TRENDS IN THE POWER SECTOR IN MAURITIUS

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ABSTRACT

The power sector in Mauritius has undergone drastic changes during the last few years. We have moved from a state of almost complete dependence on petroleum products for electricity generation to a new position whereby most of our electricity is generated from coal and bagasse. The sugar industries have invested huge amounts to generate more electricity from bagasse during crop season and from coal during off-season. This development has been welcomed by the government's bagasse energy development program (BEDP) and has been accelerated by a major driving force at work namely the looming threat of the global liberalisation of sugar trade. A removal of all preferential tariffs will have a devastating effect on the sugar sector and electricity generation is one very profitable way of safeguarding against such potential losses. At current pace, soon enough Mauritius will find itself in a situation where most of its electricity will be generated by the sugar sector and it is not clear how ready the government is to experience this change.

1. INTRODUCTION

With the continuous rising cost of petroleum products and the devaluation of its currency vis-à-vis other major currencies, Mauritius has found itself with little option but to become proactive in finding other ways to generate electricity from alternative sources of energy. The government recognized this tendency in the early 1990s and acted accordingly by proposing the "Sugar Sector Strategy Plan". The aim of this plan was to promote and encourage the setting up of bagasse/coal power plant. Bagasse is "freely" available in huge quantities in Mauritius as a sugar producing nation while coal is by far cheaper than other common fuels used for electricity generation. The sugar industries acted promptly on the incentive provided and since then, we have moved a long way from the traditional way of generating electricity using mainly petroleum products. We are now well into a new era where soon enough most of our electrical energy will be generated using bagasse/coal. This change has been possible thanks to massive investment from the private sector which currently provides for about 40% of the total electricity generated. This paper presents an analysis of the current situation, the prevailing trends and provided an outlook on future directions in the power sector. It is divided as follows: Section 2 looks at the change that has happened over the years with respect to the fuel source used to generate electricity and a quick estimate of the cost representation of each fuel is made. The contribution of the utility and that of the independent power producers (IPP) towards power generation is compared in Section 3. Section 4 points out the direction towards which the power sector is headed and try to put things into perspective for the coming years. We finally conclude in Section 5.

2. SOURCES OF ENERGY USED FOR POWER GENERATION

Fuel oil is the main source of energy used for electricity generation in Mauritius. It was used to produce almost 35% of the total amount of electricity generated by the country in 2003 [2]. The remaining electricity was generated using coal and bagasse with 32% and 30% share respectively while kerosene and diesel oil were only minor contributors to the generation of power. Currently, there does not seem to be much difference between the relative percentage contribution of the three main fuels. However, the picture in the energy sector was very different 10 years ago. A quick comparison of the percentage contribution of each of the three main fuels used for electricity production in Table I shows the trend which has been in progress during the last decade. There has been a reduction of over 20% in the percentage of fuel oil used for electricity generation, while coal used to generate electricity has experienced an increase of 24% from 1994 to 2003. The contribution of bagasse on the other hand has experienced an increase of only 5% but we need to bear in mind that this increase is quite considerable since bagasse is used as a fuel source for electricity generation only during crop season, i.e., for about 5 months during the year.

FUEL TYPE	1994	1999	2003
Fuel Oil	57.7%	43.8%	34.5%
Coal	8.1%	16.6%	32.0%
Bagasse	25.9%	27.4%	30.1%

Table 1: Percentage Fuel Input for Electricity Production

Bagasse is the fibrous matter that remains after sugar cane is crushed, the juices extracted and falls into a category of fuel which is more commonly known as "biomass". It has the great advantage of being carbon neutral, meaning that using it as a fuel does not contribute to the production of carbon dioxide and hence greenhouse effects. It is also readily available in abundance during half of the year. Mauritius produces about 6 million tonnes of sugarcane every year and about 35% of this is left as bagasse after processing [3]. However, it needs to be mentioned that even though bagasse is widely available, it is owned by the sugar estates and is not exactly free of charge [1]. The sugar estates ensure that they make the most out of it by "selling" it to themselves, since they also own the power

plant. To the utility, it looks like the IPP are purchasing the bagasse used and this cost is reflected in the price the IPP agree to sell electricity to them.

