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Bagasse energy cogeneration potential in the Zimbabwean sugar industry

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Abstract

The cogeneration of steam and electricity has become the norm in the sugarcane industry worldwide. This process has been taken further to a stage where sugar companies can export a substantial amount of energy to the grid. Mauritius and Reunion Islands have implemented state of the art technology in bagasse energy cogeneration. It is on this basis that the potential for cogeneration in Zimbabwe's sugar industry is being examined. The findings indicate that it is technically feasible to implement such a project. A full economic and financial feasibility study would still need to be done. Two plants of 105 MW each can be put in place, providing about 517 GWh of clean bagasse firm power to the Zimbabwe Electricity Supply Authority. Bagasse would be used during the crop season and coal during the off-crop season. Coal usage during the off-season, will enable the exportation of extra power to the grid. This kind of project, which can save money for the utility, meets about 8% of the country's electrical energy needs, reduces the amount of foreign currency needed to import electricity, results in improved efficiency in the sugar industry and can avoid the use of 293 750 tonnes of coal, hence avoiding the emission of 885 000 tonnes of carbon dioxide and the production of 47 000 tonnes of coal ash. The sugar millers would accrue revenue benefits equal to those revenues from selling sugar that accrue to the milling activities only.

Keywords: Renewable energy; Bagasse electricity potential in Zimbabwe; Biomass

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1. Introduction

Zimbabwe has been faced with a serious shortage of electricity, resulting in imports soaring to about 50% of total energy needs at times. Given that it is expensive to invest in new generation facilities and the fact that the government and the utility cannot raise the necessary capital, a role has been opened up for independent power producers (IPPs) to contribute to meeting the country's electrical energy needs. Generation, transmission, distribution and supply of electricity to the customers are currently the domain of the utility company, Zimbabwe Electricity Supply Authority (ZESA). The company has access to a total of 1928 MW made up of 633 MW hydroelectric power at Kariba Dam and 1295 MW of coal thermal power mostly from the Hwange Power Station in the west of the country. Four of the oldest power stations range in age between 44 and 55 years and account for 345 MW out of the

Nomenclature

BPC	Botswana Power Corporation
CDM	Clean development mechanism
DOE	Department of Energy
EDM	Electricidade de Mozambique
ENE	Empresa National de Electricidade
ESCOM	Electricity Supply Commission of Malawi
IPP	Independent power producer
IET	International emissions trading
JI	Joint implementation
GWh	GigaWatt-hour
kWh	KiloWatt-hour
LEC	Lesotho Electricity Corporation
MW	MegaWatts
NamPower	Namibia Power
SADC	Southern Africa Development Community
SAPP	Southern African Power Pool
SEB	Swaziland Electricity Board
SNEL	Societe National d' Electricite
TA	Turbo-Alternator
TANESCO	Tanzania Electricity Supply Company Limited
TCH	Tonnes of cane per hour
tsc	Tonnes of sugarcane crushed
Z$	Zimbabwean Dollar
ZESA	Zimbabwe Electricity Supply Authority
ZESCO	Zambia Electricity Supply Corporation Limited

total thermal power capacity. They are mostly out of service and their survival is threatened by their long distance from the coal supply areas.

Central to Southern African Development Community (SADC)'s energy management programme is the Southern African Power Pool (SAPP), under which some of the member states are linked to one electricity grid. SAPP enables easier export and import of electricity throughout the region. The pool is made up of 12 national utilities, namely ENE of Angola, Botswana Power Corporation (BPC) of Botswana, Lesotho Electricity Corporation (LEC) of Lesotho, Electricity Supply Commission (ESCOM) of Malawi, EDM of Mozambique, Namibia Power (NamPower) of Namibia, ESKOM of South Africa, Swaziland Electricity Board (SEB) of Swaziland, Tanzania Electricity Supply Corporation (TANESCO) of Tanzania, SNEL of Zaire, Zambia Electricity Supply Corporation (ZESCO) of Zambia and Zimbabwe Electricity Supply Authority (ZESA) of Zimbabwe (see Fig. 1). Zimbabwe imports electricity from South Africa (150 MW), Mozambique (up to 500 MW), Democratic Republic of Congo (100 MW) and Zambia (50 MW). Imports from Zambia were expected to stop in the year 2000, but this was not the case, as planned investment in the power sector was not implemented. The electricity system is interconnected with Zambia through two 330 kV transmission lines, South Africa through a 132 kV transmission line from Beitbridge and a 400 kV transmission line from Insukamini in Bulawayo,

