December or January every year. The total capacity include the stand-by capacity, which will supplement the shortage of generation caused by unexpected failure of plants during the peak demand period. The peak demand in 1996 was estimated as 216 MW, and the total available capacity of CEB (excluding Fort George No.3) was considered as 246 MW. This include very possible capacity failure, which is estimated as 21 MW. This mean the real stand-by capacity was only 4% of total, and therefore, acceleration of the activation of

No.3 Fort George 28 MW was considered very necessary.

At present, the peak demand in AD2000 is estimated as 289 MW, and the No.4 Fort George (28 MW), Beau Champ (15 MW), Bell Vue (40-50 MW) are expected to be completed by the time. On the other hand some of old diesel power plant (18 MW) is to be closed down. It is believed that the real stand-by capacity should be 10% above available capacity at peak period minus probable failure capacity. It is considered effective capacity at AD2000 should be about 348 MW which include 10% stand-by capacity. This means the additional capacity of CEB and BEDP 93 MW (56 + 55 - 18) is not sufficient, and the reliability of FUEL and Beau Champ plant is not very high.

In order to secure the stable supply during peak demand period a new 25-30 MW Gas turbine generator may be required. The important point of the investment for such stand-by capacity is the non-profitable investment, because the stand-by machine will be used in principle only the time of failure of middle & base load plants during the peak demand period. This imply that capital recovery for the stand-by plant is very limited unless the unexpected failure of the all other plants are very frequent. When we assume these cost is born by CEB, this will be additional financial burden to CEB.

In order to equalize such burden to CEB and BEDP/IPP, the investment cost related to the stand-by equipment and the operation/maintenance cost of such equipment must be share by all power generation parties in accordance with the total sold kWh in the year. It is awared that normally some penalty is imposed to the failure of supply of BEDP/IPP, but this penalty normally cover a portion of loss incurred by such failure.

In the long future, the whole-saler of electricity will have contract kWh supply with multiple power generation parties which should be equivalent to the estimated demand for the contract period.

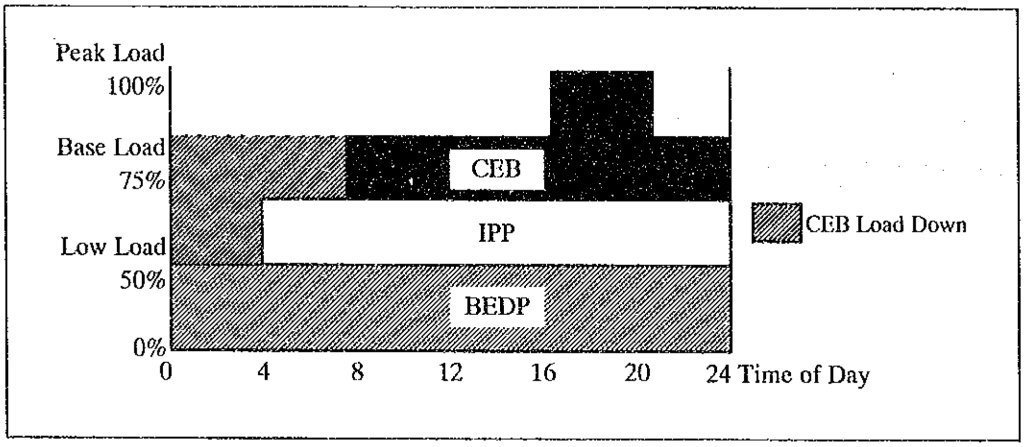
However, if demand exceeds the estimate unexpectedly, the additional supply in time is required. In addition, one of large generation plant may out of service unexpectedly. Unless additional supply is readily available power shading or black-out will be unavoidable.

Although, the party fail to supply the contracted amount is penalized, the adequate provision to maintain spinning-reserve capacity is required some where in the whole system.

It is not economical way let all the supplier to have 100% stand-by capacity for securing the supply. Therefore, the whole generation parties should cooperate to maintain the spare capacity at some point of generation system, and the cost of operation of such spare capacity should be shared by whole generation parties. This type of cost sharing must be taken into consideration to the purchase price of power from individual parties.

5.7.2 The Allocation of Power Supply During Low Demand Period

In case when all the BEDP/IPP projects are contracted on the basis of base load supply, this means as much as the plant can supply through the year will be purchased by CEB, this will cause significant reduction of income of CEB by very low annual generation of CEB base load plants. It is understood that the generation load control during low demand period is considered in the contract of Bell Vue, but the concept applicable to any BEDP/IPP must be established. In order to clarify the above problem, the daily load duration pattern and share of supply can be indicated in simplified way as bellow:



The compensation to CEB supply power should equivalent to the capital recovery + other fixed cost + variable cost, and the difference between the purchase price, which includes capital cost, CEB pay to BEDP/IPP and the CEB sales price can not exceed the CEB capital recovery + other fixed cost (Generation). This means the decreasing of CEB generation amount during low load period by giving priority to BEDP/IPP supply will results the financial loss of CEB.

In the future, the compensation (tariff) for the generated power of BEDP, IPP and CEB must be determined with the consideration of salable amount of each party for the long term.

In another word, the avoided cost of CEB, which will be the basis of kWh tariff to BEDP/IPP must be determined with due consideration on the salable amount of electricity as total generation system instead of the generation capacity of each project. When the full operation of BEDP/IPP is granted, financial compensation to the generation sector of CEB must be considered.

5.7.3 The Cost Increase of CEB When a New Large BEDP/IPP Commence Power Supply

The current rapid increase of power demand in the country is expected to continue in the near future. The construction of Fort George No.4 & No.5 and Bell Vue are currently planned. In the last few years, the realization of new-power plants in Mauritius experienced significant delay such as No.3 Fort George and the cancellation of the project as the case of Union St. Aubin case.

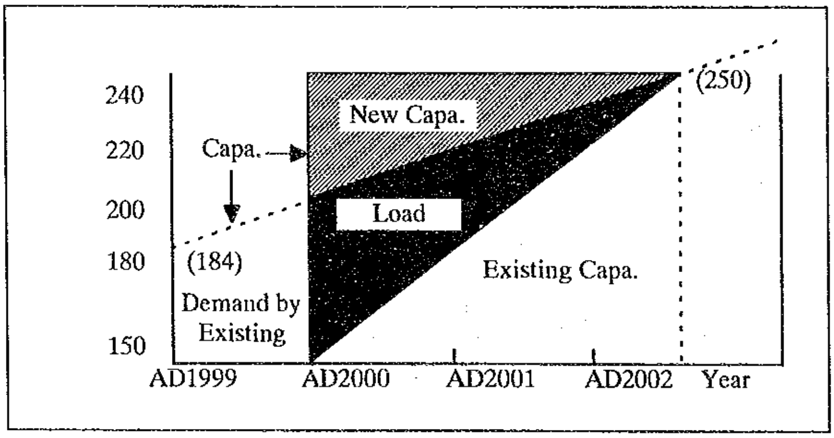
The construction of Fort George No.4 may faces similar problem when the finance arrangement for supplier's credit take time or the BOO contract takes time. The Bell Vue project also may take time when the project cost increase significantly by the additional cost for pollution mitigation or by additional cost for securing large amount of raw water or others.

In order to avoid the shortage of generation capacity around AD2000 by possible delay of new projects, CEB is considering to implement early construction of Gas Turbine, which is scheduled as AD2002 completion in present plan.

However, the early investment made to prepare the delay of other project is to be the wasting of money if the other project is completed as scheduled and the demand increase is not exceeding the current estimate. The advanced construction of the plant may results additional idle capacity as the whole generation system, and the interest for the money spend for the additional capacity will be wasted two-three years. This means, such cost required to secure stable supply of whole country in future should be considered the cost of all the power generation parties or the cost should be considered as a part of the distribution cost.

In addition, there is similar supply share problem to the power supply during low demand period at the time of commencement of operation of a new large scale plant. Since the total revenue of power generation is determined by the total sold kWh in one year, when the increase of supply capacity is exceeds the increase of sold kWh in one year some capacity of some party must sit idle in that year.

The increase of annual salable kWh around AD2000 is estimated at around 8.6%/annually, and therefore in average the increase of demand will be 17 MW. Accordingly, if the new plant capacity adds 50 MW to the total capacity, the increase to demand to catch up the 50 MW additional supply capacity will require almost three years. During the time the supply capacity exceeds demand, the share of supply between the new plant and the existing plants will be problem. The problem is indicated in the simplified form as bellows.



When we assume a new 50 MW plant commence supply at full load, at that instant the supply of existing plant will decrease by 50 MW. In the practice, the conditions are not so simple, but there are the possibility of increase of idle capacity. The idle will be average 25 MW every day in two and a half years average. The reduction of generation means increase of financial loss unless the actual cost of power generation exceeds the compensation given to the generation reduction.

Therefore, the operation load of a new large plant should be controlled to equalize the impact to CEB and other BEDP/IPP.

5.7.4 Prevention of Subsidy to BEDP/IPP

The currently proceeding BEDP and the planned development IPP schemes in Mauritius are primarily aiming the improvement operating efficiency of power sector of the country to reduce the cost of electricity supply from the national economy point of view. This means, the cost of purchase of electricity from BEDP/IPP must be lower than the real cost (economic) of electricity generation by the CEB power plants.

Further, the participation of IPP to the generation sector is expected to be a stimulation to CEB for improving his operating efficiency by creating an adequate competition between public sector and private sector in the similar industrial activities.

The national economic merit of bagasse energy utilization by BEDP must be appreciated, but this does not mean the purchase price of power from the BEDP can be set with creating additional cost to CEB.

In order to determine the purchase price of power by CEB from BEDP/IPP logically and transparently and to assess the adequate power sales price of CEB from long term national economy point of view, a permanent neutral team, which will have sufficient capability to do required assessment and provide adequate advice to MLGPU and Government in relation to electricity sector of the country should be set up in MLPU or a new organization which may be formulated for the total national energy sector administration.

It should be noted that the purchase price of electricity for new BEDP or IPP, which is very much different from the Union St. Aubin BEDP project in timing wise and project scheme wise, should not be determined by escalation and adjustment of the avoided cost estimated for this specific project at that time. In particular the cost of fuel at the battery limit to the power projects and the plant cost of power plant are keep changing and the impact of the change are significant to the cost of power generation, the tariff for existing projects and new project must be reviewed every year with due consideration both on the reasonable return to the investment for BEDP/IPP and the national economic point of view including the sustaining development concept of the country. The above mentioned a permanent task force for the electrical sector development will be very useful for effective development of new CEB, BEDP and IPP in Mauritius

5.7.5 The Power Generation Plant Mix in AD2000

The daily load duration data of Mauritius is indicating that (Ref. Figure 4.2.3) there is the short but highest evening peak at around PM 6:00 to PM 8:00, which last less than two hours, and other long lasting day peak during the office time which last from AM 8:00 to PM 6:00.

The evening peak gives highest demand 10-15% above the day peak demand, and the night load is only 50% of day time.

It is also observed that the seasonal change of power demand in the country is not significant but the total monthly consumption changes about 20% between highest month, normally December, and lowest month, normally September.

Based on the daily load duration pattern of the day, when peak demand of 1995 (highest in history) was appeared, the demand of average day of the year of AD2000 is estimated (Ref. Figure 5.7.1).

The data indicates that the demand in the average day can be met by base load capacity including 27 MW firm bagasse power plants but excluding Fort Victoria 1. However, the evening peak will require the base capacity plus peak capacity (Nicolay).

Therefore the additional capacity of BELLE VUE and Fort George No.5 will be needed as base load capacity after AD2000.

At around AD2003 the evening peak during high demand season may reach to 360 MW, and it is expected that the day peak will be 300-330 MW.

Accordingly, the existing CEB base load capacity excluding Fort George No.5 but plus firm bagasse power 67 MW, 254 MW, can not meet the demand. Further, Nicolay's peak shaving capacity, which exclude 34 MW as spare, also short at the peak hour in the peak season.
The additional base load capacity required to meet the demand during day peak in high demand season will be 20-30 MW.

The construction of additional capacity by Belle Vue project plus No.5 Fort George should be considered to fulfill the shortage of the day peak capacity. The use of continuous bagasse power principally during day peak time will supplement day peak capacity, but the increase of peak capacity, gas turbine, by 30-40 MW still seems required. This additional gas turbine will be converted to CCGT in future.
Depend on the close down schedule of obsolated plant in St. Louis and Fort Victoria the early construction of base load plant CCGT/DIESEL may also required.

However, the assessment of annual operation load of base load generation plants after Bell Vue and Fort George No.4 & No.5 is completed is required to determine the total system economy.

