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OPTIMISATION OF POWER GENERATION IN THE LOCAL CANE SUGAR FACTORIES

by

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ABSTRACT

This article looks at the contribution of electricity using the Biomass Integrated Gasification – Combined Cycle (BIG-CC) technology with bagasse, cane tops and leaves (CTL) in the Mauritian Sugar Industry. The contribution of the energy of bagasse for 1996 represented 10.34% of the island's electricity requirements (CEB Annual Report, 1996). The main contribution came from Flacq Union Estate Limited (FUEL) generating 78.43GWh or 66% of the total energy from bagasse. This was possible only after FUEL improved its Combined Heat and Power (CHP) system by investing in high pressure boilers and generating on a firm basis throughout the year. However, it is shown that by using bagasse and cane tops and leaves and investing in high pressure boilers and condensing-extraction turbo-generator sets, it is possible to increase the share of bagasse derived electricity to approximately 50%. The use of the most promising technology derived from the BIG-CC can make a significant contribution to the country's energy requirements, in fact the country can be self-sufficient in its electricity requirements for the year 2000!

Keywords: Bagasse energy potential, cane tops and leaves, inter-crop season, off-crop season,sugar factories, BIG-CC technology, electricity production.

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INTRODUCTION

To assess the real energy potential of bagasse and CTL, two scenarios are considered: (I) off-crop power generation and (ii) gasification technologies. Some years ago, only FUEL was generating power during the inter-crop season and was therefore the main contributor in the share of bagasse derived electricity. Recently, Belle-Vue and Beau-Champ sugar estates have manifested their intentions in off-crop power generation, by upgrading their power plants so as to run on a bagasse cum coal basis. This shows that we are still unaware of the energy potential of bagasse. It was in 1996 that a step towards the recognition of the bagasse energy potential was made.That year, FUEL reduced its coal consumption by purchasing surplus bagasse from neighbouring factories.

USE OF HIGH PRESSURE BOILERS AND CONDENSING-EXTRACTION T.G SETS

To fully exploit the energy potential of bagasse, it is necessary for the local sugar factories to review their combined heat and power systems. By investing in high pressure boilers or upgrading their actual boilers, and making use of condensing-extraction turbo-generator sets, it is possible to increase the production of electricity from bagasse. It should be noted that it is essential to reduce process steam requirements when considering cogeneration on a firm basis. It was shown that on using high pressure boilers of up to 45 bar, condensing-extraction turbo-generator set and 340kg of steam/cane (tc), it is possible to generate at least 100 kWh/tc cane (Riviere, 1992). Assuming a mean annual cane production of 6 million tonnes, then the estimated annual electricity production from bagasse is as shown in Table 1.

The attractiveness of off-crop power generation can be increased by considering the use of cane tops and leaves which are usually left in the fields for the following reasons: reduced soil erosion, improved water conservation and infiltration rates, reduced cost of weed control, enhanced macro and microbiological activity, build up of organic carbon in certain soils and increased soil fertility.

Table 1. _Annual electricity production from bagasse

	Improved CHP system
Electricity production from bagasse	600 GWh
Assuming a mean power requirement of 20 kWh/T cane, then factory electricity consumption	120 GWh
Annual exportable electricity	480 GWh

Deepchand (1988) has shown that cane tops and leaves at a moisture content of 72% make approximately 20% of the weight of cane. Assuming that 30% of the CTL are left in the fields for the above reasons, then CTL represent about 840,000 tonnes of additional boiler fuel. On the basis that 1kg of bagasse is equivalent to 2.5kg of CTL, then the annual electricity production from CTL is 112 GWh as given in Table 2.

Table 2. Annual electricity production from CTL

	Improved CHP system
Electricity production from CTL	112 GWh
Assuming a mean power requirement of 20kWh for processing 1T of CTL, then factory electricity consumption	16.8 GWh
Annual exportable electricity from CTL	95.2 GWh

From the above tables, the net annual electricity production from bagasse and CTL is 575.2 GWh as opposed to 119 GWh in 1996 (CEB Annual Report, 1996). The island electricity requirements for 1996 totalled 1150.94 GWh, showing that the appropriate use of bagasse and CTL would have satisfied nearly half of the island electricity needs. Assuming electricity production at a specific generation cost of Rs1.05/kWh from fossil fuels, then the proper use of bagasse would save some Rs603.4 million (CEB Annual Report, 1996).