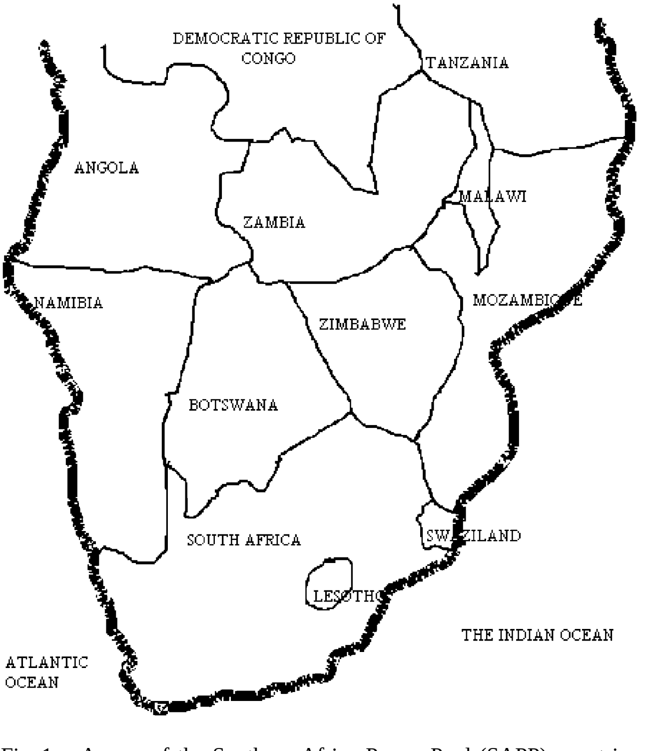

Fig. 1. A map of the Southern Africa Power Pool (SAPP) countries.

Mozambique through a 330 kV transmission line and with Botswana through a 220 kV line from Bulawayo to Francistown. Zimbabwe is now permanently dependent on imports, worsening further the foreign currency shortages, which caused >200 companies to close down in the year ending July 2001.

Plans for capacity expansion have not been implemented due to failure to set tariffs at levels that cover the long-range marginal cost. There has been no increase in capacity over the last 15 years as a result. The current plan is shown in Table 1. It is observed that the next expected capacity addition is 600 MW in 2005. This is in a situation whereby the country is already saddled with a heavy electricity import bill. In Zimbabwe, a unique opportunity presents exists to generate clean energy using bagasse in the sugar industry. Bagasse is the moist fibre that remains after sugar juice has been extracted from the shredded sugar cane. In Zimbabwe, there are two companies that produce sugar, Triangle Limited and Hippo Valley Estates. They can be encouraged to invest in the state of the art technology, which is already proven and is in use in Mauritius and Reunion Islands to invest in the power sector. The companies can increase their profits whilst reducing Zimbabwe's foreign currency commitment to electricity imports substantially.

This paper explores the bagasse energy cogeneration potential in Zimbabwe, given this background. The demand for electrical power in Zimbabwe is certain, given the fact that the country already imports up to 50% of its electricity. The next section looks at the current use of bagasse and its potential use. It is argued that bagasse is currently poorly used since it sustains at most 40 MW generating capacity for use in the sugar industry. The total installed capacity is 81.5 MW. This could be increased to 210 MW, whilst ensuring that bagasse based power exported to the grid after meeting sugar processing requirements goes up to more than 500 GWh. This would be in addition to coal-produced electricity.

Table 1
Zimbabwe electrical energy supply system development plan from 1999 onwards [8]

Project	Capacity	Commissioning Date
Hwange Units 7 and 8	2×300 MW	2005
Gas Turbine	2×150 MW	2008
Batoka Unit 1	1×200 MW	2010
Batoka Unit 2	1×200 MW	2011
Batoka Unit 3	1×200 MW	2012
Batoka Unit 4	1×200 MW	2013
Kariba South Extension Unit 1	1×150 MW	2014
Kariba South Extension Unit 2	1×150 MW	2015
Gokwe North Unit 1	1×320 MW	2016
Gokwe North Unit 2	1×320 MW	2018
Gokwe North Unit 3	1×320 MW	2019

Source: ZESA 1999 [8].