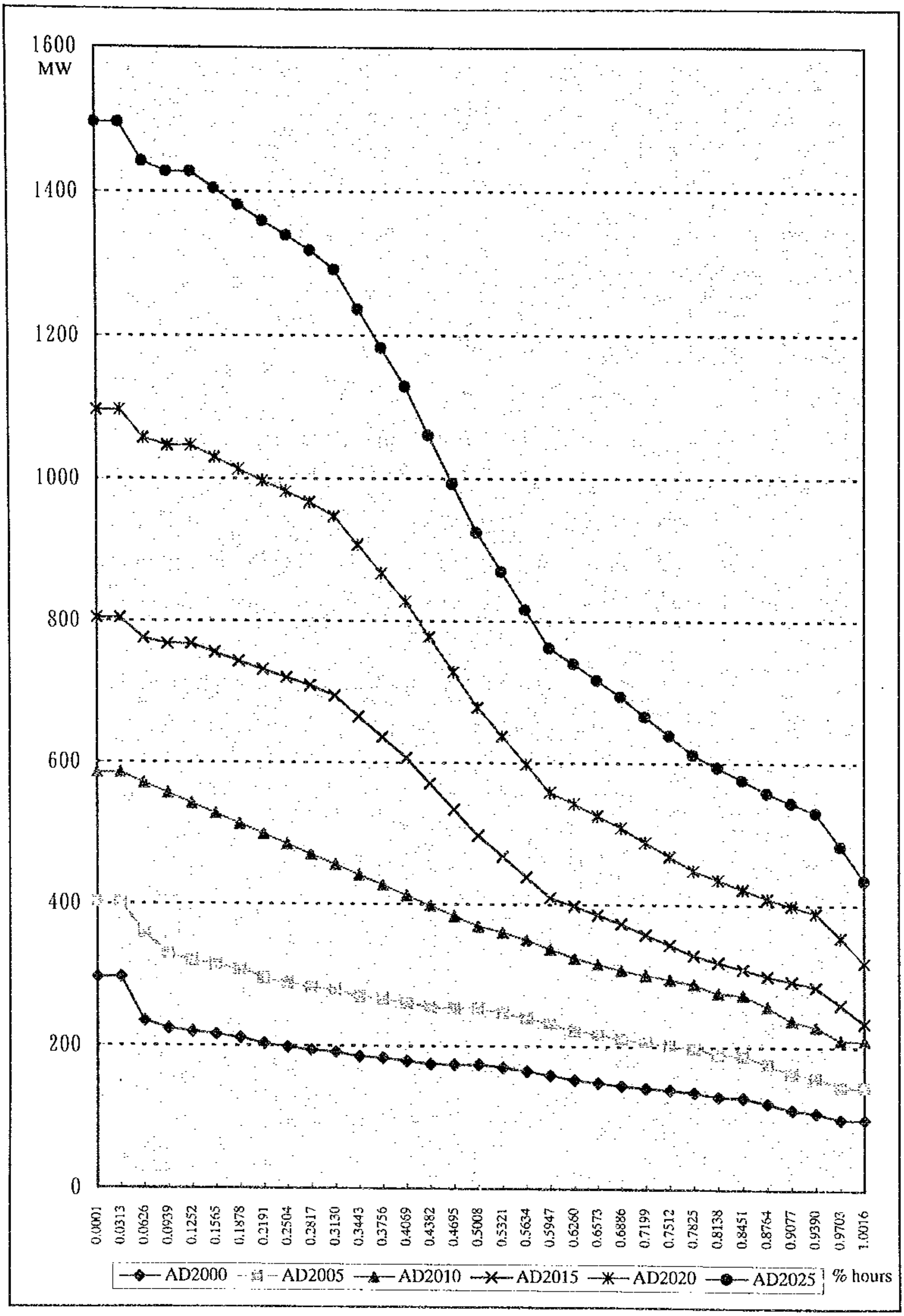


Figure 5.7.1 ANNUAL LOAD DURATION CURVE

5.8 New Prospect of Bagasse Power and Sugar Mills Integration

(1) Prospect of the modernization of Sugar Industry

Producing sugar cane and restructuring the sugar industry, including the sugar-making process, have been discussed in Mauritius ever since the early 1980s. The Mauritius Sugar Authority announced its "Restructuration Programme" in July 1984 and its "Action Plan for The Sugar Industry 1985-1990" in February 1985. The Action Plan involved the following three fields.

* Sugar cane production (as the agriculture sector)
  Improvement of productivity, effective utilization of cultivated land, reorganization of small-scale farms, etc.
* Sugar (raw sugar) mill (as the industry sector)
  Renewal of equipment, rationalization of production process, integration of factories, etc.
* Electricity generation (as the energy sector)
  Propulsion of utilization of bagasse as a fuel for power generation.

In particular, propelling the integration of sugar cane farms and sugar mills is the key to successful restructuring of the sugar industry. During the second field survey (conducted in last June), the Study Team heard the latest movements of restructuring and integration from the Mauritius Sugar Producers' Association (MSPA) and factory managers of five of the major sugar mill factories. The direction of integration has already been indicated by the above Action Plan. However, the progress of integration seems to be two to three years behind the schedule.

(a) Reorganization movement by region

Northern region:
There were six sugar mill factories in 1990. Since then, three of them have already been closed--SOLITUDE (in 1991), ST. ANTOINE (in 1993), and THE MOUNT (in 1995). Sugar canes which had been produced for SOLITUDE and THE MOUNT have been shipped to BELLE VUE and those for ST. ANTOINE have been directed

to MON LOISIR. So, the northern region now has three sugar-making factories (BELLE VUE, MON LOISIR, and BEAU PLAN). It is a common view that if another factory is to be closed in this region, BEAU PLAN will be the one. By the year 2000, BELLE VUE and MON LOISIR are expected to be the only sugar mill factories that remain in existence in this region.

Eastern region:

This region is where sugar cane was produced for the first time in Mauritius. It is said that the productivity of the crop in this region has generally been higher than elsewhere in the country. In 1990, there were three sugar mill factories--FUEL, BEAU CHAMP, and CONSTANCE. Though these three factories still exist, BEAU CHAMP is going to merge CONSTANCE. In the near future, therefore, FUEL and BEAU CHAMP will be the only factories that survive in this region. These two factories are large in scale and known as aggressive investors among the industry. So, it is expected that they will be sure to continue in existence even if the sugar mill factories of the country are integrated into five or so in the future.

Midwestern region:

The western region has a relatively small rainfall and contains some highlands. Therefore, the area of land where sugar cane is cultivated has not been very large. Besides, the central region has been increasingly urbanized and the limitations on sugar cane growing are becoming stringent (e.g., development of new residential areas and traffic congestion). REUFAC was closed in 1990, and now there are three factories -- MEDINE, HIGHLANDS, and MON DESERT ALMA. Of these, HIGHLANDS is very likely to be closed by the year 2000. Apparently, MON DEWSERT ALMA boasts the highest rate of factory automation (80%) in the country. It is generally believed, however, that when the factory is demanded to display the economy of scale, it will find it difficult to survive.

Southern region:

At present, this region has eight factories, including ROSE BELLE--the only state-managed factory. Of these, BEL OMBRE and ST. FELIX, which are located in the southernmost part, have plans to start centralizing cane to UNION ST. AUBIN for processing. By this, UNION ST. AUBIN plans to promote electricity generation using bagasse as much as possible and sell its electricity to CEB. The three factories--SAVANNAH, UNION ST AUBIN and RICHE EN EAU--have also signed an agreement this year for the selling of their electricity to CEB. Mon Tresor Mon Desert has not signed the agreement, but it is expected to be signed shortly. In the southern region, these four factories are considered to continue playing the central role for some time.

From the latest movements described above, it will be nine or so sugar factories that will survive through the reorganization and integration. Table 3.2.3 shows the results for 1994 and 1995 and forecasts future movements of the sugar industry of the country. This view of the Study Team coincides with the views of the managers of the major factories and MSPA Secretariat.

Estimation by MSPA

YEAR	1996	2000	2010	2020
No. of Sugar Mill	17	13	8	4 ~ 5
Cultivated Area (ha)	77,000	73,000	63,000	53,000
Cane Production (ha)	6.0 mill.	5.56.0	-- almost same	level --
Sugar Production (ton)	610,000	550,000600,000	-- almost same	level --

(2) Integration of the Sugar Mill and the Bagasse Power

Up to early 1990's, the bagasse power projects were promoted to export electrical energy to CEB, which was generated principally by the imported excess bagasse from adjacent sugar mills obtained through the improvement of energy efficiency, steam & power consumption, of sugar production. (This type of scheme is represented by the unrealized U.S.A. project and the currently implemented Bell Vue project.)

However, as it is described in preceding paragraph, recently the scale up of some of sugar mills by integrating the small size mills are envisaged and the pattern of sugar cane/bagasse production and consumption is changed. The production of bagasse is expected to be concentrated to the large scale sugar mills, where the large amount of sugar cane will be collected for processing to improve the efficiency of the sugar production by the merit of scale.

This tendency of the large scale sugar mill development will result the construction of economical bagasse power plant having large scale (30-50 MW). In addition, the application of high pressure steam generation (50-70 bar) for increase energy efficiency of the steam/power generation in the sugar mill, which will increase the exportable power, is appreciated by the people.

In the past, the application of high pleasure steam generation scheme to the sugar mill is not considered as economical because of the demerit of the smallness of the scale.

The future bagasse power project should be implemented in the sugar mill where the large amount of sugar cane is processed and can adopt the large scale power generation through high efficiency process, high pressure steam generation scheme.

Therefore, the future bagasse power project must be developed with the consideration of the co-ordination of sugar mills integration and the bagasse power plant construction.

5.9 Future Prospect of the Bagasse Power Project

It is expected that the development of bagasse power project in Mauritius will follow the stages as follows:-

Phase I : AD1996 - AD2005

Most of the existing sugar mills will continue the improvement of sugar processing plant in respect of energy efficiency by mean of small scale investment, which will be made to increase steam pressure of the boilers, introduction of condensation turbine, modification of alternator etc. to realize continuous power supply contract with CEB.

Further, some of the sugar mills as FUEL, BEAU CHAMP, BELL VUE expecting future scale up of their sugar mills will make significant investment to build a modern bagasse power plant, which is adequate to make possible the firm power supply contract with CEB.

Phase II : AD2005 - AD2015

The integration of sugar mill will proceed, and the available amount of bagasse of individual sugar mills will reach to the level of 200,000 - 300,000 ton annually. This condition will make possible the implementation of the large scale modern bagasse power plants with high energy efficiency. By this time the technology, which is enable the economic storage & reclaiming of bagasse for running the bagasse base power plant through the year and the use of alternative fuel to the coal burning during off-crop season, will be established.

Phase III : AD2015 - AD2025

During this period, the large scale modern power generation plants such as GTCC, high technology coal, etc. will be introduced to the country. This development will bring down the cost of electricity for base load supply, and the low energy efficiency coal base power (1.5 time of fuel is consumed by the coal burning in Bagasse cum Coal plant) will lose its economic ground including environmental justification.

However, the capital cost of the most of the bagasse power plants will be decreased very much by the progress of depreciation, and even the interruption of coal use which will resulting the operation of bagasse power plant only during cropping season, which means less annual sales volume, will still generate sufficient profit for sustaining its operation.

In addition, the improvement of technology to use bagasse during off-crop season and/or the integration of solid waste power generation, which will be inevitable in future for environment friendly disposal of solid waste in the country, will make possible the techno-economic feasibility of the bagasse power project without coal burning during off-crop season.

It is expected that the re-foresting project in the country infuture for improvement of natural environment and nurishing underground water resource will provide some renewable fuel for bagasse power plant during off-crop season.

5.10 Recommendation on the Bagasse Power Project

5.10.1 Foreword

The bagasse power project is very important to the Mauritius as efficient utilization of indigenous renewable energy sources, which is the desirable measure to improve the national security of energy supply, and as a measure to mitigate the possible global climate change by the increase of green house gas in the atmospheric environment.

It is estimated that the promotion of bagasse power project under the nation wide co-operation among the Government, sugar industry and CEB will make possible the increase of present (1995) annual power generation 125 Gwh to 648 Gwh.

However, the development of bagasse power project should not result the cost increase of national power supply and should not result any environmental deterioration to the national and global environment.

From this point of view, the use of coal during off-crop season of bagasse power plant must be considered as the intermediate scheme required to improve economy of the BEDP and the diversification of fuel sources up to the time the large scale modern coal base power projects are introduced to the country.

For the long term plan the reduction of coal use by bagasse cum coal power project should be pursued by utilization of another biofuel, such as fast glowing tree, development of economic bagasse storage technology and the integration of solid waste incineration.

It is concluded that the development of bagasse energy utilization without environmented pollution must be realized by the bagasse power plants equipped with adequate emission and effluent control facilities to mitigate the potential problem by coal burning during off-crop season.

In order to maintain the economic competitivity of bagasse power with coal use scheme, the scale up of the sugar mill and the bagasse power plant is very important. Therefore the national level integration plan of sugar mills and future development of the bagasse power plants must be co-ordinated.

In addition, the development of the technology for economic storage and reclaiming of bagasse is very much required to reduce coal dependency of the bagasse power project.

5.10.2 The Union St. Aubin Group (South Area Sugar Mills)

The project is the consequence of the interruption of the old USA project, which was promoted starting in the early 1990s among MEW, CEB and USA.

The intended use of the bagasse of USA itself and the surplus bagasse of the adjacent sugar mills by the USA 22 MW firm supply project has now shifted to the continuous power supply from four sugar mills, in which the new power generators will be installed, making continuous power supply in each mill possible. The investment required for this modification is considered to be the equivalent of several million US dollars.

This type of project can supply power only during the cropping season unless provisions for surplus bagasse storage and reclaiming are made. This means that this capacity may not be included in the figures for peak load capacity, which requires power to be available throughout the year. The tariff applicable to these supplies should be equivalent to the energy cost saved by CEB by purchasing the bagasse power. The energy cost will differ depending on the type of power plant that CEB could stop operating while power from the sugar mill is purchased. This project is adequate to quickly utilize the avairable bagasse in the region, but due to the small size of each of the sugar mills, fundamental modernization of both sugar mills and power plants will not be possible.

In another word, the investment for power plant modifications in this case should be minimized by making fullest use of the existing facilities and second-hand equipment. When the integration of these mills is fully implemented, the construction of a large modern bagasse power plant, which will process all the cane avairable in this region, will become feasible.

5.10.3 BEAU CHAMP (Firm Supply)

The current Beau Champ project is following the scheme of the FUEL project, which means that the total bagasse produced during the cropping season is used for power generation and during the off-cropping season either imported surplus bagasse or coal is used for power generation. The design is similar to the old U.S.A. project, but Beau Champ management intend to introduce second-hand boilers, turbines (extraction/condensation) and generators in order to reduce their capital investment. This means that fundamental modernization of the total power plant will not be undertaken.

However, the expansion of sugar processing capacity, which allows the absorption of additional cane from adjacent Constance, is included in this modification scheme. This arrangement will improve the economics of the project by the direct use of bagasse produced in its own mill, thus avoiding the transportation of surplus bagasse.

However, there is one question regarding the reliability of this second-hand equipment, used as it is, for the peak load supply generating system. The cost involved in providing for sufficient stand-by capacity or relief supplies in case this plant fails during peak electrical demand periods must be assessed.

This project should be implemented as soon as possible in order to effectively use the bagasse from Beau Champ and Constance very quickly without a huge capital investment. (The present boiler pressure of Constance at some 20 kg/cm2 and that of Beau Champ at 30 kg/cm2 will be improved to about 40 kg/cm2.)

5.10.4 BELLE VUE

Currently Belle Vue is proposing to build a 40 MW (cropping), 50 MW (off-cropping) firm supply project, but the proposed scheme should be scrutinized as the following problems may be involved.

Limitation of Bagasse Availability

The production of bagasse in the country in 1995 is shown in Table 5.10.1. When the amount of bagasse used for power generation by FUEL, Beau Champ (including Constance), Medine, U.S.A. and the other 3 mills as well as the bagasse produced far south from Belle Vue, (for which the cost of transportation will make it uneconomical for power generation) are excluded, the bagasse available to the Belle Vue project will be as follows: (Ref. Figure 5.10.1&2)

Belle Vue include Mount (Total)	109,720	ton
Mon Loisir (Surplus)	22,274	ton
Beau Plan (Surplus)	13,911	ton
Mon Desert Alam (Surplus)	16,344	ton
	162,249	ton

Even in the case where bagasse from the HIGHLANDS is transported to Belle Vue, the total amount will be about 160,000 tons/y. If the cropping season is assumed to be 150 days, 42 tons of bagasse will be consumed every hour. The amount of power which can be exported to CEB will thus be approximately 18 MW. This means that the expected large scale power plant will require more than fifty percent of its power to be generated from coal.