Cost Representation of Fuel used for Electricity Generation							
		1994		1999		2003	
Fuel Oil	Tonnes	147129		190683		200067	
	Average Import Price(Rs/tonne)	1696		2914		5045	
	Cost(Rs in million)	249.5	74.2%	555.7	66.6%	1009.3	71.3%
Diesel Oil	Tonnes	2844		3064		2423	
	Average Import Price(Rs/tonne)	2807		3769		7137	
	Cost(Rs in million)	8.0	2.4%	11.5	1.4%	17.3	1.3%
Kerosene	Tonnes	14789		41948		9864	
	Average Import Price(Rs/tonne)	3355		4040		8350	
	Cost(Rs in million)	49.6	14.7%	169.5	20.3%	82.4	5.8%
Coal	Tonnes	31949		112123		287176	
	Average Import Price(Rs/tonne)	919		870		1064	
	Cost(Rs in million)	29.4	8.7%	97.5	11.7%	305.6	21.6%
Bagasse	Tonnes	395800		714000		1046794	
	Average Import Price(Rs/tonne)	–		–		–	
	Cost(Rs in million)	–	–	–	–	–	–
TOTAL COST (Rs in million)		336.5	100%	834.2	100%	1414.6	100%

Table 2: Cost Representation of Each Fuel used for Electricity Generation

Coal used in Mauritius is imported from South-Africa or Mozambique and is generally low in sulphur content. The main problem associated with coal-fired generation is with regards to its carbon-dioxide emission. Dust and ash residues are other issues which need attending to after combustion and secondary usages need to be identified for them [1]. About 92% or 287,176 tonnes of the coal imported in 2003 was used by IPP to produce electricity and with the coming to operation of "Centrale Thermique du Sud"(CTDS) in October 2005, the imported amount is expected to experience a 25% increase.

The direct cost of imported fuel to Mauritius for the purpose of electricity generation is of major interest in making a proper assessment of the savings that we are currently making as a result of the lesser dependence on petroleum products. Table II shows the amount of each type of fuel imported(tonnes), the corresponding average import price associated with the fuel(Rs/tonne) and the computed total cost of importation of that particular fuel. It also shows the percentage cost representation of each type of fuel. It is interesting to note from Table I and Table II that even though fuel oil represents only 34.5% of the fuel input for electricity production, the cost associated with its purchase represents 71.3% of the total cost of fuel used for electricity generation. Furthermore, even though fuel oil still represents 71.3% of the total cost of imported fuel to generate electricity, there has been only a 35% increase in the tonnage imported since 1994. The rising cost of fuel oil has not been beneficial to us and fuel oil still eats up about the same percentage of the total cost of imported fuel as it did in 1994. Had the country not invested in coal/bagasse power plants, fuel oil imports for electricity generation would today have represented over 90% of our importation cost. The imported volume of diesel oil for the purpose of electricity generation has remained more or less constant while that of kerosene has dropped dramatically (from 41948 tonnes in 1999 to 9864 tonnes in 2003). Given the very high import price of kerosene, it was critical to minimise its usage as a fuel used to generate electricity. The price of diesel oil and kerosene have both been subject to large rises, in excess of 150%. Coal is the fuel that has seen the largest volume change. The tonnage of coal imported has experienced an increase of about 900% since 1994, and it is interesting to note that the average import price of coal has remained very stable. Using coal as a source of energy has clearly got its economic advantages. Similarly for bagasse, there has been a 200% increase in the use of bagasse to generate electricity, and there is no import cost associated with it. The price at which it is purchased though is not clear. Nevertheless, it must be mentioned that there is a lot of room for improvement with respect to the usage of bagasse to generate electrical energy. With proper logistics and planning, we could be using all or close to all of our 2 million tonnes of bagasse produced annually to generate electricity. Looked at another way, we are currently operating at only 50% of our potential capacity as far as bagasse is concerned.