2. The current use of bagasse in Zimbabwe

The two sugar companies in Zimbabwe, Triangle Limited and Hippo Valley Estates produce over 1 400 000 tones of bagasse every year, based on crushing about 4.7 million tones of sugarcane [5–7]. This is a large amount of fuel that can be used to produce electricity for the grid. The two companies are situated in the lowveld, which is south west of Masvingo. See the Zimbabwean map in Fig. 2.

2.1. Triangle Limited power plant

Triangle Sugar Limited crushes up to 2.5 million tonnes of sugarcane a year and produces about 750 000 tonnes of bagasse. There are ten boilers, which produce live steam using bagasse as fuel during the on-crop season and coal during the off-crop season. Normally the plant uses four boilers only. Cumulative investment and improvement in technology over the years has resulted in non-utilisation of the oldest boilers. Boiler number 10 is a water jacket boiler and produces about 150 tonne of steam per hour at 3100 kPa. It can super heat to 400°C. Boilers 7–9 are also water jacket boilers. Boiler number 9 is rated at 3 100 kPa, superheats to 400°C and produces 120 tonnes of steam per hour. Boiler number 8 is rated at 45 tonnes/hour steam and boiler 7 is also rated at 45 tonnes/hour of steam. Boilers 1–6 are not used

Fig. 2. A map of Zimbabwe.

and they are standby capacity. The boilers drive the alternators, boiler feed-water pumps, the 66”mill, de-watering mills and provide steam for the ethanol and sugar plants. Exhaust steam from the generators is used for evaporation at the evaporator stations, process heating and for heating at the ethanol plant [7].

The plant uses bagasse and coal as fuel and can produce up to 35.5 MW during the harvesting season and about 5 MW during the off-crop season. The current maximum generating capacity is about 140 GWh. Some of the old alternators are rarely used. Generally, the plant operates at an output capacity of 21 MW, which is just enough to meet domestic consumption needs. This is about 59% of full capacity. Electricity is not sold to ZESA at the moment [7]. The sugar plant operates about 9 months a year, using bagasse for power generation. Coal and stored bagasse is used during the off-crop period, which averages 3 months per year. During this time power is also imported from the ZESA grid, when necessary. There are six turbines coupled to alternators at Triangle Limited. Five of them are backpressure turbines, which exhaust steam at 150 kPa and the sixth one is a condensing turbine, which exhausts at below atmospheric pressure. The company produces 44 kWh per tonne of sugar crushed. New and better technologies can produce >120 kWh per ton of cane using high-pressure boilers. The Flow diagram of the high-pressure steam line is shown in Fig. 3.

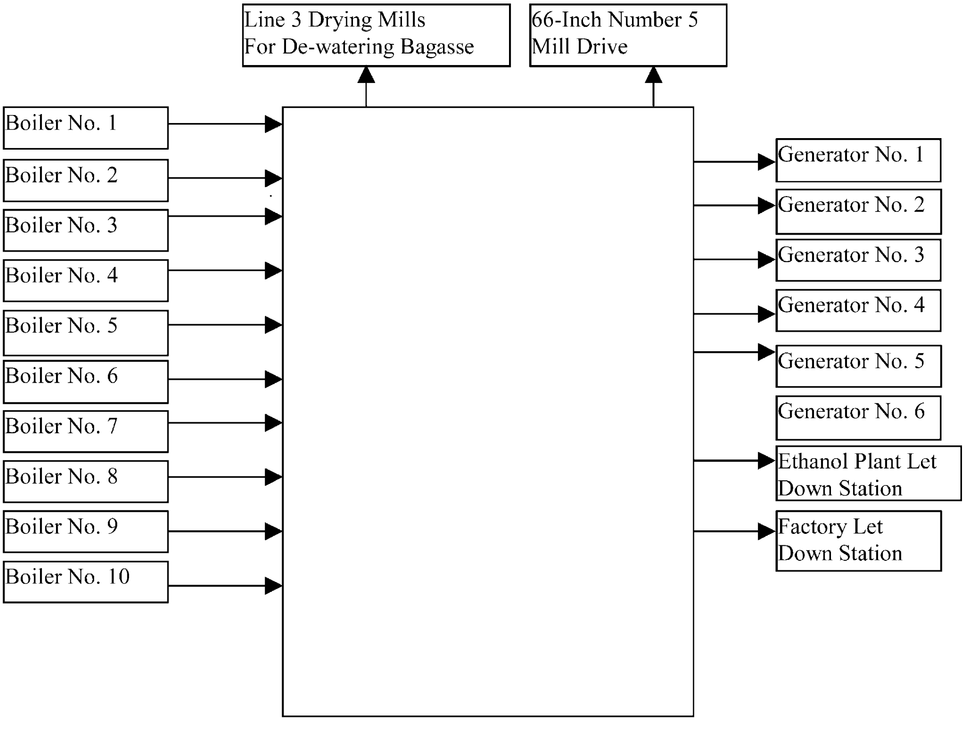

Fig. 3. The high-pressure steam line at Triangle Limited.

