Adaptation, Deployment and Use of the Modern Bio-fuel/Bio-power Technologies: A Case Study of Bagasse Power Cogeneration in Zimbabwe.

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EXECUTIVE SUMMARY

Zimbabwe currently has an electricity generation capacity of just about 2,000 MW. Energy imports have shot up to close to 50% of total energy needs at times faced with a stagnant capacity over the last 17 years. (Mangwengwende 2002, Kayo 2002) The scarcity of foreign currency has made it an imperative that load shedding be introduced at times. The scale of energy disruptions, whether planned or unplanned for, has resulted in huge losses to industries. The losses incurred are an invisible tariff that the customers of the utility have to pay. On the other hand, it is clear, that large-scale investment in electricity generation requires a lot of capital. An extra capacity of 300MW would require around US$ 450 million in investment capital, assuming that it costs an average of US$1,500 for every 1KW of capacity developed. (Mangwengwende, 2002) This investment level is beyond the capacity of the currently heavily indebted Zimbabwe Electricity Supply Authority (ZESA) and the Government of Zimbabwe at the moment.

Bagasse energy cogeneration in Mauritius has over the last few years demonstrated that the sugar industry has the potential to meet a substantial portion of a nation's energy needs. The current state of the art technology, in Mauritius and Reunion islands, is the generation of firm power, using a high-pressure boiler at 82 bars, with an efficient generation rated at over 120 kWh per tonne of cane. Plants with a capacity of 70 MW have been put up in Reunion and Mauritius at a total cost of about US $110 million each. (Deepchand, 2000) This is a sizeable medium scale investment level, which can be emulated in Zimbabwe in order to address the current power shortage. However there would be a need to ensure that the electricity tariffs and incentive schemes available can sustain such a level of investment in the sugar industry. The Zimbabwean electricity tariffs would need to be set at a level that takes into account long-term marginal costs. This if put in place might in the case of the Zimbabwean situation offer an incentive for a direct business arrangement between the sugar companies and the utility ZESA, without a need for a lot of government intervention.

However, for long-term stability and sustainability, a clear and comprehensive government policy on bagasse power development is necessary. This is particularly so given the current low state of electricity tariffs, which are far below the long-range marginal cost. It is noted that the current tariffs have been eroded by further devaluation of the Zimbabwean dollar and when placed at the black market or parallel market rate fare dismally. They are generally set at about US 4.2 cents per kWh, at the official foreign currency exchange rate. (The Financial Gazette 1999; Mangwengwende, 2002) It is the focus of this research to determine specific policies, policy instruments and laws that would be needed in order to attract investment in cogeneration in the sugar industry in Zimbabwe. The study considers; the current state of technology transfer in the area in the Zimbabwean sugar industry, the question of ownership and organisational structure of the envisaged new power plants, the role of the government and the utility and the training needs in order to enable successful technology transfer. Based on literature and previous studies, performance indices have been computed for bagasse-based cogeneration technology. The status of bagasse electricity generation technology is therefore summarised by the following Table E1, which gives the performance indices of the power plants in Zimbabwe as compared to Mauritius and world best practices.

Table E1 A comparison of cogeneration technology indices[1]

	Current Status in Zimbabwe	Best Available Technology Option from Mauritius	Estimated Cogeneration Potential for Zimbabwe if Best Available Technology in Mauritius is Applied	Best Available Technology Options Globally	Estimated Cogeneration Potential for Zimbabwe if Best Available Technology Globally is Applied.
Bagasse Gasification	None	None	Not Applicable	Not yet available potential 500 kWh/ Tonne Cane	2,350 GWh
Highest Boiler Specifications	150 Tonnes steam per hour, 30 bars, 400° C	140 Tonnes Steam per hour, 82 bars, 525° C	705 GWh	140 Tonnes Steam per hour, 82 bars, 525° C	1,175 GWh
Power Output per Tonne Cane	44 kWh/ Tonne Cane	150 kWh/ Tonne Cane	705 GWh	250 kWh/ Tonne Cane	1,175 GWh
Power Export per Tonne Cane	None	110 kWh/ Tonne Cane	517 GWh	210 kWh/ Tonne Cane	1,175 GWh
Maximum Turbo Alternator Capacity	20 MW	35MW	35 MW	35 MW	35MW
Bagasse Moisture Content	48%-50%	48%	705 GWh	48%	1,175 GWh

The document goes on further to give an overview of modern bio-power technologies that can be used in Zimbabwe's electricity industry based on the bio-resources available in the sugar industry. In order to justify the choice to use these resources, a broader energy supply and demand scenario in Zimbabwe is discussed. This highlights power supply and demand in Zimbabwe. It is clear that the import level at about 50% of national electricity demand is very high and not sustainable in the future. Information on current use and potential future use of bagasse in electricity generation is presented. The current power generation capacity in the Zimbabwean sugar industry of 81.5 MW, which is normally operating at about 36 MW can be expanded to 210 MW, a higher operating level. Based on experiences in Mauritius, a number of policy recommendations and conclusions have been made for the Zimbabwean case.