It is our understanding that it is expected that annual power generation of this project will depend about 75% on coal. This means that the project is already not a Bagasse cum Coal project but a coal-fired power plant supplemented by bagasse instead. Economic power generation based on coal requires modern improved technology, which is essential in order to improve energy efficiency and to eliminate environmental problems.

Table 5.10.1 CURRENT AVAILABILITY OF BAGASSE BY SUGAR FACTORY

Unit : tons

	Sugar Factory	Available Cane	Available Bagasse	Steam Required	Bagasse Used Factory	Currently Available Bagasse
1	Belle Vue	335,758	90,655	151,091	71,948	18,707
2	Beau Plan	195,323	52,737	87,895	41,855	10,882
3	Mon Loisir	366,598	98,981	164,969	78,557	20,425
4	Mount	186,144	50,259	83,765	39,888	10,371
	North Area	1,083,823	292,632	487,720	232,248	60,384
5	FUEL	599,653	161,906	269,844	128,497	33,409
6	Beau Champ	408,830	110,384	183,974	87,606	22,778
7	Constance	210,122	56,733	94,555	45,026	11,707
8	Mon Desert Alma	283,602	76,573	127,621	60,772	15,801
	Central–East Area	1,502,207	405,596	675,993	321,902	83,694
9	Union St. Aubin	257,235	69,453	115,756	55,122	14,332
10	Bel Ombre	132,669	35,821	59,701	28,429	7,392
11	St. Felix	118,277	31,935	53,225	25,345	6,590
12	Riche en Eau	251,881	68,008	113,346	53,975	14,033
13	Mon Tresor	259,214	69,988	116,646	55,546	14,442
14	Savannah	272,120	73,472	122,454	58,311	15,161
15	Britannia	177,023	47,796	79,660	37,934	9,863
16	Rose Belle	172,579	46,596	77,661	36,981	9,615
	South Area	1,640,998	443,069	738,449	351,642	91,427
17	Medine	389,441	105,149	175,248	83,452	21,697
18	Highlands	196,410	53,031	88,385	42,088	10,943
	West Area	585,851	158,180	263,633	125,540	32,640
	Total	4,812,879	1,299,477	2,165,796	1,031,331	268,146

Calculations:

(a) Total canes crushed = Available cane

(b) (Available cane x Percentage Bagasse per ton cane : 30.0%) x (1–Startup losses of 10%) = Available Bagasse

(c) (Available cane x kg steam required to process raw juice per ton cane : 450kg/ton cane)/1,000 = Steam required

(d) Steam required/Steam produced at each factory per ton Bagasse = Bagasse used factory

(e) Available Bagasse – Bagasse used factory = Excess Bagasse currently or potentially available

Table 5.10.2 CRUSHING PERIOD (1995)

Sugar Factory	Available Cane	Available Bagasse	May	June	July	August	September	October	November	December
1 Belle Vue	335,758	90,655								
2 Beau Plan	195,323	52,737								
3 Mon Loisir	366,598	98,981					N.A.			
4 Mount	186,144	50,259					N.A.			
North Area	1,083,823	292,632								
5 FUEL	599,653	161,906								
6 Beau Champ	408,830	110,384								
7 Constance	210,122	56,733					N.A.			
8 Mon Desert Alma	283,602	76,573								
	1,502,207	405,596								
9 Union St. Aubin	257,235	69,453								
10 Bel Ombre	132,669	35,821					N.A.			
11 St. Felix	118,277	31,935					N.A.			
12 Riche en Eau	251,881	68,008								
13 Mon Tresor	259,214	69,988					N.A.			
14 Savannah	272,120	73,472								
15 Britannia	177,023	47,796					N.A.			
16 Rose Belle	172,579	46,596								
South Area	1,640,998	443,069								
17 Medine	389,441	105,149								
18 Highlands	196,410	53,031								
West Area	585,851	158,180								
Total	4,812,879	1,299,477								

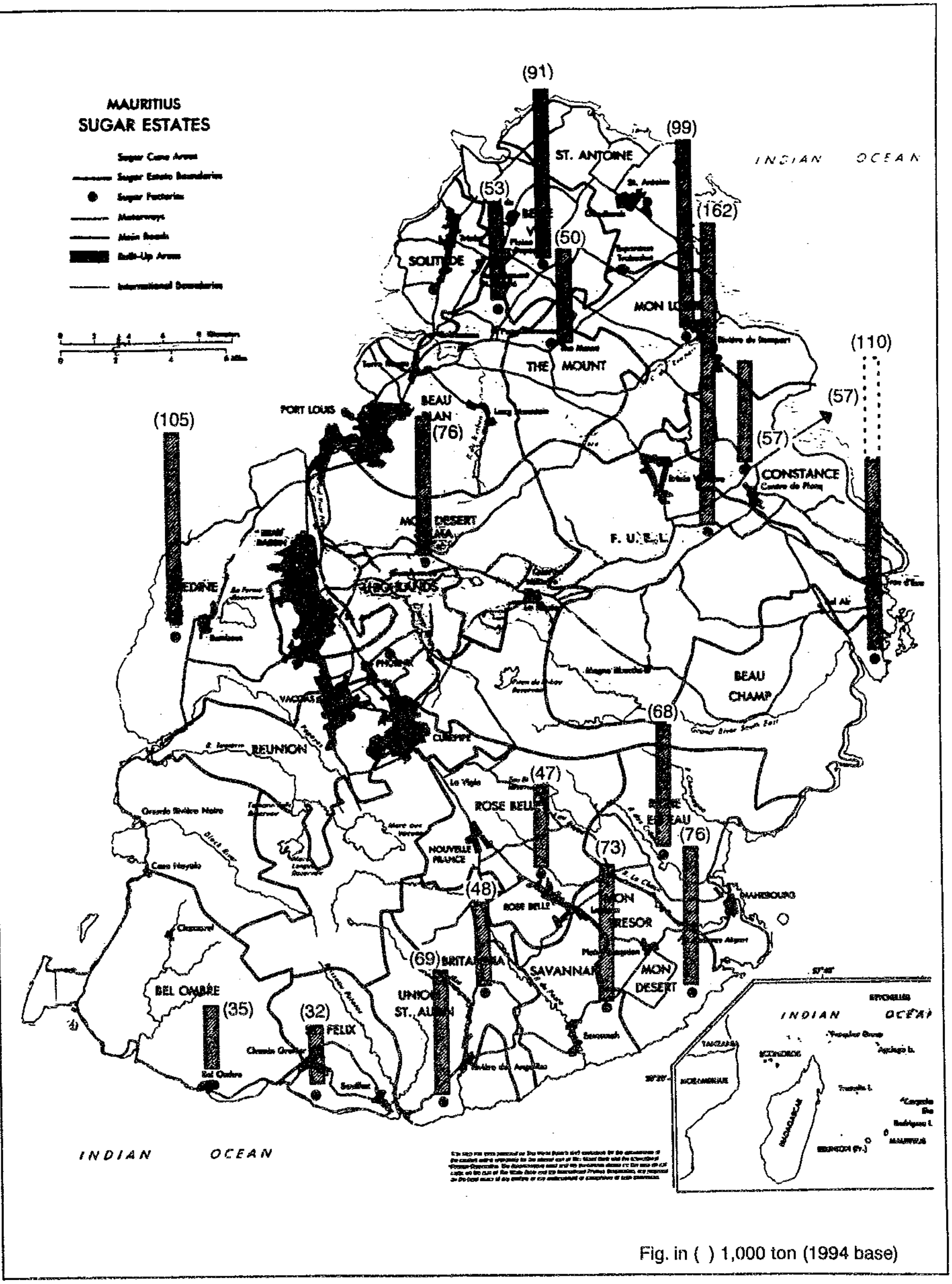


Figure 5.10.1 BAGASSE PRODUCTION

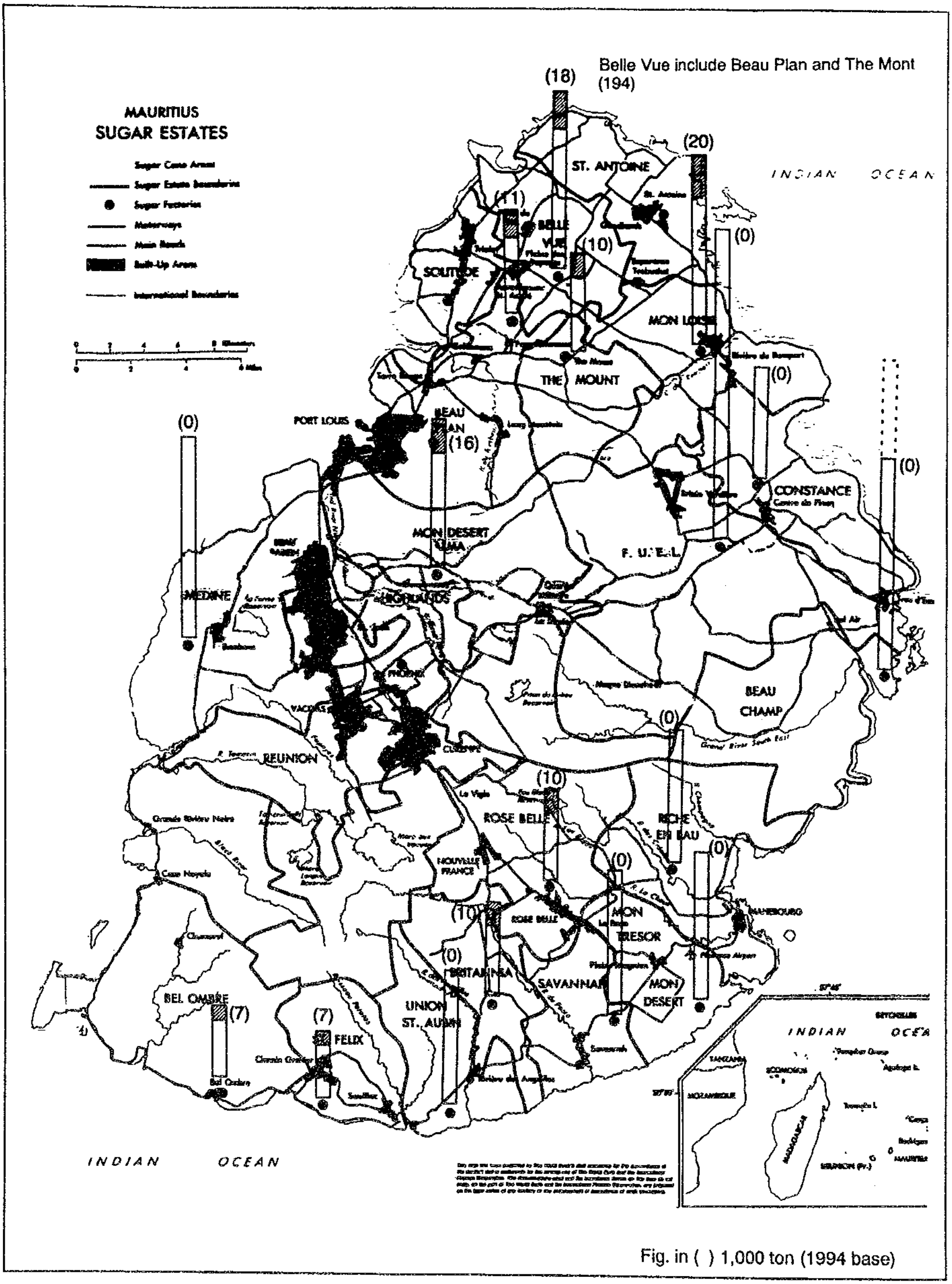


Figure 5.10.2 SURPLUS BAGASSE (Exclude Existing Power Use)

◆ Chapter 6 Energy Policy and Institutional Framework ◆

Chapter 6 Energy Policy and Institutional Framework

6.1 Current Energy Policy Framework

6.1.1 Outline of Energy Policy and Institutional Framework

In Mauritius, there are three laws regulating the energy sector, Electricity Act of 1939, Central Electricity Board (CEB) Act of 1964 and Petroleum Act. Electricity Act covers a whole range of electricity business, while CEB Act defines CFB's organization and activities. Petroleum Act defines regulations on the production, production, storage, sale, export and import, so on. On the other hand, there are no laws and regulations covering such as new energy development, promotion of energy saving activity, and electricity business by the private sector, so far. The government is now reviewing the above two acts which have passed a relatively long period of time since their enactment and plans to make a new, comprehensive energy bill by the end of this year. (Ref. para 1.1.3)

The government is implementing various energy-related programmes and projects. First of all, as part of the domestic energy resource development plan which has formally been adopted as national policy, Bagasse Energy Development Programme (BEDP) is being implemented under assistance of the World Bank, UNDP, and other international organizations. Its main objectives and areas of investment are as follows:

<Objectives>

a) Expansion of power generation capacity using bagasse
b) Promotion of use of biomass fuels produced by the sugar industry

<Major areas of investment>

- New bagasse-cum-coal power plants
- Improving sugar mill efficiency
- Bagasse transportation and handling equipment
- Technological development and training
- Institutional strengthening

Other new energy resource development initiatives include a existing wind power generation project and a subsidy programme on use of solar heaters. Nevertheless, it is not clear how these individual programmes and projects are linked to the national energy policy. In other words, the country has still to develop a comprehensive and coordinated energy policy.

Meanwhile, the government seems to be consistent in energy policy in terms of its underlying context. President Cassam Uteem, in his speech at the first parliament session after the general election in December 1995 (Note[1]), addressed the following policy agenda as the basic direction of the national energy policy:

a) Government will encourage a more systematic and strategic approach to future developments in the energy sector including a medium-term and a long-term energy plan, with a greater participation of private capital. The Central Electricity Board will be restructured for greater efficiency and the Central Electricity Board Act will be updated.

b) More efforts will be made to optimise the use of renewable sources of energy such as bagasse and solar energy. Energy-saving habits among consumers will be actively promoted.

The policy direction clearly forms the basis of the current energy policy as evidenced in programmes and activities planned or carried out by related government agencies.

6.1.2 Outline of Electricity Laws

Electricity Act was promulgated in July 1939, when Mauritius was under the rule of the British Common Wealth and did not have its own governmental organization. The act essentially provides for the establishment of a Central Electricity Board and operation and management of electricity business under the board's supervision. It covers limited areas of electricity business, mainly consisting of i) grant of permit, ii) tariffs, iii) right of undertakers, iv) business operation, v) management and supervision system, and vi)

Note [1] : Address by His Excellency The President at the Opening of the First Session of the Second National Assembly of the Republic of Mauritius, on January 12, 1996.

penalties.