2.2. Hippo Valley Estates power plant.

Hippo Valley Estates crushes between 2.2 and 2.4 million tonnes of sugarcane, producing at least 660 000 tonnes of bagasse. The company has had five turbo-alternator sets that have been in use for over 20 years. A new turbo-alternator rated at 20 MW has been commissioned. The previous alternator capacity addition was in 1978. The oldest sets were procured in 1964 and they were secondhand when they were bought. The company does not export power to the local utility, Zimbabwe Electricity Supply Authority (ZESA). It has plans to do so in the near future, if a good price is agreed upon.

There are a total of six boilers, three rated at 45 tonnes of steam per hour, two at 68 tonnes of steam per hour and finally one rated at 100 tonnes of steam per hour. They operate at 31 bars and 400°C. The factory operates at 55% (550 kg steam per tonne of cane) steam on cane. The total installed capacity is now 46 MW and the turbo-alternator sets are as follows: a 3.5 MW back-pressure set, 5 MW pass-out set, 7.5 MW fully condensing set, 2 MW fully condensing set, 8 MW back-pressure set and a 20 MW back-pressure set, which is the latest installation. The first five turbo-alternator sets are very old and they need to be replaced soon. Normally, the whole estate requires about 14.5 MW of power. Moreover, the old turbines are not run at full power because of stability problems and old age considerations. The characteristics of the four of the six alternators are shown in Table 2 [1,5,6].

The consumption correction factor is the factor used to correct the expected consumption calculated as a proportion of the full power rating consumption. When operating below full rating, more steam than expected is consumed, hence the use of this adjustment factor. It should be noted that the steam consumption shown in the table is the maximum possible. However, in practice it is lower because turbines are run to meet the electricity requirements tallying with the demand. The next table presents data collected from four alternators over a 10-day period in order to show the typical operational characteristic of the power plant, before the installation of the new 20 MW set (Table 3).

Normally, the whole estate requires about 14.5 MW, about 31.5% of total installed capacity. Over a 10-day period, it was noted that the power plant on the average

Table 2
The specifications of the turbo-alternators at Hippo Valley Estate [5]

	TA1	TA2	TA3	TA5	Total/average
Type of turbine	Back pressure	Pass out/ condensing	Condensing	Back pressure	
Rated power (MW), temperature, pressure (bars)	3.5, 400°C, 31 bars	5, 400°C, 31 bars	7.5, 200°C, 17.5 bars.	8, 400°C, 31 bars.	24
Steam consumption (t/h)	26.40	44.00	66.00	70.400	206.80
Normal power condition (MW)	2.58	3.50	4.50	6.00	16.586
Consumption correction factor	1.04	1.06	1.15	1.08	1.09
Normal consumption	23.57	32.71	45.54	57.02	159.03

Table 3
The power generated by turbo-alternators at Hippo Valley Estates over a 10-day period [5]

Type of turbine	Turbo-alternator (TA) set			
	TA1	TA2	TA3	TA5
	Back Pressure	Combined Pass-out and condensing	Condensing	Back-pressure
Maximum power RATING (Total 24)	3.5	5	7.5	8
Day 1 (16.32)	2.55	3.40	4.45	5.92
Day 2 (16.47)	2.65	3.47	4.43	5.79
Day 3 (16.43)	2.65	3.60	4.35	5.83
Day 4 (17.13)	2.60	3.91	4.45	6.17
Day 5 (16.29)	2.39	3.30	4.49	6.11
Day 6 (16.65)	2.75	3.41	4.50	5.99
Day 7 (16.44)	2.70	3.45	4.36	5.93
Day 8 (16.86)	2.40	3.51	4.70	6.25
Day 9 (16.94)	2.57	3.50	4.66	6.21
Day 10 (16.32)	2.50	3.46	4.56	5.80
Mean (16.58)	2.58	3.50	4.50	6.00

produces more electricity than required. The plant produced 16–17 MW, just over 61% of the previous full capacity. This presents a small surplus, which could be exported to the grid. The coming into operation of the new 20 MW turbo-alternator has increased the level of that overproduction. The water from the condensing turbine is directly forwarded to boiler water feed for reuse. Exhaust steam from the pass-out and back-pressure turbines combines with the exhaust coming from the prime mover turbines and is sent for process heating in kestners, evaporators and clear juice heaters. During the 10-day experiment electricity production used about 58.5% of the live steam. See Table 4.