3. CENTRAL ELECTRICITY BOARD AND INDEPENDENT POWER PRODUCERS

Electrical energy is generated (partly), transmitted and distributed by the Central Electricity Board(CEB). They have the plant capacity to generate most of the electricity the country requires(installed capacity of 408 MW) and the remaining electricity is bought from the Independent Power Producers(IPP)(installed capacity of 236.8 MW). CEB has power purchase agreements with three IPP that produce electricity all year round using a combination of coal and bagasse(during crop season). These three IPP, known as "firm producers" are Compagnie Thermique de Belle-Vue Ltée, Fuel Steam and Power Generation Co. Ltd and Consolidated Energy Ltd. Power purchase agreements have also been signed with seven IPP that produce electricity

during crop season only and they are referred to as "continuous producers".

All IPP are affiliated to the sugar sector and they are as old as the sugar industry. Sugar factories initially utilized bagasse boilers for sugar processing and electricity generation of the factories in an attempt to be self-sufficient. Any surplus power generated using this scheme was sold to the power utility (CEB). With time, realising the potential of this new opening onto the power sector and with the help of the government's "Bagasse Energy Development Program"(BEDP) in 1991, the IPP began investing heavily in power plants that are operational all year round. The BEDP included fiscal incentives for industry modernisation, steps to centralise sugar production, tariff reduction on sugar exports and on imports of cogeneration technologies. However it was soon realized that bagasse alone would not be sufficient to supply the IPP with the necessary fuel for the whole year. It is available for only half of the year and it has a relatively low energy content compared to other conventional fuels. The cogeneration plants to be used had to rely on an additional source of fuel, coal. As at 2003, the firm producers had an effective plant capacity of 121 MW and the continuous producers an effective capacity of 84.8 MW, making up a total effective thermal generation capacity of 205.8 MW. The total effective capacity of Mauritius is 568.3 MW, meaning that over 36% of the power generated by the country comes from the IPP [2]. Table III shows the trend over the years of the percentage share of electricity generated by CEB and IPP that is available for sales.

YEAR	1994	1999	2003
CEB	87%	75.8%	60.4%
IPP export to CEB	13%	24.2%	39.6%

Table 3: Percentage share of electricity generated available for sales by CEB and IPP

It is clear that the IPP have increased their share of the market quite considerably over the last 10 years(by over 26%) and they plan to keep doing so for years to come. The CTDS will be another addition to their armour and will be commissioned by October 2005 adding another 30 MW to their production capability. It is however going to be powered by coal only. Of equal interest is the ratio of bagasse to coal used to generate power by the IPP. Table IV shows the amount of GWh sold to CEB by the IPP using bagasse and coal. With increasing demand in energy and given the limitations on the availability of bagasse as an all year round fuel, there has been an increasing percentage of coal usage to generate power. In fact, coal has been gradually eating up the share of bagasse and there has been an increase of over 20% in the percentage representation of coal powered generation. And this is the case even though the amount of electricity generated using bagasse has increased by almost 300% during the same time.

4. FUTURE TRENDS

Over the 10 year period, from 1994 to 2003, the installed capacity of the IPP has increased from 43 MW to 237 MW. This has been possible through heavy investment from the private sector(sugar mills) implementing cogeneration technology. As an example, the implementation of the "Centrale Thermique de Belle-Vue" is estimated to have required an investment of around US$100 Million. The private sector is still investing heavily, the more so as it is fully aware of the changes facing sugar trading on the world market. With the Organisation for Economic Cooperation and Development(OECD) pushing forward with the liberalisation of the sugar trade and the removal of all preferential tariffs from which Mauritius is currently benefiting as a developing country, the sugar sector can/will be dealt a heavy blow if it does not ensure its own survival through other means. The production of electricity from bagasse is certainly one of them. The sale of electricity will add more to the revenue of sugar companies or at least compensate for the potential losses they may incur. However, only the number of units of cogeneration plants alone is not going to make the difference. The country will also need to invest in more efficient bagasse-to-electricity processes. In the year 2003, we were producing 61 kWh/tonne of cane, compared to 16 kWh/tonne of cane in 1994. Indeed we have become much more efficient during these 10 years but if we compare our performance with that of for example our neighbour Réunion, we find that we still are far behind. Réunion Island currently produces on average 110 kWh/tonne of cane, about twice as efficient as Mauritius. It is true though that Réunion Island uses only two power plants, both of which operate as separate entities distinct from cane milling activities. Furthermore, they operate under similar conditions to the power plant we have at Belle-Vue and which has been operational since 2000 and which is capable of the same efficiency given the very high pressure and temperature (80 bars, 525°C). Nevertheless it is good to know what sort of power generation is possible from a given mass of bagasse and what we should aim for.