Under the act, several power companies including private undertakings started commercial operation. Subsequent growth of the electricity industry and evolution of related laws are not known due to the lack of literature or report, until December 1952 when the current CEB was established by merging private undertakings. In 1956, CEB became the sole public supplier of electricity in the country, responsible for electricity supply throughout the island, as continued to this date.

As there was no law to regulate the new CEB at that time, Central Electricity Board Act (CEB Act) was established in January 1964. The act was revised several times and continues to serve as the governing law. CEB Act defines CEB as a legal entity which is responsible for generation, transmission and distribution of electricity throughout the country. Mauritius became independent in February 1968, after then the government organization was developed, and CEB Act was revised to allow representatives of related agencies to become CEB's board members and reflect their policy in CEB's management, e.g., resulting in an increasing role of the Ministry of Energy (current MLGPU) in power development planning and that of the Ministry of Finance in the areas of investment and finance.

Yet, CEB Act is only concerned with CEB's organization, activity and legal status, and does not provide for other electricity suppliers. Although suppliers other than CEB are supposed to obtain license and operate pursuant to the provisions of Electricity Act, the act does not set forth any rules or standards to address the currently contemplated changes, such as the entry of new suppliers under the presence of the sole supplier. More importantly, CEB Act warrants monopoly of electricity business within the country, which must be revised to encourage new entries. To implement energy policy in response to the changing environment, therefore, the country requires a new electricity business law or energy law.

A new electricity business law should be naturally reviewed in conformity with new situation. In a concrete way, the following matters are expected to review from a new point of view.

(1) Reviewing a new definition on electricity and energy related words.
(2) Reviewing a monopoly of electric utility supply business operator and the expansion of potential business operator.
(3) Authorizing a wholesale electric utility supply business and stipulating the suply conditions.
(4) Stipulating the standard of various electric utility supply system and that's conditions.
(5) Reviewing a role of the government, and private sector.
(6) Coordination among electric utility supply business operator.
(7) Introducing an incentive system for promoting self-effort by electric utility supply business operator for business efficiency.

6.1.3 Energy Policy and Government Organization

At present, a government agency responsible for energy policy making, supervision and guidance of the energy industry in the country is the Ministry of Local Government and Public Utilities (MLGPU), which is generally referred to as the Ministry of Energy, an abbreviation of the former name which was changed to the present name in December last year (Note[2]). MLGPU essentially inherited responsibilities of the Ministry of Energy, while those related to local government were added. Its major areas of responsibility are summarized as follows:

- Local government matters
- Electricity including supervision of CEB
- Water resources including supervision of Central Water Authority
- Postal services

Even an energy policy administration, a number of agencies, including the Ministry of Industry and Commerce (MIC), the Ministry of Finance (MOF), the Ministry of

Note [2]: The name of government agencies in Mauritius has been frequently changed. In December 1995 when implementation of this study was agreed between the two government, MLGPU was called the Ministry of Energy, Water Resources and Postal Service, which was renamed to the Ministry of Energy and Water Resources in March 1996, then to the present name in December.

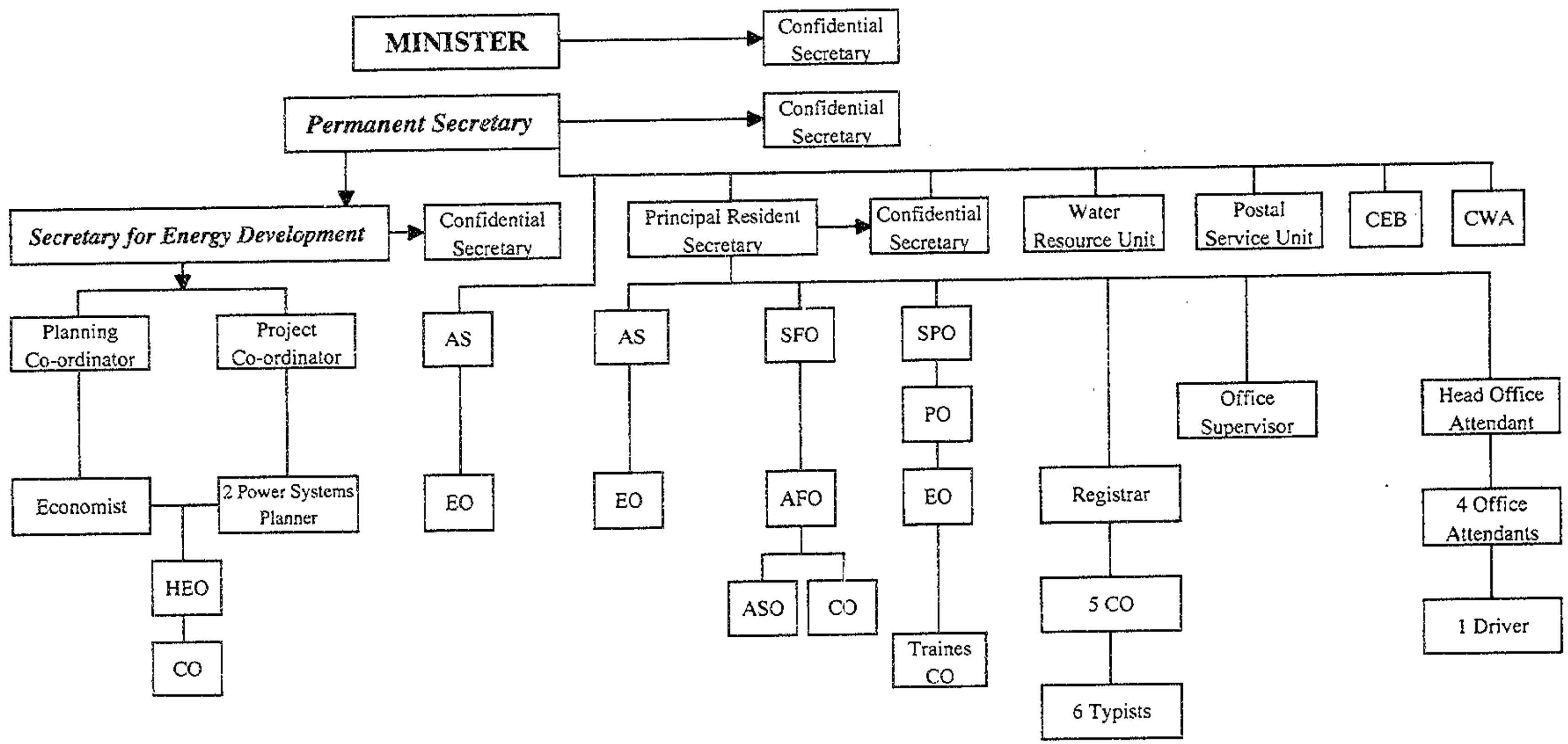
Agriculture and Natural Resources (MANR) or the Mauritius Sugar Authority (MSA), are assuming some roles in the fields of energy price policy and bagasse utilization program. Also, MLGPU has authority to supervise and guide the energy industry, however it is rather limited for the following reasons. Therefore, MLGPU's authority is virtually limited to the electricity sector. In fact, it is evidenced from MLGPU's current organization and the fact that it has formally been called "the Ministry of Power" (see Fig.6.1.1 for MLGPU's organizational chart). Besides, MLGPU's current staffing indicates that it does not have enough manpower to fulfill all the responsibilities related to the entire energy industry even if it is mandated to do so.

In Mauritius, energy prices other than electricity are designated as goods subject to price control that is conducted for the purpose of protecting domestic industries or stabilizing prices. For the purpose of price control, most of imported energy resources are distributed through State Trade Corporation (STC) under MIC. MLGPU is involved in the discussion stage of the process to determine prices of energy-related products, but energy price policy is primarily under the control of MIC which is the policymaking organization for price control, and MOF which is involved in tariff policy.

Similarly, promotion of exploitation of bagasse fuels is an important issue in energy policy, which is carried out under Bagasse Energy Development Programme (BEDP). Nevertheless, commercial use of bagasse as a viable energy resource has various implications in addition to the development of domestic energy resources, the rationalization of the sugar industry and industrial restructuring to achieve international competitiveness, where NANR and MSA play critical roles on account of their strong ties with industries.

In summary, the major problem related to the country's energy policy is found in the lack of organic linkage and coordination among various energy-related programmes and projects conducted by different agencies due to departmentalism, while MLGPU is struggling with coordinate them fully for convergence to the medium- and long-term national energy policy. Also, MLGPU does not have enough energy data required as the basis of formulating and evaluating the medium- and long-term policy. Clearly, the success of MLGPU's future tasks such as promotion of IPPs in the electricity sector hinges upon coordination with related agencies. In this sense, a major challenge is to develop the environment where MLGPU can secure and maintain the leadership and fulfill required functions it assumes.

Organization Chart for Administrative and Technical Staff



HEO : Higher Executive Officer
CO : Clerical Officer
EO : Executive Officer
AS : Assistant Secretary
SFO : Senior Finance Officer

AFO : Assistant Finance Officer
ASO : Assistant Stores Officer
SPO : Senior Personnel Officer
PO : Personnel Officer

As of Dec. 1, 1996

Figure 6.1.1 MINISTRY OF LOCAL GOVERNMENT AND PUBLIC UTILITIES

6.2 The Present Activity and Task of CEB

In this section, the performance of CEB company operation will be analyzed and evaluated in the light of mainly financial perspectives. The results will be utilized for the discussions of future energy pricing and restructuring of CEB.

6.2.1 Financial Statement Analysis of CEB

The financial analyses are focusing on seven items; balance sheet, income statement, cash flow, profitability, risk, growth, and productivity. The benchmark for assessing the CEB financial position will be the ratios of other firms in the utility industry. The financial data prepared for these analyses are Comparative Balance Sheets (1992-1995), Comparative Income Statement (1993-1995), and Comparative Statements of Cash Flows (1993-1995).

(1) Balance Sheet

The overall trend on the balance sheets from 1993 to 1995 is shown in the following table.

Table 6.2.1 CEB BALANCE SHEETS

	1992	1993	1994	1995
Assets				
Current Assets:				
Cash	34,080,025	89,801,104	111,994,046	79,230,813
Stocks	147,970,490	187,349,604	274,902,574	308,005,742
Prepayments	22,780,027	36,176,934	50,237,669	49,552,235
Accounts receivable	280,518,923	306,136,648	350,945,234	376,423,836
Capital works in progress	375,779,896	23,209,606	230,171,919	363,055,922
Investment	0	0	3,500,000	0
Total Current Assets	861,129,361	642,673,896	1,021,751,442	1,176,268,548
Noncurrent Assets:				
Fixed Assets	9,866,411,415	10,643,606,826	10,890,579,793	11,382,996,215
Accumulated Depreciation	(4,708,905,639)	(5,040,223,540)	(5,403,349,369)	(5,762,304,884)
Total Noncurrent Assets	5,157,505,776	5,603,383,286	5,487,230,424	5,620,691,331
Total Assets	6,018,635,137	6,246,057,182	6,508,981,866	6,796,959,879
Liabilities and Shareholders' Equity				
Current Liabilities:				
Accounts payable	92,156,645	177,400,658	207,477,356	153,061,676
Bank Overdrafts	72,833,294	56,285,817	17,900,402	0
Current Portion of Long Term Loans	205,418,559	174,804,512	149,526,098	124,768,746
Total Current Liabilities	370,408,498	408,490,987	374,903,856	277,830,422
Noncurrent Liabilities:				
Long term Loans, Net of current Portion	2,781,135,852	2,808,548,450	3,050,026,860	3,371,471,158
Total Noncurrent Liabilities:	2,781,135,852	2,808,548,450	3,050,026,860	3,371,471,158
Shareholders' Equity				
Common Stock	2,700,311,234	2,740,453,845	2,806,295,816	2,844,889,939
Other reserves	0	670,856,197	670,856,197	670,856,197
Retained Earnings	166,779,563	(382,292,297)	(393,100,863)	(368,087,837)
Total Shareholders' Equity	2,867,090,797	3,029,017,745	3,084,051,150	3,147,658,299
Total L. & E.	6,018,635,147	6,246,057,182	6,508,981,866	6,796,959,879

Total assets have been increasing steadily from 1992 to 1995 because of the solid investment in new power plants. Noncurrent liabilities also have been increasing because of the heavy borrowing on the new plants such as Fort George #2. In 1993, the extraordinary item of about 670 mil. Rs. was declared in Other Reserves. This is the accumulated on Government loans which were written off in the Board's books in 1992, and will be used to issue equity shares to the Government of Mauritius in the event of a change in the legal status and capital structure of CEB. It is also important to note that the cyclone in 1994 gave a serious damages to the CEB facilities, causing nearly 6.5 mil. Rs. additional cost for the repair.

(2) Income Statement

The relationship between the revenue and the expense of CEB is as given in the table below.

Table 6.2.2 CEB INCOME STATEMENT

	1992	1993	1994	1995
Sales Revenue	1,414,326,596	1,630,263,887	1,777,807,731	1,958,194,766
Less Expenses:				
Cost of Goods Sold	904,009,453	936,351,350	1,049,386,097	1,071,761,849
Operating cost(incl. Depr. & Exchange loss)	488,810,872	485,295,945	601,544,285	695,215,305
Interest	104,384,383	161,142,715	166,284,910	203,347,141
Total	1,497,204,708	1,582,790,010	1,817,215,292	1,970,324,295
Exceptional Item	0	42,386,438	0	0
Other income	25,482,665	36,284,229	34,130,174	45,012,620
Extraordinary Item	736,697,703	0	0	0
Total	762,180,368	78,670,667	34,130,174	45,012,620
Loss incurred in Rodrigues	(5,983,783)	(4,360,206)	(5,531,179)	(7,870,065)
Net Income before Taxes	673,318,473	121,784,338	(10,808,566)	25,013,026
Income Tax Expense	0	0	0	0
Net Income	673,318,473	121,784,338	(10,808,566)	25,013,026
Exclude Extraordinary Item	736,697,703			
Net	(63,379,230)			

Income tax is exempted for CEB. The sales revenues have been increasing significantly over these four years while the increase of cost of goods sold slowed down . However, the net income increased in 1993 but turned into the red in 1994. The interest payment has played a significant part in the expenses, increasing every year. The loss incurred in Rodrigues has been increasing approximately at the same rate of the sales. The loss on exchange has been accounted every year, reflecting the actual depreciation of Rupee.

(3) Cash Flow

The net change in cash from the company operations of CEB has been analyzed. The three-year cash flow from 1993 to 95 is indicated in Table 6.2.3.