Table 4
Live Steam Consumption Rates by the Turbines at Hippo Valley Estates [5]

Turbine	No. of turbines in use	Power	Consumption rate (kg/kWh)	Correction factor	Consumption (t/h)
Shredders	2	2000 hp	10.56	1.08	34.03
De-watering mills	2	1000 hp	10.56	1.08	17.02
Drying-off mills	2	900 hp	10.56	1.08	15.31
Steam feed pumps	3	450 hp	10.27	1.04	11.17
TA sets	4	11.5MW	8.81	1.09	110.37
Total consumption					187.90

3. Possible improvements of the bagasse power plants at Triangle Limited and Hippo Valley Estates

In improving the operations at Triangle Limited and Hippo Valley Estates, a number points need to be taken into account. Table 5 presents the ideas.

3.1. New technologies relevant to the sugar power industries

A number of new technologies, with an impact on bagasse and electricity use in sugar processes are being developed in the sugar industry (Table 6). This means that feasibility studies in Zimbabwe can be considered.

4. Proposed cogeneration projects in the sugar industry in Zimbabwe

The two sugar companies should introduce state of the art technology in sugar processing, so that they can save energy, hence saving more bagasse. By storing bagasse, there is a possibility that they would need to use very little or no coal. The

Table 5
The possible improvements in the sugar industry in Zimbabwe

1. The factories should export surplus electricity to the grid using surplus bagasse. The handling excess bagasse is avoided. ZESA purchase price to be negotiated. ZESA and the economy would benefit from the resulting electricity import substitution.
2. Co-generation technologies offered by many companies worldwide should be evaluated and economically feasible options adopted. Objective should be to lower plant costs, ensure higher rate efficiencies, improving process energy balance and maximise power plant efficiency simultaneously e.g. power factor correction. Modernise the boilers and turbo-alternators. High-pressure boilers offer a very high amount of energy output per unit mass of sugar cane. The two companies should consider them, when they replace the old boilers in future.
3. A modern power plant like Belle Vue in Mauritius consists of two boilers of 140 tonnes of steam per hour each, at a pressure of 82 bars and a temperature of 525°C. These independently drive two turbo-alternators of 35 MW capacity each. This is at a plant with a crushing capacity of 370 tonnes of cane per hour, consuming 110 tonnes per hour of bagasse, well below the capacity of each of the two plants in Zimbabwe. Process, equipment and efficiency improvements at the Zimbabwean plants can produce about 105 MW of electricity using three 140 tonnes of steam per hour boilers and three 35 MW turbo-alternators at each of the plants.
4. Union St Aubin in Mauritius has demonstrated that, using electrical motors for prime movers of the mills instead of steam, results in reduced total energy consumption of the sugar plant. Zimbabwean companies need to do the same. Live steam would then be dedicated for use in electricity generation.
5. ‘Steam transformer’ can de-couple the factory steam from the powerhouse steam and condensate loops. This prevents return of contaminated condensate to the boiler after undergoing sugar processing.
6. Power generation from primary fuels can achieve 15–55% efficiency. However sugar factories can use sugar processes as a sink to generate electricity at around 75% efficiency. The efficiencies in the sugar industry in Zimbabwe range from 73 to 77%. There is room to increase them to up to at least 88%.

Table 6
New sugar technologies that can be considered in Zimbabwe.

