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The potential for sustainable management of biomass resources in the South African sugar industry.

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Abstract

The sugar industry has the potential to contribute to better a better ecosystem through the effective management of biomass resources in the sector. There is the potential to produce sugar, electricity and ethanol, among many other by-products. This paper considers parts of the lifecycle of the sugar production process in South Africa focusing on the potential for energy efficiency in sugar production, cogeneration of electricity and steam and the impact of extension to the production of ethanol for fuel blending. The scope for improved energy security, avoided green house gas emissions and use of bio-waste in more efficient ways is examined. The paper explores the important role that sugar cane derived biomass can play in a way that contributes to a greener and more sustainable economic activity with far reaching and positive social impacts.

Key words**:** biomass and energy, efficiency, sugarcane bio-resources, cogeneration

1. Introduction

Biomass resources is a renewable energy source, which is a biological material derived from living, or recently living organisms, such as wood, waste, and alcohol fuels. Biomass is commonly plant matter grown to generate electricity or produce heat [1]. Globally, sugar cane's biomass is increasingly being acknowledged as a potential solution to greenhouse gas emissions and global warming. Many countries have recognized the value of a renewable energy component in their national energy strategies – South Africa included [2]. The South African Government has committed itself to the use of renewable energy. Electricity generating capacity in South Africa is approximately 40 000 MW, with a portion of this capacity deployed to meet non-South African demand. The Department of Minerals and Energy estimates that South African demand will be 42 000 MW by 2013. The White Paper on Renewable Energy sets a target of 10 000 GWh to be achieved by 2013, which is approximately 4% of the projected electricity demand for that year [1].

2. Potential for Energy generating in the South African sugar industry

2.1 The current electricity generation

Eskom generates 95% of the country's demand, this totals to 38 736 MW of capacity generated. There are 17 power stations located nationwide which generate a total of 38736 MW capacities. Eskom plans to increase its capacity by 1600MW, this is dependant on a 6% increase in the economy. To ensure the reliability of supply, Eskom plans to increase the generation of electricity by 22000MW by 2017 [1], this will include the construction of power stations and an increase in the capacity generating of existing power stations, to meet the forecasted demand in electricity.

2.2 The sugar industry and bagasse in South Africa

Bagasse is the fibrous biomass that remains after the sugarcane stalks are crushed to extract the juice. This is then the waste product of sugar, which is then used to generate surplus electricity. There are some small milling plants that use cogeneration of electricity, which is the production of mechanical energy from sugar. Table 1, reflects the sugar production levels for South Africa in the past 10 seasons [4]

Table 1: Harvested sugar cane in South Africa

Sugar cane production (tonnes)	
1999/2000	21 223 098
2000/2001	23 876 162
2001/2002	21 156 537
2002/2003	23 012 554
2003/2004	20 418 933
2005/2006	19 094 760
2006/2007	21 052 266
2007/2008	19 724 000
2008/2009	20 453 722
2009/2010	19 224 782
Average per season	21 194 789

The decline in the African Sugar production has been caused mainly by the deterioration in various environmental factors.
Temperatures during the 2009 growing season were slightly below average in most mill areas and were all lower than the previous two seasons. Radiation was significantly below average in all mill areas and lower than for the previous two seasons. The 2009 growing season therefore had lower climatic potential for well watered cane than the preceding two seasons [10]. Sugarcane requires high temperatures to build structure, and high levels of solar radiation to fill the structure

with mass. It also requires adequate water to maintain growth processes at high rates. Cane quality is promoted by high radiation and cool, dry conditions during the period leading up to harvest.

2.3 The Current use of Bagasse in the South African sugar industry.

According to Tongaat Hullets Sugar Company every 100 tonnes of sugarcane harvested and milled produce 10 tons of sugar and 28 tonnes of bagasse [3]. The mills then use portion of the bagasse in a low efficiency steam cycle to produce the electricity and steam for their own use. The bagasse cogeneration technology that is widely used in the South African sugar industry is the direct combustion. In direct combustion fuel is fired into boilers to produce high pressure steam which drives a team turbine. And the turbine in turn drives the electric generator. In the direct combustion turbine system power generation efficiency increases with increase in temperature and pressure meaning that large scale power plants have to set up large scale expensive heat resistant facilities in order to achieve high power generation. The power output in the South African industry per tonne of sugar cane crushed is approximately 30 KWh [4], this gives a high room for improvement in terms of generating efficiency for the sugar industry in South Africa. This can be achieved through the application of more efficient cogeneration technologies that are now available [1]. The integrated gasification combined cycle (IGCC) can also be applied to the sugar industry in order to increase its power generating efficiency. The IGCC technology employs more than one thermodynamic cycle. The result is high generating efficiency as compared to direct combustion effects. The IGCC technology can achieve up to 250- 500KWh/ tonne of sugar cane crushed [5].