Table 6.2.3 CEB CASH FLOW

	1993	1994	1995
Operations:			
Net Income	121,784,338	(10,808,566)	25,013,026
Additions:			
Depreciation Expense Add-back	331,317,900	363,125,829	358,955,515
Decrease in Capital Works in progress	352,570,280	(206,962,313)	(132,884,003)
Increase in Accounts Payable	85,244,013	30,076,698	(54,415,680)
Total Additions	769,132,193	186,240,214	171,655,832
Subtractions:			
Increase in Stocks	39,379,114	87,552,970	33,103,168
Increase in Prepayments	13,396,907	14,060,735	(685,434)
Increase in Accounts Receivable	25,617,725	44,808,586	25,478,602
Decrease in Bank overdraft	16,547,477	38,385,415	17,900,402
Decrease in Current Portion of LT Loan	30,614,047	25,278,414	24,757,352
Total Subtractions	125,555,270	210,086,120	100,554,090
Cash Flow from Operations	765,361,261	(34,654,472)	96,114,768
Investing:			
Increase in Fixed Assets	(777,195,411)	(246,972,967)	(492,416,422)
Increase in Investment	0	(3,500,000)	3,500,000
Cash Flow from Investing	(777,195,411)	(250,472,967)	(488,916,422)
Financing:			
Increase in Noncurrent Liabilities	27,412,598	241,478,410	321,444,298
Increase in Common Stock	40,142,611	65,841,971	38,594,123
Dividends	0	0	0
Cash Flow from Financing	67,555,209	307,320,381	360,038,421
Net Change in Cash	55,721,059	22,192,942	(32,763,233)

CEB has no dividends for the government. The depreciation of assets is a large factor in the cash flow of operations, holding more than ten times of net income in 1995. On the other hand, CEB has invested heavily on the fixed assets, especially these couple of years. The general tendency for these three years is that while the profit of cash flow from operation is too small to cover the cash for investment, CEB borrows most of the funding necessary for it. This spurs the increase of net long term loan and also the exchange loss.

(4) Profitability

The profitability of CEB has been analyzed in terms of the three ratios; Rate of return on assets, Total assets turnover ratio, and Return on common shareholders' equity.

1) Rate of Return on Assets

The rate of return on assets measures a firm's performance in using assets to generate earnings independent of the financing of those assets.

Rate of return on assets =

(Net Income plus Interest Expense Net of Income Tax Savings)/(Average Total Assets)

Rate of return on assets for the three years has been from 2.4 to 4.6%. Given the rather high market interest rate in Mauritius (approximately from 10-15%, depending on the industry), the figure for CEB is not high.

2) Total Assets Turnover Ratio

The total assets turnover ratio measures a firm's ability to generate revenues from a particular level of investment in assets.

Total assets turnover ratio = (Revenues)/(Average Total Assets)

Total assets turnover ratio has been slightly improving for these three years. From a viewpoint of comparison with other companies in the industry, the ratios do not necessarily indicate high efficiency of generating revenue. (Tokyo Electric Power company has 37% in 1993, for example.)

3) Return on Common Shareholders' Equity

The rate of return on common shareholders' equity measures a firm's performance in using assets to generate earnings.

The rate of return on common shareholders' equity =

(Net Income - Dividends on Preferred Stock)/(Average Common Shareholders' Equity)

Return on shareholders' equity also remains low value for the three years, ranging from 3.39 to 4.48%. The rates fluctuate depending on the amount of investment. These figures show a flimsy structure for generating income for CEB.

(5) Risk

The financial risks involved in the CEB company operations has been evaluated through calculating the following ratios; Current ratio, Quick ratio,

1) Current ratio
   Current ratio assesses short-term liquidity risk.
   Current ratio = (Current Assets)/(Current Liabilities)

   Current ratios have improved from 1.57 to 4.23 for the three years. Since current ratio generally expected for a company would be more than 2.0, the ratio for CEB indicate the healthy short-term liquidity position.

2) Operating Cash Flow to Current Liabilities
   Operating cash flow to current liabilities also measures the liquidity of a firm.
   Operating cash flow to current liabilities =
   (Cash flow from operations)/(Average current liabilities)

   Operating cash flow to current liabilities, especially for 1994-1995 is thought to be less than the expected level for a financially healthy company (usually 40%).

3) Debt-equity Ratio
   Long-term liquidity analysis has been carried out by Debt-equity ratio.
   Debt-equity ratio = (Total liabilities)/(Total liabilities plus shareholders' equity)

   Debt-equity ratios are around 50% for the three years, which is low value for a utility company. However, this does not always suggest CEB's healthy long-term financial position. This leads us to the discussion on other ratio analysis like cash flow from operations to total liabilities ratio and interest coverage ratio.

4) Cash Flow from Operation to Total Liabilities
   The debt-equity ratio does not consider the availability of liquid assets to cover various levels of debt. The cash flow from operation to total liabilities overcomes

this deficiency.

Cash flow from operations to total liabilities =

(Cash flow from operations)/(Average total liabilities)

Cash flow from operation to total liabilities are also affected by the fluctuation of the net income structure. Since reference value for this rate would be more than 20%, the ratios for CEB are lower than expected.

5) Interest Coverage Ratio

Interest coverage ration also evaluates long-term liquidity risk.

Interest coverage ration =

(Net income before interest and income taxes)/(Interest expense)

In order to cover the interest payment without a financial difficulty, a company is anticipated to have the value 2.0 at least. CEB, however, stays below 2.0 for the three years. The debt financing policy for CEB may have to be re-examined.

6) Exchange Risk

The exchange risk is assessed by calculating the number of times that earnings cover exchange loss.

(Exchange risk coverage ratio) = (Net income before exchange loss)/(Exchange loss)

Exchange risk is another serious issue for CEB along with interest payment. Although theoretically the exchange rate fluctuates every year, because of the recent depreciation of Rupee, the exchange coverage ratio has been low.

(6) Growth

The growth of company operation is measured by evaluating the following ratios.

1) Annual Growth Ratio for Sales

Annual growth for Sales are increasing solidly every year. The rate of increase is more than that of consumer price index during the same period. The main source for the increase was commercial and industrial consumers.

2) Annual Growth Ratio for Net Income

Annual growth ratio for Net Income is affected drastically by the fluctuation of net income. The values for 1993-1995 are -81%, -108% and 131%. The heavy loss in 1994 causes the large negative figure during the period.

3) Annual Growth Ratio for Total Assets

Annual growth ratio for Total Assets has been steady for the three years, indicating around 4%. Above three growth ratio tell a solid expectation in the growth as a company.

(7) Productivity

The productivity of CEB employee is evaluated by measuring sales and net income per employee.

1) Sales per Employee

Sales per employee has been increasing at a high rate. This trend does not always indicate the increase in the operational/managerial efficiency. We need to examine the relationship between cost and sales features, which will be discussed in the next section of pricing.

2) Net Income per Employee

Net Income per employee has the same features as annual growth ratio for net income. Because the loss by the cyclone was huge in 1994, we may have to watch this value for the moment.

Table 6.2.4 FINANCIAL STATEMENT ANALYSIS

	1993	1994	1995
Profitability			
Rate of return on assets	4.61%	2.44%	3.43%
Total assets turnover ratio	0.27	0.28	0.29
Return on common shareholders' equity	4.48%	-0.39%	0.89%
Risk			
Current ratio	1.57	2.73	4.23
Operating cash flow to current liabilities	196.52%	-8.85%	29.45%
Debt-equity ratio	51.51%	52.62%	53.69%
Cash flow from operation to total liabilities	43.00%	-1.93%	5.19%
Interest coverage ratio	1.76	0.93	1.12
Exchange risk coverage ratio	2.10	0.93	1.11
Growth			
Annual growth ratio for sales	15.27%	9.05%	10.15%
Annual growth ratio for net income	-81.91%	-108.88%	131.42%
Annual growth ratio for total assets	3.78%	4.21%	4.42%
Productivity			
Sales per employee	741,029	808,094	890,089
Net income per employee	55,357	(4,913)	11,370

6.2.2 Overall Position

The CEB company operation has been assessed through the financial ratio analyses. The interpretation of these information is and the operational background is analyzed in this part.

The overall financial position is flimsy, being influenced by the level of electricity tariff, change in exchange rate, and the natural condition like cyclone. The profitability level is lower than the market interest level, not even covering the inflation rate in the country. The procurement of funding is dependent on the huge amount of borrowings. The sales are not enough to cover the loan payment, the interest payment and the exchange loss. The continuation of this heavy borrowing may be fatal factor for the company.

However, the market demand is essentially increasing at higher rate than that of the whole economy of the country. Therefore, CEB has a good chance to recover the financially healthy position during the growing period by overcoming the challenges mentioned next.

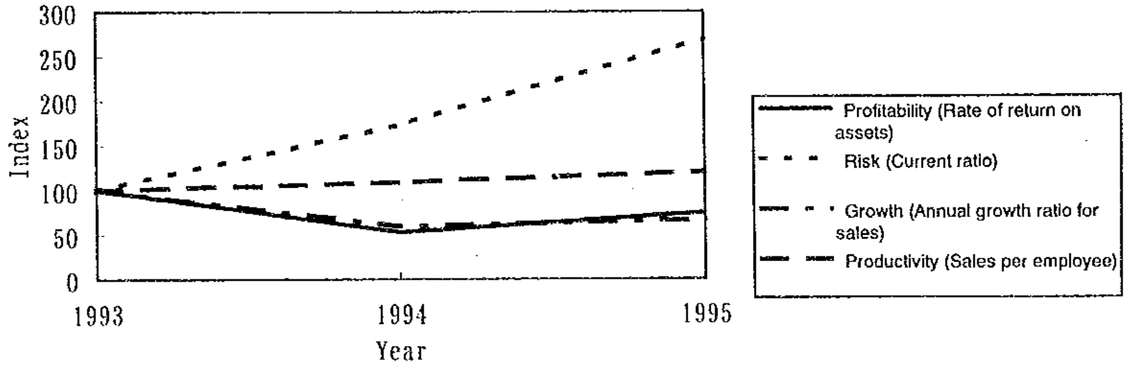


Figure 6.2.1 FINANCIAL STATEMENT ANALYSIS

6.2.3 Review of CEB Activities

The recent organizational situation of CEB has been analyzed in the light of the suggestions and recommendations given in the past study reports. This would lay a foundation to study and discuss the next steps CEB may have to consider.

(1) Organizational and Management Changes

CEB has assessed the job content and managerial structure, and also examined the job value in respect of its employees. Deputy general manager has been abolished. Dynamic information exchange has been done for top to bottom, bottom to top, and cross-department circulation of viewpoints and information. This assists substantially the organization in making efficient decision making and eliminating bureaucratic problems.

The efficient arrangement for employees in the organization has also been discussed in order to reduce the operational costs.

(2) Operational Changes and Cost reduction Measures

Inventory management for has been improved in order to reduce the costs involved in warehouse management. Just-in-time concept and proper communication between sections have reduced the inventory level and operating costs. The efforts for minimizing costs for wastage have also been made in every operating plant.

The jobs have been computerized dramatically, eliminating the redundancy and enhancing the efficiency. This has been a strong vehicle for improving operational system from power plant operation to accounting jobs.

Open communication through regular job meeting has given employees higher motivation and the sense of accountability. Employees feel heard their opinions on the continuous efforts to improve the efficiency.

CEB has also reduced its level of accounts receivable. This helps CEB to pursue more efficient budget control and financial management.
Finally, the training system has also been reorganized for empowering engineers and technicians.

6.3 Energy Pricing Policy

6.3.1 Pricing System and Control Organization

At present, almost all of sales prices of energy products are fixed by the government as official prices. Prices of gasoline and other petroleum products are determined by the Ministry of Industry and Commerce (MIC); those of electricity and bagasse by the Ministry of Local Government and Public Utilities (MLGPU); and prices of fire wood are set by Forestry Service of the Ministry of Agriculture and Natural Resources. Coal is only exception to the official pricing system, as it is directly purchased by the principal user, CEB, from foreign sources, and the remaining small portion of coal imported for industrial use is priced by an oil company who serves as an importer and marketer.

Except for bagasse and fire wood, most of energy items are imported. In Mauritius, imports and sales of basic goods closely related to daily life (e.g., rice, flour, fresh fruit, petroleum products, cement, and medical products) are monopolized by State Trading Corporation (STC) under MTS, which was established in 1982. Note that STC's role is limited to those of trade companies such as administration and management of the international bidding process and domestic wholesaling, while MTS is responsible for the establishment of domestic sales prices and the monitoring of market prices. Also, STC contracts out shipping work as well as storage service to private companies such as SHELL Mauritius Ltd.

Figure 6.3.1 shows gasoline, diesel and kerosene price trends in the domestic market. Note that the latest applicable prices quoted on December 21, 1996 are Rs.14.15/litre for gasoline (premium), Rs.7.65 for diesel oil, and Rs.5.65 for kerosene. To look at how domestic energy prices fluctuate compared to international price trends, Figure 6.3.2 shows gasoline price trends in the country with those in the U.S., France, and Japan, where prices are determined through the market mechanism. During the period between 1983 and 1994, price trends in oil importing countries were invariably on the rise (rising trendline), including Japan and France. On the other hand, those in Mauritius did not always follow the rising trendline due to the government's price control. (Note: Figure 6.3.2 also reflects the effect of variation of the exchange rate between the local currency and the U.S. dollar. For instance, as shown in Figure 6.3.1, market prices denominated in Mauritius rupee remained unchanged between February 1986 and September 1990, but dollar-denominated ones show the falling trendline due to the depreciation of the rupee, as seen in Figure 6.3.2.)

Of petroleum products, the country imports two types of fuel oil, 180CST and 380CST. The 180CST is exclusively imported by STC, and 70% of total are purchased by CEB via wholesalers such as Shell Mauritius Ltd. and the remaining 30% are shipped in small quantities. The wholesale price of fuel oil (180 CST) to CEB is currently set at Rs.4.064/litre as revised in December 1996. The wholesale price for industrial use is set at a higher level since the shipping cost is higher due to a small lot. On the other hand, the 380CST is directly imported by CEB who is the sole user in the country. Similarly, CEB is a major user of coal (Note[3]) and small lots are imported for other industrial uses, with prices being set at Rs.1,410/MT for CEB and Rs.1,735/MT for others as of 1996. Finally, LPG is also subject to the official price, based on which oil companies purchase from foreign sources on their own. As of September 1996, the retail price of LPG is set at Rs.12.92/Kg.

Based on the above observations, major characteristics of the energy pricing system in Mauritius are summarized as follows (note that electricity charges are analyzed in detail in the following section):

1) Petroleum prices including gasoline are controlled by selling them via STC. Thus, international market prices are not directly reflected in domestic prices.