1. Decanter centrifuges for extracting juice from clarifier mud. Vacuum filters currently separate juice from the mud underflow of the clarifier using bagacillo (fine bagasse particles). Causes pollution and contaminates the juice. Process is cumbersome, occupies a large working area and leaves a significant amount of sugar in the filter cake. Decanter centrifuge for solid–liquid separation is very effective in separating solids from sugar bearing liquid, with low sugar loss in the cake. The technology requires small space, saves power and is a neat/clean operation. Bagacillo used as fuel for the boiler.
2. Low pressure extraction system. Brings down operating pressure to about 10% below that required in conventional sugarcane juice extraction systems and saves electric/motive power by about 40% in addition to lower maintenance costs. Frees steam power for electricity generation and export to the grid.
3. Cane separation technology. Extracts very clean juice. Separates the rind from the pith of the cane. Less impurities, sugar losses and cleaning chemicals. Rind is a value-added raw material for paper manufacturing. However this reduces bagasse quantity. Chemically Modified Bagasse can be used as a de-colouring agent for sugarcane juice by treating it with amino-based reagents.

two sugar plants can produce 105 MW of electricity each, using three 140 ton steam per hour boilers and three 35 MW turbo-alternators[1]. The plants would use coal during the off-crop period, which is between 2 and 3 months. The investment can be done in three stages, with each stage involving the purchase of one boiler and one turbo-alternator set, until all three sets have been commissioned. This rating is based on a production capacity of 560 tonnes of cane per hour. Hippo Valley indicate that they have extended their capacity to 600 tonnes of cane per hour (180 tonnes per hour bagasse) and Triangle are in the process of doing the same. Such a capacity would easily handle the 165 tonne per hour bagasse requirements of the planned three boilers and three turbo-alternator sets at each of the plants.

The proposed power projects require a total investment of about US$126 million to US$135 million at each plant, assuming that the minimum capacity cost of a kWh produced in a bagasse plant is about US$1200. This is much lower than the US$700 million to US$900 billion needed for the next power sector capacity expansion project that ZESA plans to implement by the year 2005, which involves investing in two thermal power stations with a total capacity of 600 MW. (Thermal power plant capacity normally costs about US$1500 per kWh.) The other advantage is that the project implementation can be done in phases. One third of the total capital required for the full project, would be what the company needs at each phase. The next phase can be partly financed with proceeds from the previous phase.

Planned investment in a new diffuser line at Triangle Limited will improve its production capacity. The improvement process will entail doing away with all the ten boilers existing at the plant in stages and embarking on a high-level investment

[1] This is based on two similar plants at Belle Vue in Mauritius. Each boiler needs 55 tonnes of bagasse per hour (165 tonnes of cane per hour) to drive a 35 MW plant. A plant would need to operate at >560 tonnes of cane per hour in order to generate enough bagasse for a 105 MW plant.

programme. Hippo Valley would also need to replace its boilers. Both companies would need to scrap the existing turbo-alternator sets in stages. Other possible areas of improvement at both Hippo Valley and Triangle Limited include improvement of load profiles, plant availability, automation requirements and meeting environmental constraints through cleaner production.

High-pressure boilers offer a very large amount of energy output per unit mass of sugar cane. The two factories at Reunion Island produce firm power using boilers, operating at around 82 bars, and export electricity to the grid at a rate of *ca* 110 kWh per tonne of cane [3,4]. Triangle Limited and Hippo Valley have not been able to export any electricity at all recently. It is also noted that each plant in Reunion processes around 900 000 tonnes of cane per year, compared to Triangle's 2.5 million tonnes per year and Hippo Valley's 2.2 million tonnes per year. On average, the Zimbabwean plants produce between 32.2 and 44 kWh per tonne of sugar cane crushed. The manpower levels required for this new technology are less, based on the manpower levels at Belle Vue compared to other sugar plants in Mauritius [3]. Belle Vue is the most sophisticated firm power plant in that country.

Gasification technology can be used in future to enhance the use of biomass in the production of electricity. This is being developed for the sugar industry. In Brazil it has been estimated that 6000 MW of electricity could be generated in the sugar industry using gasification. Typical sugar and ethanol industries in Brazil generate in the low efficiency cogeneration units about 14 kWh per tonne of sugarcane crushed (tsc). This can be increased to 120–250 kWh/tsc with conventional but high efficiency turbine cycles and to about 500 kWh/tsc if biomass integrated gasifier steam turbines were used [2]. In the case of Zimbabwe, the potential power capacity in the sugar industry has been estimated to be about 210 MW (517 GWh)[2] of bagasse generated power for export to the grid, using the Reunion example. Gasification technology can raise this export potential from 517 GWh to at least 2170 GWh. Research and development in this direction at the two companies should be supported (Table 7, [2,3]).

Zimbabwe imports about 6000 GWh of electricity currently at a cost of at least US$180 million dollars annually[3]. The full potential of the proposed projects in the sugar industry would produce about 975 GWh, including coal-produced power, reducing this bill by close to US$ 30 million. It is assumed here that the sugar-processing season becomes shorter, due to increased sugarcane crushing rate, hence enabling usage of coal to produce electricity mainly for export during the off-crop season.