USE OF THE BIG-CC TECHNOLOGY

In order to satisfy the ever increasing demand for electricity, the use of bagasse for energy production with the most promising technology, derived from the Biomass Integrated Gasification Combined Cycle (BIG-CC) system, would need to be considered in the Mauritian context. Actually, the local cane sugar industry, after satisfying its own steam and electricity demand, supplies an average of 15kWh/tc of electrical energy to the national grid. With the BIG-CC technology, an average of 100 kWh/tc or more can be generated, if the conditions of low process steam consumption and a reduced factory power consumption are imposed.

THE BIG-CC

Fig. 1 shows the key elements of the BIG-CC (Kong Win Chang & Lau Ah Wing, 1997).

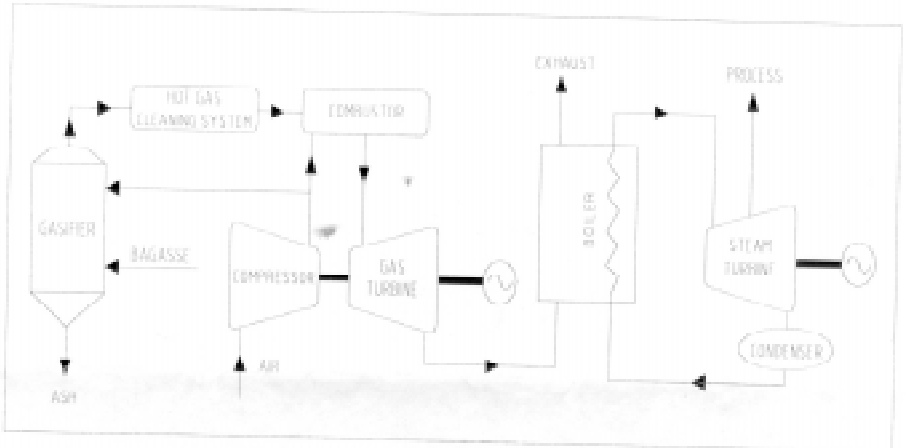

Fig. 1. Key elements of the BIG-CC

In this cycle bagasse is burnt in a gasifier to produce a combustible gas. The gas is then cleaned before being fed to the combustor. The air/gas mixture is burnt in the combustor to produce hot combustion gases which is conveyed to the gas turbine to generate power. The exhaust of the gas turbine is fed to a heat recovery steam generator (HRSG) to raise steam. The steam produced is expanded in a steam turbine to generate more power and process steam, at the required pressure and temperature, is extracted from the turbine.

An energy balance based on the gasifier/gas turbine configuration is shown Fig. 2. Appropriate efficiencies for the different equipment were assumed, based on woody biomass, and that gas cleaning is achieved. From the energy balance, some 824 kWh/t bagasse can be generated from the gas turbine (Beeharry & Baguant, 1995). This energy balance excludes the output from the steam turbine when operating as a Combined Cycle.