2) With relatively small domestic demand, the number and amount of imports are limited for all the petroleum products, which CIF prices are inevitably higher than those applied to major consuming countries.

3) As most of petroleum products are sold at official prices, there is virtually no price competition within the domestic market.

Note[3] Although CEB purchases coal, its actual user is a sugar refinery for power generation during the off-crop season.

4) While energy prices are generally close to international levels, the high tax rate (45%) makes the fuel oil price much higher than international prices (Note[4])(see Figure 6.3.3). On the other hand, the gasoline price is not as high as the fuel oil price despite the fact that the gasoline tax accounts for 65% of retail price (Figure 6.3.4).

6.3.2 Taxation System Related to Energy Items

Tax revenues from petroleum products in Mauritius still account for approximately 10% of the total government revenue. The taxation system covering petroleum products is decided through discussion among the Ministry of Finance, ministries in charge of energy product items, and other related government agencies. Since the modification of the taxation system in June 1996, there are two kinds of taxes imposed on petroleum products, import duty (ad valorem) and sales tax which replaced the old import duty (specific tax) and import levy at a uniform rate of 17%. Current tax rates on major petroleum products and coal are summarized in Table 6.3.1.

Table 6.3.1 TAX RATE ON PETROLEUM PRODUCTS AND COAL

	Import Duty (ad valorem)	Sales Tax
Gasoline	220% NP	8%
	200% P	
Diesel Oil	75% NP	8%
	55% P	
Kerosene	0	0
	0	
Fuel Oil	75% NP	8%
	55% P	
LPG	0	0
	0	
Coal	35% NP	8%
	15% P	

Note: NP = Non Preferential Tariff
P = Preferential Tariff
Sales Tax = Only for Inland Sales
Source: State Trading Corporation

Note[4] Overall, the tax rate for fuel oil is lowest among petroleum products, while that in OECD countries is around 15% on average

Import duties are classified into preferential and non-preferential. The former tariff rate is applied to the country's major trade partner, South Africa, and the latter to Kuwait and other oil producing countries around the Gulf. At present, one half of petroleum products imported by the country come from South Africa, and the remaining one half from the Gulf states. From Madagascar to which special tariff rates are applied as part of the special regional economic zone, only low-viscosity fuel oil is imported by CEB for power generation since the country is not capable of supplying petroleum products that meet quality requirements of Mauritius. The sale tax is imposed at a uniform rate of 8%, but kerosene and LPG are exempted for social welfare as their major users are in the low income class. Note that prices of petroleum products include, in addition to the national taxes, special levies for social development including the Road Construction Fund and the Development Assistance Fund for Rodrigues Island, which are collected by STC as part of price and paid to the government.

Table 6.3.2 shows price structure of major petroleum products as of November 1995 (prior to the recent price increase). Since the details of the price structure are partially classified against public disclosure, the table shows prices at each stage of import, domestic wholesale (STC) and retail. In summary, petroleum product prices in Mauritius are fixed and maintained by controlling tax rates including import duties and profit margins of STC which solely controls the domestic distribution system. The STC's margin is essentially a difference between the CIF-based price and STC transfer price to domestic retailers, the latter being determined through prior consultation with MTS. As a result, variation of the CIF price produces profit or loss on STC. In reality, profit is more often incurred than loss to create additional cost impacts on domestic users.

Table 6.3.2 PRICE STRUCTURE OF PETROLEUM PRODUCTS

(as of June,1996)

	Gasoline *1	Diesel Oil	Kerosene	Fuel Oil *2
a. c.i.f. US$/l	0.1395	0.1346	0.1588	0.0864
b. Exchange Rate (Rs./US$)	20.00	18.00	20.00	16.00
c. c.i.f. Rs./l	2.7891	2.4228	3.1754	1.3824
d. STC Transfer Price	9.1677	4.5201	3.4200	2.9700
e. Surplus (Deficit)		0.0396	0.2003	0.3257
f. Retail Price	11.3000	6.1000	4.5000	3.2724 *3

Note : *1 Premium gasoline
*2 180.80 CST, and based on 27.04.191 price structure
*3 Price for CEB, delivered by Shell Mauritius Ltd.

Source : State Trading Corporation

While the pricing policy, to some degree, intends to relieve the low income class and residents in remote islands of economic burdens, it creates various problems, e.g., it prevents the industry and other sectors from choosing an optimum mix of energy based on international prices (the high fuel price is a primary example), while the government cannot reduce kerosene consumption despite safety problems. In the so-called ESMAP Report prepared in December 1994 (Note[5]), it is recommended that the current fixed pricing policy should be replaced with price liberalization to remove the above problems. It should be noted, however, that there are strong voices to urge that the distorted energy pricing system be perceived in the context of national security for the small and island country.

Note[5] A joint Report "Mauritius Energy Sector Review, December 1994", by UNDP and World Bank, Energy Sector Management Assistance Programme (ESMAP)

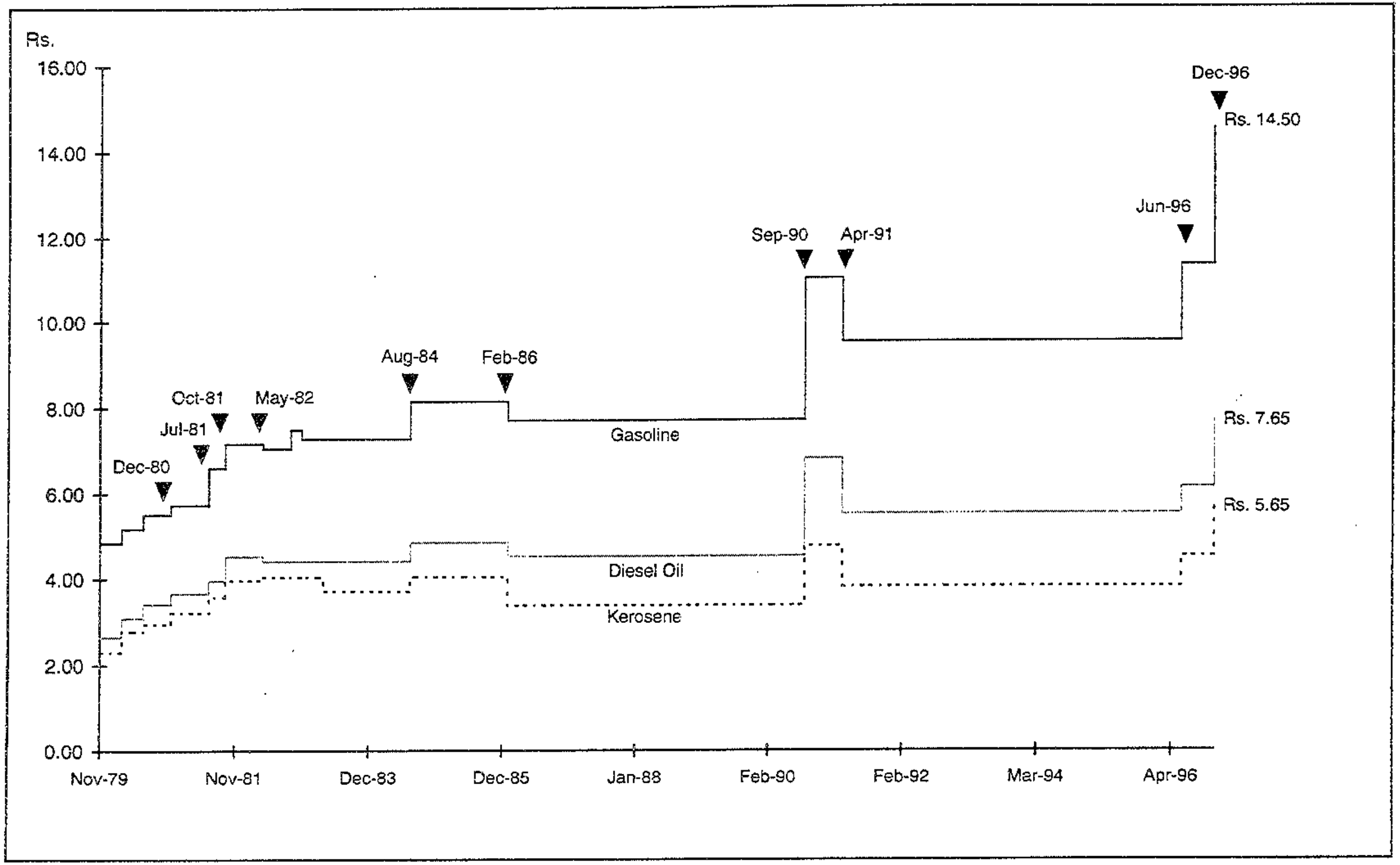


Figure 6.3.1 TRENDS IN PETROLEUM PRICES (RETAIL PRICES)

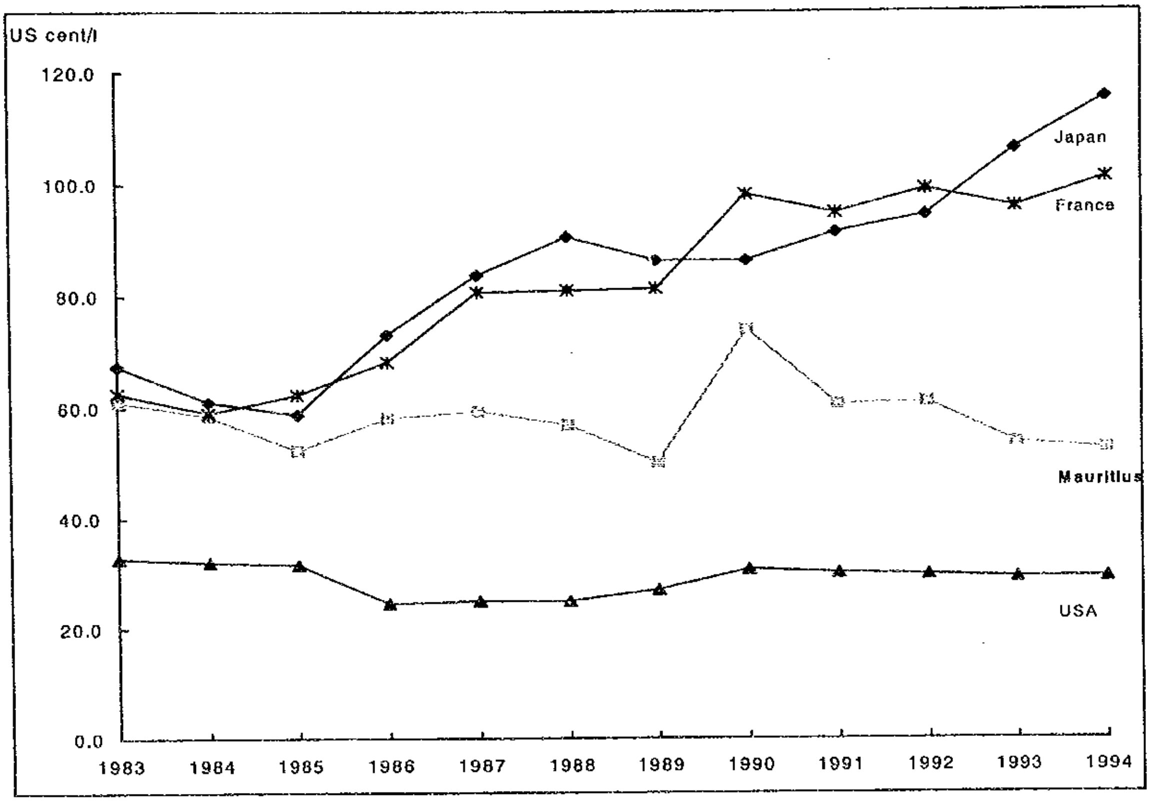


Figure 6.3.2 COMPARISON OF PREMIUM GASOLINE PRICES

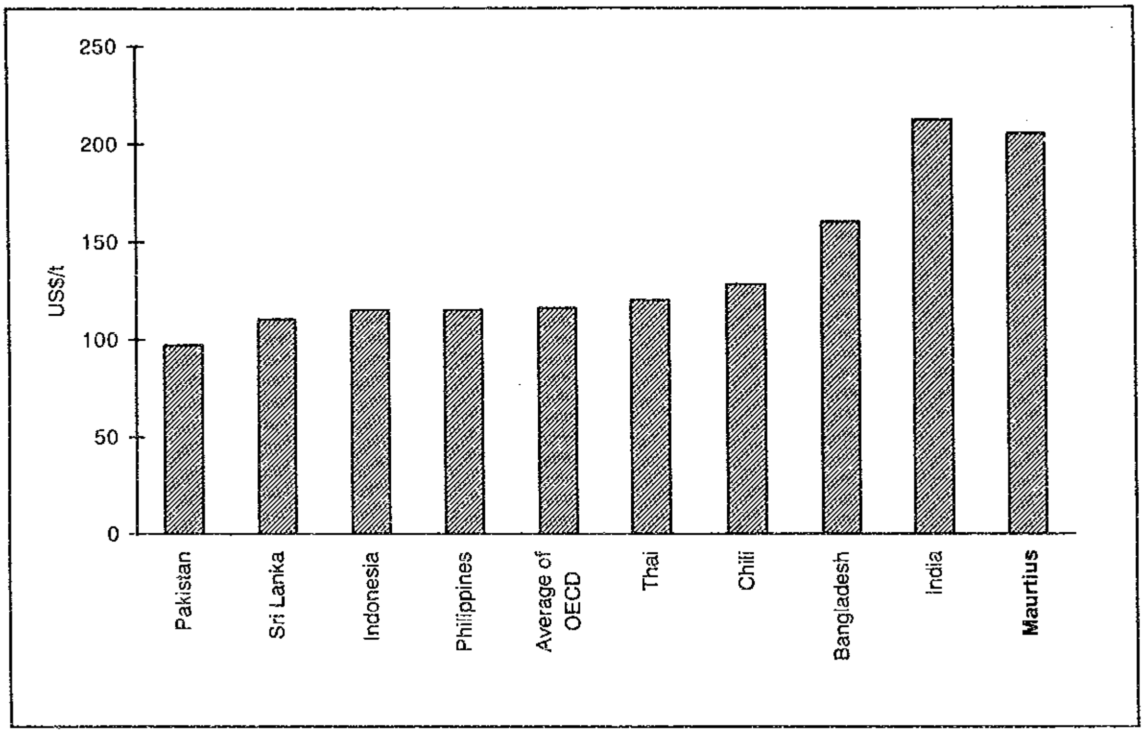


Figure 6.3.3 PRICE COMPARISON OF FUEL OIL (1989)