[2] The calculations of bagasse power exported are based on those achieved in Reunion Islands of 110 kWh per tonne of cane crushed. On the average Zimbabwe crushes 4.7 million tonnes of cane per year. Gasification is claimed to produce 500 kWh per tonne of cane. In Zimbabwe that would produce 2350 GWh. It is assumed that the sugar companies use 180 GWh and exports the rest.

[3] Electricity imports in Zimbabwe were 7461 GWh in 1998, dropping to 5275 GWh in 1999. The estimate is based on reduced industrial activity as compared to 1998 and an increase in percentage of electricity imported since then. Currently it costs US 3 cents (Z$1.65 at a controlled exchange rate or $9 at parallel market rates) to import electricity. The price goes up when importing for peaking.

Table 7
A comparison of cogeneration technology indices [2,3]

	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	2350 GWh
Highest boiler specifications	150 tonnes steam per hour, 31 bars, 400°C	140 tonnes steam per hour, 82 bars, 525°C	705 GWh	140 tonnes steam per hour, 82 bars, 525°C	1175 GWh
Power output per tonne cane	44 kWh/tonne cane	150 kWh/ Tonne Cane	705 GWh	250 kWh/ tonne cane	1175 GWh
Power export per tonne cane	0	110 kWh/ tonne cane	517 GWh	210 kWh/ tonne cane	1175 GWh
Maximum turbo alternator capacity	20 MW	35MW	35 MW	35 MW	35 MW
Bagasse moisture content	48–50%	48%	705 GWh	48%	1175 GWh

5. Conclusions

This paper has shown the current status at the two Zimbabwean companies and has recommended projects that can enable the sugar industry to maximise its production of electricity for grid export. Incremental addition of new technology over time has resulted in each of the companies having an assortment of boilers and turbo-alternators over a long time. It is clear that a time has come for the sugar industry in Zimbabwe to chart a strategic course that will manage the evolution of technology in the sugar power plants in the most beneficial way. The Government of Zimbabwe and ZESA will have to play a very significant role in that process if the country and the utility are to maximise the benefits that would accrue. The electricity production capacity of the two power plants can be increased from the current 81.5 MW to 210

MW. This coupled with improved utilisation of capacity will enable the sugar industry to contribute a substantial amount of electricity to the grid.

Triangle Limited has a maximum capacity of 35.5 MW, producing about 110 GWh from crushing 2.5 million tonnes of sugar cane. On the average, 44 kWh are produced for every tonne of cane. Production of electricity is maintained at a level that enables the plant to meet an average demand, which at 21 MW represents about 59.1% of full capacity. Hippo Valley produces about 70 MWh of electricity for local consumption. It has just commissioned a 20 MW turbo-alternator set. Hippo Valley has been generating electricity at between 16 and 17 MW, which is about 35% of its full capacity of 46 MW, against a demand level of 14.5 MW. The new turbo-alternator should change the operating practices at the company and most of the old turbo-alternators might become redundant.

Areas of possible improvement have been outlined. New technologies that are being researched on in the sugar industry were highlighted with a view to opening wide the areas that the sugar companies can explore in an effort to improve their processes. More value can be added to the bagasse so that it can generate more power, using higher-pressure steam giving an extra 90–100 kWh per tonne of cane. The projects suggested for the companies are technically feasible. Gasification technology has not been fully developed and it is considered as a technology of the long-term future. It is estimated that it would become usable in at least twenty years from now. The sugar industry in Zimbabwe has the potential to generate 210 MW of electricity, exporting about 517 GWh of bagasse-generated electricity to the grid, after meeting its own requirements for electricity. If firm power plants are introduced as suggested, the use of 293 750 tonnes of coal a year would be avoided. Emission of 885 000 tonnes of carbon dioxide and production of 47 000 tonnes of coal ash would be avoided[4] What is needed is to perform a financial and economic feasibility analysis so that the proposed projects can be considered for funding under the CDM, IET and JI mechanisms.

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[4] Avoided tonnages of coal are based on the calorific value of coal and bagasse. The coal required to produce the same amount of electricity that the 1.4 million tones of bagasse produced annually in Zimbabwe can produce is computed. Carbon dioxide and coal ash estimates are simply computed from the amount of equivalent coal.

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