2.4 The Calorific Value of Bagasse

Gross calorific value (GCV) of dry bagasse has a mean value of 19605 KJ/kg. The gross calorific value (GCV) of wet bagasse is based on the composition of wet bagasse. Water has no calorific value and it also absorbs heat being vaporized during combustion. The combustion reactions of bagasse as a fuel are as given in Table 2. The net calorific value of bagasse, with around 48% moisture content is about 7670 KJ/kg. [8].

Table 2: Combustion reactions for bagasse

Constituent	Mass (%)	Oxygen Required (kg)	Product	Mass of Product (kg)
Carbon	22.5	0.6	CO_2	0.825
Hydrogen	3	0.24	Water	0.27
Nitrogen	-	-	Nitrogen	2.01
Oxygen	23	-	-	-
Water	50	-	Water	0.5
Ash	1.5	-	Ash	0.015

2.5 The Bagasse cogeneration potential in South Africa.

The South African sugar industry crushes an average of 21 194 789 tonnes of sugar cane per year. This amount of sugarcane generates 5 934 543 tonnes of bagasse. The energy conversion factor for the current power plants is 0.25[6].The energy conversion efficiency in Mauritius is 0.27. The energy conversion factor achievable from IGCC energy conversion factor for the current power plants is 0.25[6].The energy conversion efficiency in Mauritius is 0.27. The energy conversion factor achievable from IGCC assuming that it produces 500KWh/ tonne [7][8]of sugar cane is 0.92. The energy to power conversion is based on the standard energy conversion factor: IKWh =3.6MJ.

Table 3.0 shows the present technology in South Africa, The best available technology from Mauritius and best available technology using IGCC [1].

Table 3: Results of cogeneration using different technologies

Technology	Power Generation technologies
Direct combustion(current technology	3 160 969
Best available technology from Mauritius	3 512 187
Best Available technology	11 632 364

2.6 Expected benefits of cogeneration in South Africa

- The abundant energy from bagasse can help compliment the present generating capacities of coal plants in South Africa, there by helping meet the local power demands
- Electricity from bagasse is renewable. The substitution of coal a fossil fuel with bagasse will save the non renewable coal deposits [1]

- There is significant reduction in the emission of green house gases specially carbon dioxide when bagasse is used instead of coal. The use of biomass is said to green house gas neutral that is only releasing the gases the plant absorbed. [6].
- Bagasse energy projects enhance sugar factory modernisation because boilers, turbo alternators and other energy efficient equipment are the major contributors (Up to 50 %) of the cost of a sugar factory. Therefore investing in energy projects means that this part of the investment crucial to sugar processing will be financed independently of sugar activities.
- The cogeneration activities will increase the competitiveness of the sugar industry, including the cane growers. This is due to more revenue from the sale of electricity. Decreasing sugar prices on the international market due to trade liberalisation and commitments at WTO means that the industry should exploit the by products for long term viability. [8]

2.7 Challenges of bagasse cogeneration in South Africa

- The determination of a viable price per unit of electricity generated from cogeneration. A higher price than that for electricity from coal is imperative in order to lure investors in the project.
- Conversion technologies for renewable energy can not compare in terms of cost with conventional fuels at the moment.
- The seasonal availability of bagasse means that there is need for storage of the energy source or alternative fuel source when the bagasse is out of season
- Dealing with technical issues with regard to protection systems when exporting to the grid, these include lightning and cane fires in the Natal areas
- There is need for allocation of bagasse to other uses like animal feed. So not all bagasse can be directed to cogeneration[1]

3 Current Ethanol Production in South Africa

Ethanol is a clear, colourless, flammable liquid, which is produced by the fermentation and distillation of sugar cane molasses. Ethanol can be produced from carbohydrates such as sugar, starch, and cellulose by fermentation using yeast or other organisms [9]. Currently South Africa produces 410 million litres of ethanol annually [10] and is the leading ethanol producer in Africa. South Africa's ethanol production is currently controlled by Sasol, which produces (synthetic) industrial alcohol from coal and gas, used to make ethyl acetate, high purity ethanol and a small volume for fuel. South Africa also produces fermentation ethanol from sugar molasses. Illovo Sugar also produces molasses for feedstock in addition to ethanol. The average sugar cane produced in South Africa per season 21 198 789, and for every 100 tons of cane crushed, 30 tons of bagasse, 12 tons of sugar and 4 tons of molasses are made[11].