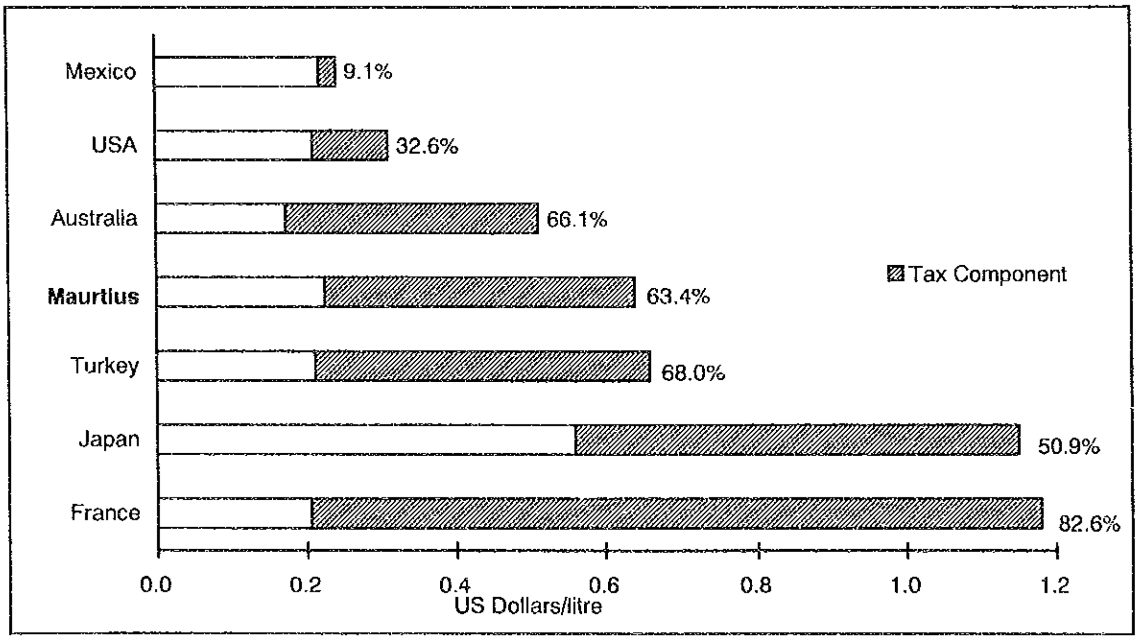


Figure 6.3.4 GASOLINE PRICES AND TAXES (US DOLLARS/LITER) THIRD UARTER 1995

6.4 Electricity Tariff

6.4.1 Price Level

The following chart shows the transition of cost and price of electricity during the recent ten years.

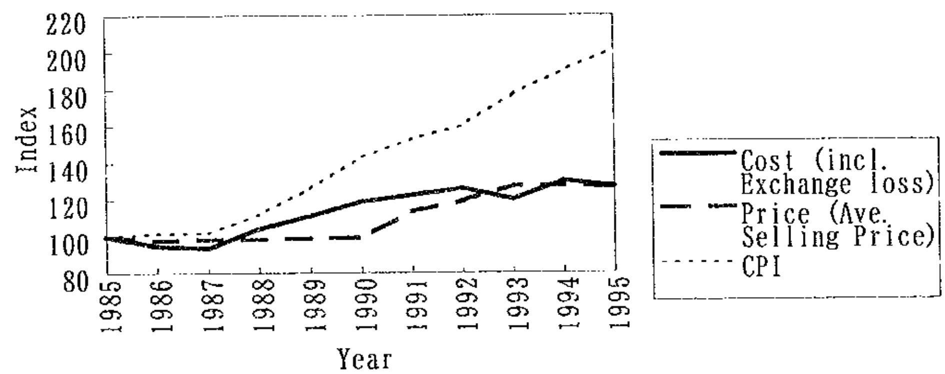


Figure 6.4.1 COMPARISON OF COST AND PRICE (per kWh)

Overall electricity tariff level in Mauritius is not reflecting enough financial level to cover the operating costs of CEB. Given the domestic energy resource scarcity in Mauritius and small scale of economy in power generation, it may be difficult to compare the price level in Mauritius with those in other developed or developing countries which may have different components of energy resources, tax system, scale of power supply, combination of power plants, financial condition, development history, and technological level. However, the comparison of the recent rate level is far below that of consumer price index during the same period. On top of that, the price has been revised only twice during the last decade and the increased rate does not cover the financial costs incurred by CEB. Therefore, periodical revise system for electricity tariff rate should be employed so that the price shall be maintained appropriate and the consumers' financial capacity is accounted.

6.4.2 Disparities Among Final Consumers

The current electricity tariff rates are determined based on consumer categories, consumed energy level(kWh/month), total connected load(kW), maximum demand(kW). The final consumers are basically classified into five categories: Domestic, Commercial, Industrial(General), Industrial(Irrigation), and others.

The units sold and average price/unit for each categories during the last decade is shown in the chart below.

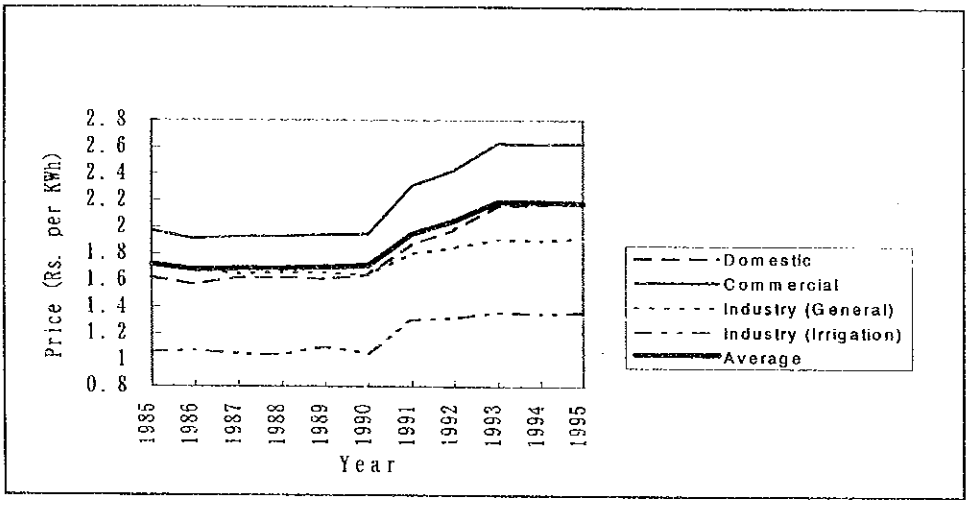


Figure 6.4.2 ELECTRICITY PRICE

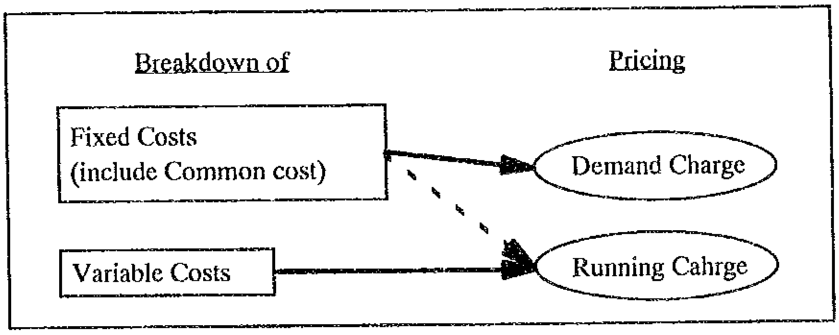
While the price for commercial use is higher than the average, those for industrial and domestic use are below the average. This reflects the consideration of the economic effects on EPZ and domestic households. However, the tariff system should not differentiate EPZ from non-EPZ industry if they have the same connected load and energy use. The favorable policy for exporting industry shall not be implemented in the electricity pricing system but, if any, in other regulatory frameworks, because the economic efficiency in power industry will be attained through fair pricing system.

Second, the disparity features can be found in the block rate system: the domestic households are subject to the increasing block rates, while the decreasing rates are used for EPZ consumers. The increasing rates are usually considered under a tight supply condition, encouraging the energy conservation to consumers, securing the stable supply, and thereby minimizing the social costs. Therefore, this block rate system may have to be discussed along with the other load levelling methods. For instance, the effort for mininizing the load fluctuation may have to be sought, especially the further introduction of solar water heater.

Third, the resulting increased percentage for the revised rate for domestic consumers is higher than those of other consumers, especially of irrigation consumers. Therefore, domestic households may undertake the seemingly expensive price. The increased cost for supplying power should be fairly apportioned among each final consumer.

6.4.3 Price Component

The price components are classified into the following two; the demand charge and running charge(per kWh). The demand charge is based on the total connected load (Watts) for domestic consumers and the maximum demand(kVA) for non-domestic consumers. The running charge is calculated by the energy consumed(kWh). Basic concept for determining the allocation for the demand charge and running charge would be as follows:



Fugure 6.4.3 COST AND PRICING STRUCTURE

Some of the fixed cost may be transferred to running charge because the amount of investment for new plants may be too large to collect as a demand charge. Regarding the price level of demand charge, the impact for lower-income consumer should be taken into consideration.

6.5 Environment Management in Mauritius and Its Impact to the Energy Sector

6.5.1 Introduction

The conservation of natural and social environment of the country has been one of the most important national movement with high priority. The Government is providing leadership to the nation in improving environment management which is the foundation of sustainable development of the country. However, the nature of environmental management in Mauritius is quite different from that of the industrially developed country and the rapidly developing countries as coastal areas of China, where rapid development of heavy industries in the past caused serious deterioration of the natural and social environment.

Thirty years ago, the sugar industry was the only sizable one in the country. The development of export oriented manufacturing, mostly textiles, and the rise of tourism in recent years have resulted in remarkable economic development for the country, but unlike most other countries, Mauritius' economic development did not include energy intensive industries, such as steel, petrochemicals, non-ferrous metals, bulk chemicals, and so on, which tend to create severe pollution problems. Accordingly, the energy consumption per capita and per unit GDP of Mauritius are comparatively low among middle-income countries. (Ref. Table 6.5.1) This means that the serious deterioration in both the natural and the social environments, which often occur in many middle income countries as a result of rapid industrial development, does not exist in Mauritius.

The geographical features of Mauritius, a small island (about 2,000 km^2), with ample rain, remote from any continents and surrounded by the ocean also helps to preserve the natural environment. However, improvement of the environment is imperative for sustaining tourism, which is a very important sector of the country. In particular, the lagoons and seaside areas of the country are important resources for tourism.

Table 6.5.1 ENERGY CONSUMPTION/CAPT. (1991)

	TOE/CAPT	TOE/10^3US$ (1987$)
World	1.53	0.43
OECD	4.81	0.29
East Asia	0.67	0.54
Mauritius	0.57	0.16

Generally speaking there are not many environmental issues in Mauritius, with the exceptions of some deforestation, complaints (usually related to noise or dust) of residents living nearby industrial plants, and occasionally, some complaints that sea water or lagoons have been polluted by waste water.

The Government of Mauritius is greatly concerned with improving both the natural environment and the living conditions of its people. The basis of the environmental management of the country was established in 1991 with the effecting of the Environmental Protection Act 1991, and since then efforts have been made to establish various regulations. National environmental standards and emission standards for the protection of the atmosphere have now been published publicly.

Currently the governmental policy on environmental controls follows the Program of Action for the Sustainable Development of Small Island Developing States, which was prepared by The Global Conference on Sustainable Development of Small Island States in May 1994, which was organized based on the Agenda 21 of UNCED Rio meeting. This action plan emphasizes the following points:

* The limited environment resources of small islands increase the possibility of complete destruction of the natural environment.
* The maintenance of the coastal ecological system is very important for the entire environment.
* International cooperation is necessary to support the environment control movement on small islands both technically and financially.

6.5.2 Present Status of Environmental Management in Mauritius

As described in the previous chapter, the Government is proceeding with its program of environment management based on the Environment Protection Act of 1991. In particular, an environmental impact assessment (EIA) is mandatory for all new projects that could influence the environment, as a condition of obtaining Government approval. The EIA of energy projects is evaluated by the Government to make sure that the project will not cause environmental problems.

The Government evaluation is conducted on an individual project basis, and therefore sometimes takes a very long time; sometimes, the transparency of the evaluation is also questioned. National standards for both emissions and effluents are being prepared to establish a clear basis for environment controls. No governmental controls existed on the conditions of projects established prior to 1991. When national standards are put into effect, these will be applied to existing projects after a two- to three-year grace period.

When strong complaints are received from residents near an industrial facility, the Government acts as a mediator, attempting to bring both sides to a settlement. Laws and regulations required for better environmental management are being prepared, but systematic measurements of present levels of atmospheric and water pollution have not as yet been conducted. Improvements to both the hardware and software for the monitoring of environmental conditions in the country are crucial.

6.5.3 Specific Environment Management Plan (Other than EIA for individual new projects)

(1) Atmospheric Emission Standard and Environment Standard

Based on the Environment Act 1991, the regulations for control of emission from industries are being finalized. The drafts of atmospheric emission standards have been published for public comment. The contents of these standards are outlined in Table 6.5.2 and 6.5.3).

The staff of the Ministry of Environment in charge of establishing the standards informed

JICA team that they do not intend to impose severe standards that will require sophisticated pollution control facilities to be installed by companies in the country. They expect that existing plants will be able to meet the new national standards insofar as the normal operating and maintenance procedures are adopted.

However, there is no precise definition of the standard technology to be applied by both existing and future plants. The draft standards are based on those of the WHO standards. The WHO standards are normally considered adequate for worker protection under conditions of limited-time and high- concentration exposures. However, the WHO standards for extended exposures over a long period of time and for exposures to low concentrations of contaminants are not always adequate.

According to the stated intentions of the Ministry of Environment of Mauritius, the proposed emission standards have been compared with actual operating data of industrial boilers in both Japan and the USA. (See Table 6.5.2); (the SO_2 emission standard has not yet been published.)

The data indicates that when low sulfur fuel (less than 1.0%) is used, the emission standard will be satisfied, but if the fuel oil common in Mauritius (containing a maximum of 3.5%) is used, the 0.2 g/Nm^3 S.S. standard may be difficult to be satisfied. The current Japanese emission standard for fuel oil boilers is 0.05 g/Nm3 and for coal boilers is 0.1g/Nm^3 assuming the use of low sulfur fuel.

(2) Environment Water Quality Standard and the Effluent Quality Standard

In accordance with the Environmental Protection Act, the Ministry of Environment Mauritius is currently finalizing the inland surface water quality standards and the draft regulations have disclosed for public hearing in '96, and the work to set the effluent water standards are proceeding.

The proposed environment water quality of Mauritius is indicated in the Table 6.5.4. When we compare the figures with the inland water quality standard of Japan, Table 6.5.5, the level is very close in general.

