PRODUCTION OF ELECTRICITY FROM BAGASSE IN MAURITIUS

S Marie-Jeanne
Mauritius Sugar Industry Research Industry, Reduit

ABSTRACT

The problem and potential of electricity production from bagasse is reviewed in the light of the work done by the Sugar Technology Division of the MSIRI on energy balances of sugar factories and on the storage of bagasse. Present energy requirements of sugar factories are analysed and improvements towards energy savings suggested. Boiler performances and bagasse storage problems are also discussed. Examples of excess bagasse potentials are worked out from results obtained and the production of electricity is outlined in connection with excess bagasse handling and storage constraints.

INTRODUCTION

Bagasse potential as a source of renewable energy has been discussed and analysed at various levels since the first seminar on Energy held at the University of Mauritius in 1977.

There was a National Energy Conference in 1980, a Feasibility Study by Trans Energ in 1982, a Master Plan for the sugar industry in 1984 and most recently a plan of action was announced by the Government. On the production side, power plants at Medine, Mon Desert Mon Tresor and FUEL and a bagasse pelletisation plant at Beau Champ have been installed.

The Mauritius Sugar Industry Research Institute (MSIRI) has directed its efforts to producing accurate data on the energy utilisation of our sugar factories with the object of proposing energy saving measures through plant and operating procedure modifications. It has also studied bagasse conservation problems.

SUGAR MANUFACTURE

For many years now sugar has been manufactured in Mauritius under conditions which do not require energy saving measures as a surplus of bagasse results in increased expenditure for its disposal.

Boilers and prime movers which have been installed have in many cases relatively low efficiencies, the former consume large amounts of bagasse and the latter large quantities of high pressure steam which are exhausted to meet process house demands. Furthermore, operating procedures are geared to conditions of generous fuel supply, for example the time taken for starting up, shutting down or boiling off are governed more by labour costs than by energy costs.

Measurements of energy flows in a factory have rarely been made. As a result studies on the potential of excess bagasse have had to make several assumptions, or base their calculation on manufacturer's specifications not verified in practice.

ENERGY BALANCE SURVEYS

In 1981, the Sugar Technology Division of the MSIRI ordered equipment for the continuous monitoring of flow rates, pressures and temperatures of steam at the various stages of sugar manufacture. From 1982, factories were surveyed in turn on a round-the-clock basis for periods varying from two to three weeks. Problems were encountered at the beginning and it took some time to assess and implement the techniques of continuous monitoring and logging with electronic equipment.

Energy consumption can now be measured under various factory operating conditions such as start-ups, shut-downs, breakdowns and liquidation. It is also possible to measure fluctuations in demand which are inherent to milling systems and to the process.

There are limitations to what can be achieved for lack of equipment. It is not possible for example to assess boiler performance on a continuous basis as a system for the continuous weighing of bagasse fed to the boilers are not easily available. However, boiler efficiency tests can be carried out for short periods of one to two hours when bagasse weights can be indirectly estimated.

As measurements of flows, pressures and temperatures are taken every 0.5 to 2 minutes, a mass of information is logged and analysed from which a fairly accurate picture of the energy balance of a factory can be drawn.

OVERALL ENERGY REQUIREMENT FOR SUGAR MANUFACTURE

From the 12 factories surveyed so far, a useful comparative assessment of energy required for sugar manufacture has been obtained (Table 1). As boiler and factory performance are not necessarily interdependent, the energy output from the boiler has been related to the factory requirement and expressed in terms of Giga joules/tonne fibre.

Factories in Mauritius operate in two modes:

a. Generation of surplus electricity for export and process steam make-up.

b. Live steam throttling for process steam make-up.

In the first mode, it is possible to generate more electricity than is required for process steam if bagasse is available and surplus exhaust is blown-off to the atmosphere. The energy used up in producing this surplus electricity is not considered as a requirement for sugar production. On the other hand, process make-up requirements are dependent on prime mover efficiency, process requirements and the exhaust steam regime and varies from factory to factory. Throttling steam through a turbo alternator can produce electrical energy varying from 25 to 55 Kwh/tonne fibre.