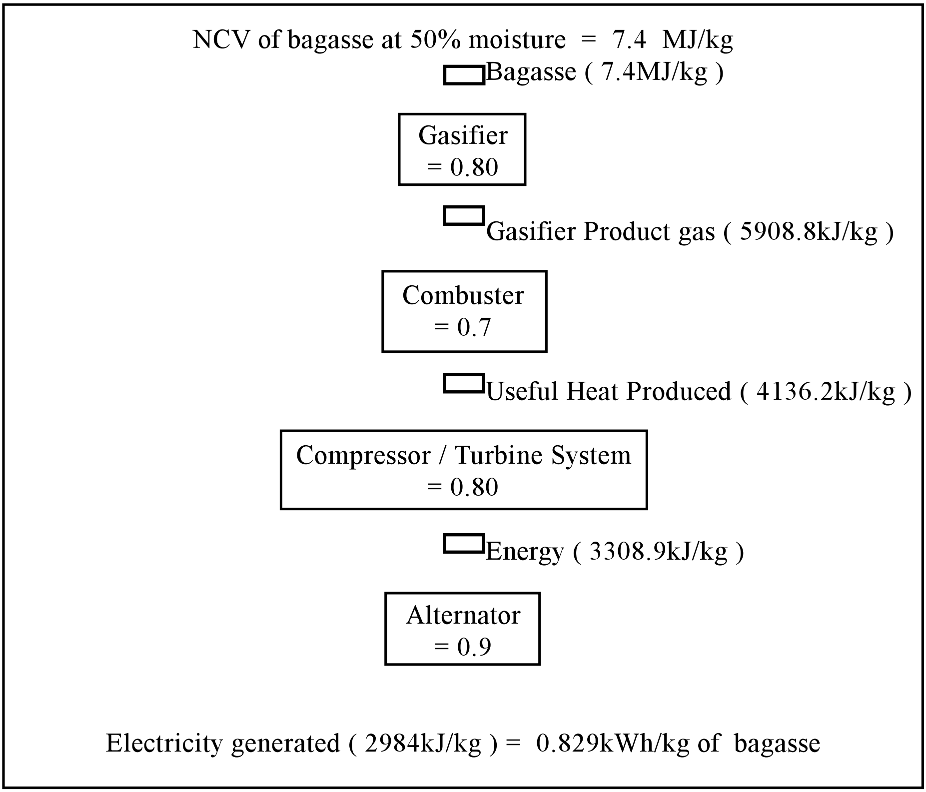

Fig. 2. Energy Balance of Gasifier / Gas turbine configuration

Based on the energy balance given above, an overall conversion efficiency on the NCV of bagasse to useful heat of more than 40% is possible. Tables 3 and 4 below give an indication of the energy potential of this technology from using both bagasse and CTL.

Table 3. Annual electricity production from bagasse

Annual Electricity Production using BIG-CC technology	
Annual cane production (t)	6,000,000
At a bagasse % cane of 30%, annual bagasse production (t)	1,800,000
Annual electricity production (GWh)	1491.8
Less factory electricity requirements at 20kWh/tc (GWh)	120
Annual exportable electricity (GWh)	1371.8

Table 4. Annual electricity production from CTL

Annual Electricity Production using BIG-CC technology	
Annual cane production (t)	6,000,000
Assuming CTL make 20% of the weight of cane (t)	1,200,000
Assuming 70% of CTL used for electricity production (t)	840,000
Assuming 1kg of bagasse = 2.5 kg CTL, then electricity production at 0.824kWh/kg bagasse (GWh)	278.54
Less factor electricity requirements at 20 kWh/tonne CTL (GWh)	14.28
Annual exportable electricity (GWh)	264.26

Thus, based on bagasse gasifier/gas turbine configuration, it is possible to generate about 1636.06 GWh annually. Assuming an annual increase in electricity demand of 9 % as from 1996 (8.76% for 1995-96), then using bagasse and CTL with gasification technologies, it is possible to satisfy the island requirements up to the year 2000 as shown in Fig. 3.

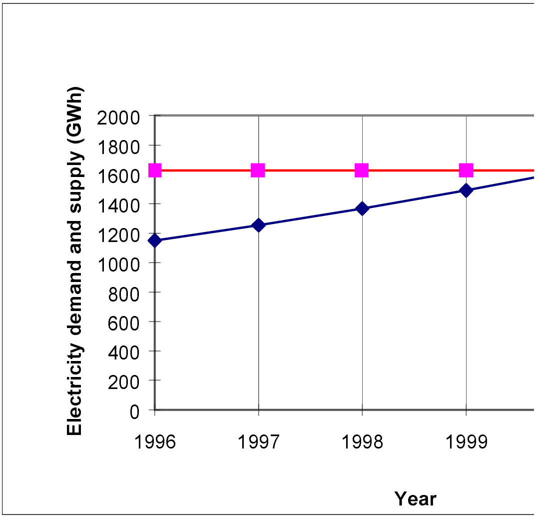

Fig. 3. Electricity demand and supply forecast

CONCLUSIONS

The local sugar factories should make efforts to enhance their CHP systems so as to become integral suppliers of the energy supply mix. Plants using CTL, such as that at Union Saint Aubin, can help to increase the share of electricity from sugar factories. The high specific investment of the BIG-CC technology (US $2260/kW) will certainly delay its application in Mauritius, but with the R&D work being carried out, the cost per kW is bound to drop in the future years. This leaves the country sufficient time to prepare this development. Also, the high cost of this technology makes it difficult to be installed in each sugar factory, thereby encouraging the centralisation of the sugar industry. Thus, if the sugar industry and the country are to benefit from the enormous energy potential of both off-crop power generation and gasification technologies, it is high time for the three parties, the Government, the CEB and the sugar factories, to come to an agreement on this subject. The Government may lead the role as a facilitator encouraging joint ventures and BOT schemes to see the advent of bagasse gasification technologies in Mauritius.

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