On the other hand, the proposed standard for effluent from sugar industry is specifying C.O.D. 50mg/l plus raw water and T.S.S. 30mg/l plus raw water. Unless large amount of dilution water is available at the discharge point of the effluent of a sugar mill, the down stream environment water may not clear the national standards.

In case, when the proposed effluent regulation is imposed to the Bagasse cum Coal power locating inland, the design of the effluent treatment system of the power plant in relation to the ash treatment and warm water from steam condenser must be reviewed carefully as soon as possible.

(3) Improvements in Automobile Fuel Quality

The Ministry of Transportation of Mauritius intends to make a number of improvements to the quality of automotive fuel.

a) Phase-out of lead from gasoline
The current 0.4 g/L level will be reduced to 0.15 g/L in January '97.
The import of non-lead high octane gasoline will begin in January '98.
b) Reduction of sulfur in diesel oil (S.P. SOx emission will be improved)
Max. 0.5% January '97 onward
Max. 0.3% January '98 onward

These improvements will be effective in reducing atmospheric pollution in urban areas. However, the introduction of non-lead gasoline requires careful control to avoid problems with older models of cars, whose engines were designed for leaded gasoline. (Ref. 4.3 (1))

Table 6.5.2 EMISSION STANDARD (WITHOUT SOPHISTICAL TREATMENT FACILITIES

	Mauritius (Proposed)	U.S.A. (Sulphur 3.0%)	Japan* (sulphur < 1.0%)
Solid Particle	0.2 gm/NM³	(kg)1.25 x (s) (3%)+ 0.38/t.fuel ≒0.3g/NM³	200 p.p.m. ≒0.2g/NM³
Sulphur Dioxide		(kg) 19x(s) (3%)/t.fuel ≒4.0 g/NM³	700 p.p.m. ≒1.0 g/NM³
Sulphuric Acid (SO_3)	0.12 gm/NM³	(kg)0.24 x (s)/ t.fuel ≒0.05 g/NM³	-
Nitrogen Oxide	1.0 gm/NM³	(kg) 6.6/t.fuel ≒0.48 gm / NM³	250 ≒0.4g/NM³
Carbon MoNOxide	1.0 gm/NM³	(kg) 0.6/ t.fuel 0.04 g/NM³	- -

* Figures are up stream of abatement facilities.

Table 6.5.3 ENVIRONMENTAL STANDARD (AVERAGE)

		Mauritius	E.C	U.S.A. (Normal)	Japan (low s fuel)
Suspended solid (PM10)	μg/NM³	150(24hr)	-	150	150
		50 (year)			
Sulphur Dioxide	μg /NM³	1000 (3 hr)	-	-	-
		200(24 hr)	35-53	140	130
		50 (year)	14-21	-	50
Nitrogen Dioxide	μg /NM³	200(24 hr)	70	-	60--90
					53 (year)
Carbon MoNOxide	μg /NM³	40,000(one hr)	-	3,500(1.5hr)	-
		10,000(8 hr)	-	9,000	20,000

(4) Noise standard and Energy Sector

As it has experienced in many industrially developed country, the development of industries increase the occasions in which the life of the many inhabitant exposed to the noise generated by the industrial plants and the vehicles for material transport.

These conditions tend to increase the complain of inhabitant to the industrial facilities locating in the vicinity. This type of problems are already exists in Mauritius including the energy sector. The increase of size of power plant, the use of high speed large rotating equipment and the application of a large combustion furnace increase such noise problem.

The most desirable solution of such noise problem is considered that the segregation of industrial zone and the residential zone in accordance with long term national land utilization program.

However, in the practical world such logical solution are not always possible. Therefore, the planner of a large industrial project must foresee the future change of the conditions surrounding the project and the technical specification of the plant facilities must include the noise, vibration limitation not only for protection of worker but also for lowering noise level at the battery limit as required.

At the case of complain of the inhabitant against existing facilities, even OSHA (Occupational Safety, Hazard Association) standards are fulfilled, the complain still not be settled. In any case, the Ministry of Environment has publicated the National Noise Standard as shown in the Table 6.5.6. This national standard will be the basis of the settlement of noise related issued.

Since the standard is supposed to be imposed to the existing facilities also within two years from the effect of the regulation, CEB must study the noise level of all the existing electrical system regardless the complain against the noise of those facilities are exists or not.

On the other hand, the techno-economic study on the noise management of the facilities having potential of noise problem must be initiated to incorporate the necessary aspect to the long term plan for the selection of site of new electrical facilities.

In addition, the techno-economic study for noise management by the way of improvement of design of houses or the gardening of the plant area must be conducted to find-out the most economic solution of "Noise" problem.

The experience of the industrially developed country in the solution of "Noise" problem indicates that the importance of step by step effort with endurance for the solution of the problem. The current noise standard on Noise Limitation in the environment is indicated in the Table 6.5.6 for reference.

(5) Disposal of Solid Waste and Energy Sector

It is apparent to every body that the development of industrial activities and the improvement of living standard of the nations always results the increase of solid waste such as packing material, industrial waste and municipal waste. At present, all the solid waste in Mauritius are buried without treatment in the adequate location inside of island.

However, the shortage of adequate land for disposal and the possibility of the contamination of surface and underground water by leaching water of such buried material become keen issues of the country.

This type of problem is being experienced in many countries already, and one of most prevalent counter measure of the problem is reduction of volume of the waste and prevention of leaching by the incineration of the solid waste.

In order to reduce the cost required to incinerate the solid waste, the utilization of energy obtained at the incineration of combustible waste for power generation are adopted in many cases. (Ref. para 4.5 Waste Power)

This arrangement is very similar to the incorporation of BEDP power supply to the national power generation system, and therefore the future plan of waste power must be the part of energy sector program.

6.5.4 Future Development of Environmental Management in Mauritius and Its Impact to The Energy Sector

According to the forecast of energy demand made by this study, the future energy demand particularly the electricity and the fuel for transportation will increase to 3 - 4 times of current level by AD2010.

Therefore, the impact of increasing fuel consumption to the environment must be assessed on the long term, and the necessary management plan must be prepared.

(1) Fuel quality and its impact to atmospheric environment

Currently the nuisance of urban inhabitant by the polluted atmospheric environment is very limited to the small area of some urban area of the island.

However, when the total fuel consumption is increased the generation of pollutant in a unit area, and the nuisance of inhabitant will increase significantly. The diffusion of polluted atmosphere by natural diffusion has the limitation, and therefore the attainment of the newly enacted national atmospheric standard must be carefully monitored before the health hazard can take place.

It is considered that the comprehensive monitoring of the pollutant such as S.S., SOx, NOx, which are definitely emitted to the atmosphere from the automobile and the power plant and has potential of resulting health hazard of inhabitant in the adjacent area of the congested road and the large power plant, must be monitored to make sure the pollution level will not exceed the national environment standards in future.

It is well known that the area such as Mexico city, Tokyo and Los Angels, the improvement of fuel quality, improvement of combustion condition of automobile engine and the emission, such as NOx, SOx, S.S., control from the power plant are applied in the most adequate combinations.

The city of Port Luis, where the traffic congestions are serious and the large power plants are located, may have pollution exceeds the national standards under the specific climate conditions.

Further, the build up of additional plants and increase of traffic in future will results serious atmospheric pollution unless adequate mitigation measure are adopted by the sources of the pollution.

As the necessary technology required to mitigate pollution at the sources of pollutant or to improve the diffusion of pollutant by high chimney are available internationally, the data obtained by the reliable monitoring system will make possible to provide adequate mitigation facilities to prevent any hazards of inhabitant before it will take place.

In addition, the mitigation of atmospheric pollution some time necessiate the discharge of waste water to the environment water from the pollution mitigation facilities. The monitoring of the level of current pollution of the lagoon water and the sea water in shore line of the country should be conducted to make sure the future new power plants will not cause destruction of ecology of the area. It is also very important to have reliable back ground pollution data of the site selected for the new plant construction to determine the cost required for protection of the environment.

It is obvious that the impact of the large power plants to be built in future has the very large impact to the environment, the MLGPU/CEB must initiate the planning of installation of the monitoring of current pollution level of the country immediately, and obtain necessary technology to implement the monitoring immediately.

(2) Environment Management of Mauritius for Global Environment Conservation

As it is mentioned in the introduction of this chapter, the impact of the pollution of Mauritius to the global environment is very limited because of the smallness of the absolute amount of pollutant generated in Mauritius.

However, the recent international movement for the mitigation of the possible climate change by reduction of fuel consumption and international movement for the free trade among the countries impose the environment management obligation to the member countries regardless the size of the country.

It is recommended that now a days the reduction of the emission of the green house effect gas by the energy saving is considered as the duty of the international society and therefore the Energy Conservation Activities in country should be promoted.

(3) Disposal of Solid Waste and The Power Generation

a) Waste Power

It is our understanding that a entrepreneur was submitted the application of waste power project in Mauritius, which is intending to prevent the pollution problem by the solid waste disposal in the country. The detail of the project is not known to JICA team, but the example of the similar project in the world indicates the importance of building of the solid waste collection & transportation system, which can segregate the combustible waste and non-combustible waste by mean of the separate waste dumping habit of people. At the first place, comprehensive assessment of the origin and its composition of the solid in the country must be conducted. The other necessary assessment is the cost the municipal government can spend for solid waste incineration because the waste power project can not be financially viable by the power sales income only. However, Mauritius has a specific advantage for the waste power project because the bagasse power plant can take the steam from the waste heat boiler of the incinerator for their power plant. This means that the investment required for the waste power plant, which may relay on the alternator of bagasse power plant, will be reduced significantly by the integration of bagasse power and waste power. However, the co-burning of bagasse and solid waste by one combuster may be not practical because of the difference of the construction material and the difference of the pollution mitigation of emission and effluent. Further, the integration of Bagasse cum Coal project and waste power project may have a possibility of reduction of coal burning during off-cropping season.

b) Coal Ash Disposal

It is expected that when all the planned Bagasse cum Coal power projects are completed, the amount of coal used for the power generation will reach 3,000 ton daily (off-crop season). This means about 300 - 400 tons coal ash must be disposed one way others. The disposal of the large amount of coal ash as the same way of bagasse ash is not desirable because the potential of soil deterioration and leaching of coal ash, which may cause underground water contamination. At present the total solid waste generated in Mauritius is estimated as 500 tons daily, and therefore the coal ash disposal process must be prepared with due consideration on the over-all solid waste disposal of the country not to cause environment problem.

Table 6.5.4 ENVIRONMENTAL WATER QUALITY STANDARD
Ministry of Environment Mauritius 1996

(a) 無機 (Inorganic)	
Boron	0.75 μg/l
Cadmium	0.70 μg/l
Chlorine Residual	2.0 μg/l
Chromium (total)	2.0 μg/l
Copper	6.5 μg/l
Dissolved Oxygen (low limit)	6.0 μg/l
Iron	1.0 mg/l
Lead	1.3 μg/l
Mercury	0.1 μg/l
Methyl Mercury Comp.	0.012 μg/l
Nickel	87.6 μg/l
pH	6.5～9.0
Selenium	1.0 μg/l
Silver	1.2 μg/l
Zinc	59 μg/l
Sulphide (H_2S)	2.0 μg/l
Phosphorus (P)	0.1 μg/l estrainewater
Phosphate	25 μg/l lake
Phosphate	50 μg/l stream to lake
Phosphate	100 μg/l stream not to lake
(b) 有機 (Organic)	
Dieldrin	0.0019 μg/l
Chlordane	4.3 ng/l
P.C.P.	3.9～9.5 μg/l for pH 6.5～7.5
DDT	1.0 ng/l
Endrin	2.3 ng/l α・β form
Guthion	0.01 μg/l
Lindane	0.08 μg/l
Oil and Grease	undetectable
PCBs	0.014 μg/l
Suspended Solid	10 mg/l at back ground conc. < 100 mg/l 10% of background > 100 mg/l

Table 6.5.5 ENVIRONMENTAL WATER QUALITY STANDARD (JAPAN)
(Prevent Health Hazard and Adequate Living Standard by Public Water)

	Health Protection (Max)
Cadmium	0.01 mg/l
Cyan	not detectable
Organic Phosphorus	not detectable
Lead	0.1 mg/l
Cr^{+6}	0.05 mg/l
Arsenic	0.05 mg/l
Mercury (total)	0.0005 mg/l
Alkyl Mercury	not detectable
PCB	not detectable

LIVING ENVIRONMENT STANDARD (DAILY AVERAGE) (JAPAN)
River Water

	Potable (AA) Good for drink by filtration	Potable (A) Good for dring after treatment	
pH	6.5 - 8.5	6.5 - 8.5	6.5 - 8.5
BOD	1 mg/l less	2 mg/l less	3 mg/l less
SS	25 mg/l less	25 mg/l less	25 mg/l less
Disolved O2	7.5 mg/l more	7.5 mg/l more	5 mg/l more
Fecal-Coliform	50 MPN/100 ml less	1,000 MPN/100 ml less	5 mg/l more
Total-Nitrogen	0.1 mg/l		
Total-hosphorus	0.01 mg/l		

Table 6.5.6 NOIZE STANDARD (MAURITIUS)
The Environment Protection (Noise Standards) Regulation 1996

dBA Leq the average equivalent A-weighted sound level measure over 4haf

Industrial Noize	Schedule (Regulation 2)		
(a) Stone Crashing or Block Making Plant	Noize Exposure Limits		
(b) Premix Concrete	(1) Neighborhood Noize		
(c) Thermal Power	Time of Day	Noise Exposure Limits	
(d) Metal Workshop	0700 - 2100 hr	60 dBA Leq	
(e) Cabinet Waking Work Shop	2100 - 0700 hr	50 dBA Leq	
(f) Panel Beating Work Shop	(2) Industrial Noize		
(g) Saw Mill	Day of the Week	Noise Exposure Limits	
(h) Sugar Factory	Time	07:00 - 21	21:00 - 07:00
(i) Textile Plant	Weekdays	65	60
"Neighborhood Noize" any noise other than	Weekend and public holiday	60	55
(a) Industrial Noize			
(b) Noize made by an air craft or an animal			

NOIZE STANDARD (JAPAN)
Noize dB(A)

Time of a day	Day	Morning, Evening	Night
	8:00 - 19:00	5:00 - 7:00 19:00 - 22:00	22:00 - 5:00
Area I Residence	45 - 50	40 - 45	40 - 45
Area II Residence	50 - 60	45 - 50	40 - 50
Area III Commercial	60 - 65	55 - 65	50 - 55
Area IV Industrial	65 - 70	60 - 70	55 - 65