The following policy recommendations are made for immediate implementation:

1. There should a Cabinet level committee and a technical committee servicing it in order to ensure top-level commitment to bagasse energy development in Zimbabwe.

[1] Sourced from Afrepren, 2001; Calle, 1999; Deepchand 2000; Murefu, 2001; Mutsambowa, 2001; Nyamuzihwa 1999; Nyamuzihwa, 2000. Calculations of estimated cogeneration potential in Zimbabwe based on Best Available Technologies in Mauritius and globally, are based on the crushing of 4.7 million tones of cane per year in Zimbabwe's two sugar industries.

2. A national research agenda and manpower development plan for the sugar and bagasse power industries should be established.

3. The government should promote energy and process efficiency in the sugar processing and bagasse power plants through sales tax, import duty and income tax holidays.

4. Investment in the sugar and bagasse power industries should be depreciated at a higher percentage in order to promote faster modernisation and replacement of plant and machinery.

5. Remove discriminatory practices in transmission, sub transmission, distribution and supply of electricity to enable easy access by bagasse power.

6. Bagasse power development investors should be allowed to raise tax-free debentures.

7. The government should put in place a policy on renewable energy development stipulating that 10% of new energy developments in future should be from renewable energy sources, cogeneration and from waste, with the sugar industry contributing at least 140 MW using firm power plants in the long-term.

Other policy issues can be considered as well. However many of them would not be feasible in the current economic and political climate. These should be noted and efforts should be made to make them feasible. It is concluded that bagasse power development in Zimbabwe is technically feasible. In addition it would contribute positively to the environment. The Governments of Zimbabwe, the two sugar companies and the national utility ZESA are the key players that would ensure the success of such a development. Once the current transient economic and political problems are over come, it is envisaged that successful bagasse power development can take place. Lessons from this experience can then be extended to other power sectors in promoting renewable energy and energy efficiency.

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LIST OF ABBREVIATIONS AND ACRONYMS

AIDS	**Acquired Immunity Deficiency Syndrome**
BPC	**Botswana Power Corporation**
CDM	**Clean Development Mechanism**
DOE	**Department of Energy**
ESCOM	**Electricity Supply Commission of Malawi**
IPP	**Independent Power Producer**
IET	**International Emissions Trading**
JI	**Joint Implementation**
GW	**Gigawatts**
GWh	**Gigawatt-hour**
kPa	**Kilo Pascals**
kV	**Kilovolts**
KW	**Kilowatts**
kWh	**Kilowatt-hour**
LEC	**Lesotho Electricity Corporation**
MW	**Megawatts**
NamPower	**Namibia Power**
PI	**Preparation Index**
PIESA	**Power Institute for East and Southern Africa**
SADC	**Southern Africa Development Community**
SAPP	**Southern African Power Pool**
SEB	**Swaziland Power Board**
SIRDC	**Scientific and Industrial Research and Development Centre**
TA	**Turbo-Alternator**
TANESCO	**Tanzania Electricity Supply Corporation**
TCH	**Tonnes of Cane per Hour**
tsc	**tonnes of sugarcane crushed**
US$	**United States of American dollar**
Z$	**Zimbabwean Dollar**
ZESA	**Zimbabwe Electricity Supply Authority**
ZESCO	**Zambia Electricity Supply Corporation**

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GLOSSARY OF TERMS

Before much can be covered it is important to familiarise with the terminology used in the sugar industry. The list of the terms given below is not exhaustive but it does highlight the most commonly used ones particularly in this project.

Bagasse: In the extraction process, sugarcane is crushed and its juice is washed out. The fibre and the moisture that remains after juice extraction is called bagasse.

Brix: the sum of dissolved matter in a sugar solution expressed as a percentage by mass or as an actual mass.

Clear juice: the juice obtained after mixed juice has been cleared of impurities like mud through the clarification process.

Diffuser: An enclosed carrier, through which a bed of prepared cane is slowly dragged, while copious quantities of water and thin juice percolate through the bed to wash out the pol-bearing juice.

Evaporator: Is a shell and tube heat exchanger where the stream is normally in the shell and the product in the tubes and in motion.

Firm Power: Electricity firmly supplied to the grid using bagasse during the on-crop season and using coal during off-crop season.

Massecuite: molasses-sugar crystal mixture.

Mixed juice: the juice obtained after crushing and diffusion or tandem milling of cane.

Molasses: is the substance remaining after sugar crystals have been removed from the mother liquid (massecuite).

Multiple effect evaporation- A system of evaporators arranged in such a way that the Vapour released by the juice being heated is used to heat the juice in the next vessel in the series.

Purity: it is the pol to brix ratio.

Pol: is the apparent sucrose in a substance, given as a percentage by mass or as an actual mass.

Raw sugar: the sugar produced by running the minimum number of turns in the centrifugal separator.

Syrup: the juice coming from the fourth effect evaporator vessel.

Vapour 1 (V1): Vapour tapped or bled from first vessel in multiple effect evaporation.

Vapour 2 (V2): Vapour tapped or bled from second vessel in multiple effect evaporation.