3.1 Benefits of Bio-Ethanol

Bio fuels also hold many macroeconomic benefits for a country engaging in bio fuel manufacture. In a South African context these include:

- Environmentally friendly fuel through indigenous production.
- South Africa is signatory to the Kyoto Protocol.
- Energy security and diversification.
- Actively contributing to regional economic development.
- Creation of employment opportunities.
- Positive impact on the balance of payments.
- Positive cost-benefit ratio.
- Strengthen domestic, rural agricultural economy.
- Giving farmers viable alternative markets.[9]

4. Energy management in the sugar industry

Energy management is the collective term for all the systematic practices to minimise and control both the quantity and cost of energy used in providing a service [6]. Efficient energy management systems lead to reduced energy consumption which also results in reduced climate change impacts. Climate change caused by greenhouse gas emissions is at the heart of the various emissions targets agreed by countries around the world and set out in the Kyoto Protocol [7]. Governments worldwide, including South Africa have agreed to reductions in greenhouse gas emissions and have introduced policy and legislation aimed at achieving these targets. While many measures can be taken to reduce emissions, using energy efficiently is widely accepted as the most cost effective way of achieving the targets set. The following components constitute a good energy management system for the sugar industry.

- Minimisation of energy wasted both process steam and electricity
- Ongoing monitoring, target setting and reporting to ensure energy use remains within policy objectives
- Optimisation of energy efficiency through passive means or the use of appropriate technology.
- Use of the most appropriate energy source (eg electricity, gas) with due regard to the environmental benefits.
- Purchase of energy at the most economical price.
- Modification of operations, where possible, to make the best use of energy price structures.
- Increasing the use of energy from renewable sources especially cogeneration from bagasse.
- Staff involvement and awareness [1]

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4.1 Benefits of good energy management practices

- **Enhancing energy supply security**

Good energy management practices will ensure that there is more energy available for other activities rather than it being wasted through inefficient practices.

- **Environmental impact**

Energy efficiency results in reduced green house gas emissions per useful energy output, especially CO_2 and this will contribute to reducing climatic change.

- **Increases competitiveness of the industry**

Energy consumption means reduced operating costs to the company. This will improve the profits margin in the organization and also help to protect the industry against energy price volatility.

- **Productivity and quality improvement**

Energy management through efficient systems means improved productivity and quality of products produced. A good maintenance system increases energy efficiency and this also improves productivity and quality [1].

5. Conclusion

A good energy management system for the sugar industry in South Africa is very beneficial. It will improve the competitiveness of the industry and also improve energy security among other benefits. A lot of opportunities for energy saving exist in the sugar industry and there is need to exploit these for better energy performance. Energy audits are very crucial for a successful energy management system. It is imperative for cogeneration to be adopted in the industry to increase electricity output and to make better use of process steam. Government policies also a play and important role in setting up good energy management practices. The potential for electricity cogeneration in South Africa is very high. There is only need to for enough capital to source appropriate technology for the energy conversion of bio energy to electricity. A viable price unit per unit of electricity generated from cogeneration has to be expeditiously agreed upon in order to encourage the private companies to invest in this project. There is also need to carry out a detailed feasibity study and a reliable cost estimate for the bagasse power plants before the projects are embarked on .bagasse cogeneration is there to reduce the power problems being faced in South Africa if taken seriously. The country should borrow experience from Brazil, Mauritius, and Australia where cogeneration has been embraced and benefits being enjoyed.

6. References

[1] Mashoko,L. Mbohwa, C. Kekana, M: Bagasse energy cogeneration potential in the South African sugar industry: International conference on energy security and climate change: issues, strategies, and options. (ESCC 2008)
[2]. Eskom annual report 2009
[3].www.info.gov.za/otherdocs/2010
[4]. http://www.smri.org/properties.php
[5].Tomohiko Sagawa. Bagasse cogeneration in Tanzania: utilization of fibrous waste from sugar cane.
[6] DME- Danida. Grid connected renewable energy –Case study.
[7].grant Norris and jako volschenk. Wanted! Greener energy. Is South Africa doing everything in its power to come clean?
[8]. Kassiap Deepchand, sugar cane bagasse – Lessons from Mauritius (5-7 October 2007) Parliamentary forum on energy legislation and sustainable development, Cape Town, South Africa.
[9] South African sugarcane growers. http://www.sacanegrowers.co.za/. August 2010
[10] Huletts, 2010, Sugar Manufacture Process. *http://www.huletts.co.za*. Last accessed on 09 July 2008…
[11] ENER.G., 2010, Energy Management., www.energ.co.uk/energy_management. Accessed 23 August 2010