New power purchase agreements have recently been signed with "Centrale Thermique de Savannah Ltée"(CTSav) which will operate on both bagasse and coal and will generate more power than currently at Compagnie Thermique de Belle-Vue Ltée (CTBV). It will provide 65.5 MW during crop season using bagasse and 74 MW during off-season using coal. Requiring an investment of Rs 3.6 billion over a period of 2 years, it should be operational by June 2007. With it, there is also going to be a centralisation of the activities of Riche-En-
Eau and Mon-Trésor, increasing the current cane processing capability from 500,000 to 1.2 million tonnes, and all of the bagasse will be provided to the power plant next door. In the next couple of years, with the coming to operation of CTDS and with the implementation of CTSav, the electricity export to the grid from bagasse alone is likely to exceed 500 GWh. With further

improvement in current cane milling activities, prompt processing(ensuring little loss in the calorific value of bagasse through fermentation) and with the use of high pressure boilers and turbo-

FUEL	1994		1999		2003	
Coal(GWh)	46.0	37.5%	155.2	45.2%	433.4	59.4%
Bagasse(GWh)	76.6	62.5%	188.5	54.8%	296.1	40.6%
TOTAL(GWh)	122.6	100.0%	343.7	100.0%	729.5	100.0%

Table 4: Amount of GWh sold to CEB by IPP using bagasse and coal

alternators around the country, a lot more power can be made available to the grid (an estimated 750 GWh) through the use of the same amount of bagasse.

With so many changes happening in the power sector, the government has come up with a new "Electricity Bill Act" (replacing the one dating back to 1939) to cater for greater transparency and fair competition between operators and to try to remain in control. The bill provides for a licensing of electricity services including the generation, transmission and distribution of electricity, all being coordinated and controlled by the "Utility Regulatory Authority"(URA). Importantly, the bill insists on all operators to provide their tariffs for inspection to the public at no charge, ensuring transparency and a right level of electricity tariff. Strict guidelines are also laid down in the bill taking into account various areas of concern to the regulatory body among which: safety, reliability, quality of service, efficiency, procedures for joint ventures and for sharing/selling of equipments between operators. If any of the conditions are not satisfied or an abuse is made of the conditions of operation, the URA has the authority and capacity to withdraw licences within a very short notice.

5. CONCLUSION

Mauritius has led the way as far as sustainable energy development is concerned in the African region. In 2003, 16% of the total electricity production was generated using bagasse and this represents the highest proportion of renewable power generated in any African country. Nevertheless, we cannot claim to be self-sufficient as far as our energy requirements for electricity generation is concerned. Far from it and we still have a long way to go. Our reliance on petroleum products has certainly been reduced over the years and even though we are no more highly vulnerable to hydrocarbon shocks, we remain at risk. Hundreds of jobs have been created in the process and will be created in the near future. There is still a long way to go towards optimising our energy generation capability but in the mean time, African countries can learn from our successes and mistakes in implementing this new technology in our sugar industry.

6 BIBLIOGRAPHY

[1] Integrated Electricity Plan 2003-2012. Technical report, Central Electricity Board, 2003.

[2] Digest of Energy and Water Statistics 2003. Technical report, Central Statistics Office, 2004.

[3] C. Bhurtun, I. Jahmeerbacus, and R. Coonjul. The potential of sugar cane bagasse as a renewable source of energy. In *Industrial and Commercial Use of Energy Conference*, 2004.

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