Energy saving measures

Major and expensive modifications will reduce overall energy requirements. In the meantime steps to improve control and balance can and should be taken to reduce unnecessary losses including:

a. Metering of boiler steam output and condensate return.

b. Installation of a clarified juice buffer tank to reduce fluctuations in process steam requirements.

c. In the absence of condensing turbo alternators, export of electricity should be limited to balance process exhaust steam requirements.

BOILER PERFORMANCE

Tests of short duration have indicated a range of boiler efficiencies varying from 50 to 80% of net calorific value. Inadequate excess air control, excessive levels of boiler feed water make-up (up to 40%), incomplete bagasse consumption resulting in high levels of unburnt bagasse in both furnace ash and flue gas are problems that need to be solved. Improvement in this field will require expensive modifications and sophisticated control systems.

BAGASSE STORAGE

Bacterial degradation of bagasse in storage leads to loss of dry matter. The heat released causes loss of moisture and sometimes spontaneous combustion.

Studies on the evolution of these parameters have shown that climatic conditions can lead to losses of up to 25% of dry matter in baled bagasse over 3.5 months, while moisture levels can drop to 20%. The rate of dry matter loss is considerably reduced in bagasse at 25% moisture and below.

Bagasse pellets at 8% moisture keep very well but are expensive to produce. Present research is aimed at drying and densifying bagasse at 25% moisture to achieve a loss of dry matter not exceeding 8% over six months storage.

EXCESS BAGASSE POTENTIAL

Excess bagasse from all factories excluding FUEL, Medine and Mon Tresor which are equipped to use their bagasse for the production of modulated electrical energy, is calculated in Table 2 from the average of results obtained to date.

From the performance of the most efficient unit and after improvement of control and operating procedures the expected potential has been estimated (Table 3).

Electricity production

The production of unmodulated energy will continue and be probably increase if adequate remuneration is obtained for excess bagasse; this production can be estimated to be about 16 GWh with maximum bagasse savings increasing to 35 GWh with more efficient prime movers. From the estimation of present and future excess bagasse availability, the location and sizing of future bagasse-fired power plants can be made with more accuracy. Taking into account the cost of drying and densification on one hand, and the high losses of green bagasse in storage, the immediate use of a maximum amount of loose green bagasse becomes an attractive proposition.

CONCLUSION

The feasibility study on electricity production from bagasse carried out by Trans Energ has shown an annual potential of some 395 GWh. This can now be reviewed and more accurate estimates obtained to determine the number, sizes and location of future bagasse-fired power plants.

The installation of additional measuring and control equipment is of immediate importance as well as the modification of certain operating procedures in sugar manufacturing. Studies on bagasse drying and densification systems must be accelerated to achieve more economical targets.

TABLE 1: Energy required at boiler outlet for sugar manufacture

Factory	Nominal Capacity (Tonnes Cane/Hour)	Energy Requirement Giga Joules/tonne fibre
1	115	9.34
2	110	9.62
3	175	10.49
4	115	10.00
5	90	9.82
6	100	10.7-11.5
7	145	9.70
8	70	10.22
9	110	9.6
10	130	9.0
11	90	11.08
12	140	11.2

TABLE 2: Calculation of excess bagasse

Cane crushed (Tonnes)		6,250,000
By FUEL, Medine & MDMT 24%		1,500,000
Balance		4,750,000
Actual x S bagasse potential calculated on:-		
Boiler efficiency		70%
Energy required for sugar Manuf.		10.25 GJ/tf
Bagasse consumption other than for actual sugar manufacture		9%
At Fibre % cane	13	16
Excess bagasse available (tonnes)	291,104	358,282

TABLE 3: Excess bagasse potential after process control and operation modifications

Boiler efficiency		70% NCV
Energy for sugar manufacture		9.0 GJ/tf
Bagasse consumption for weekends etc.		5.0%
At Fibre % cane	13	16
Excess bagasse potential (tonnes)	465,000	572,319