

Can South Africa's Sugar Industry Contribute to Clean Energy Supply?

Lessons from Best Practices in Cogeneration

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The 2015 budget speech by the South African Minister of Finance echoed the need to resolve the country's energy challenge and revitalise agriculture as the top two strategic priorities for economic growth and development. Eskom, South Africa's public electricity utility, continues to grapple with the challenge of meeting the rapidly growing demand of electricity. Repeated bouts of load shedding have been a clear testimony to this challenge. There is a desperate need to ensure the security and reliability of the country's energy supply in order to deal with the structural and competitive challenges which are retarding its growth. This brief argues that the sugar industry can contribute significantly towards addressing South Africa's energy supply challenge in a sustainable way. This argument is based on the results of a spatial systems dynamics model demonstration which simulates the overall electricity production from sugarcane production systems. The results provide interesting insights that should certainly drive and encourage more investment in bio-electricity generation, with projections of a supply of over 1950 GWh of electricity per annum. Tapping from best practices in the field of cogeneration, the sugar industry has the potential to help ensure sustainable energy security for South Africa by supplying additional electricity to the national grid in a way that avoids greenhouse gas emissions.

Introduction

Sugar cane, grown widely in African countries, is known to be one of the most productive plants in terms of its conversion of solar energy to chemical potential energy. The sugar industry has

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witnessed a fundamental shift from sugarcane production for food purposes to combined energy and food purposes. However, the industry is faced with a plethora of threats and challenges which have thus far hindered large-scale bio-electricity production across the Southern African region, stalling the potential of sugarcane in electricity generation. Among these has been a decline in sugar prices,¹ which witnessed the reformation of the sugar industry in countries such as Mauritius, and inefficient production plants.² This situation has been worsened by massive competition for the land and water resources³ needed for the feedstock that is required to generate electricity. There has indeed been much debate over food security versus energy over the past decade.⁴ Many projects have been blamed for undermining the social and environmental equity promises of biofuels development.⁵ Some fear that such development could undermine ecological systems and traditional egalitarian land use in many African countries, which could lead to greater vulnerability for the majority of the population.⁶ In some instances macro-economic factors and land policies have affected sugarcane production trends, such as in the case of Zimbabwe.⁷ The array of factors highlighted is not only a cause for concern to the sugar industry but has a significant bearing on the feedstock required for electricity or biofuel generation.

Despite these challenges, this brief contends that the sugar industry can still play a major role in supplying clean energy to most emerging and developing economies. Increasing quantities of sugarcane are and can still be directed to renewable electricity generation and ethanol production as an effective carbon dioxide (CO₂) mitigation strategy and an alternative to crude

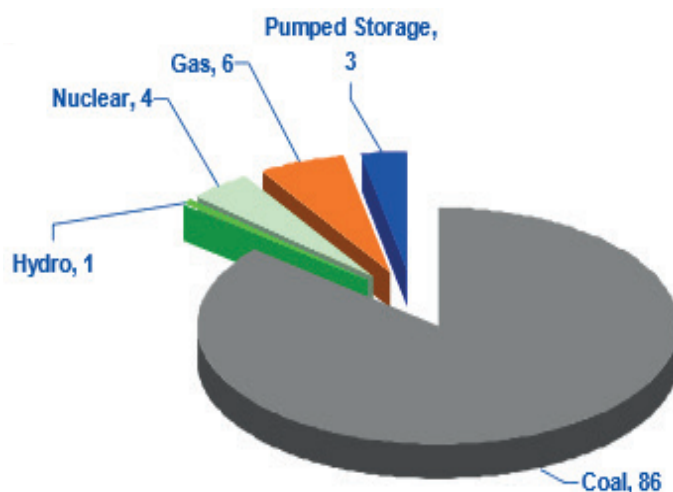
oil-based fuels.⁸ The brief contends that South Africa is correctly poised to take the lead in electricity cogeneration from industrial sugarcane ecosystems.

In line with South Africa's National Development Plan, which seeks to create jobs and resolve the energy crisis, and the drive towards a low-carbon future, the production of electricity from sugarcane fibre bagasse is assuming great importance.⁹ The national integrated energy plan for 2010 to 2030 promotes electricity procurement through independent power producers (IPPs). This has provided the sugar industry with a window to produce and add energy to the national grid. In essence, this reduces the burden on Eskom to meet the ever-increasing demand. The next section provides a snapshot of South Africa's energy challenge and the current energy supply landscape and how the sugar industry can contribute to clean electricity production and supply.

South Africa's Energy Challenge

Like many other developing and emerging economies, South Africa is not immune to the energy challenge. There is little doubt that rising energy demand and the associated problem of climate change are some of the greatest challenges facing South Africa. The recent load-shedding by Eskom epitomises the problem. By definition, load-shedding is a measure of last resort to prevent the countrywide collapse of the power system. When there is insufficient power station capacity to supply the demand from all the customers, the electricity system becomes unbalanced, which can cause it to trip out countrywide. This could cause a complete blackout which could take

Figure 1: Current share of South Africa's electricity supply



Source: Eskom¹²

days to restore. In response to the electricity demand exceeding the available supply, Eskom has developed schedules based on the possible risk of load-shedding, with stages 1, 2 and 3 allowing a national shed of up to 1000 MW, 2000 MW and 4000 MW respectively. Often, this is implemented during the winter season, when there is peak demand. During the first quarter of 2015, the power utility had to resort to stage 3 for some days due to plant failure and the need for maintenance, demonstrating the gravity of the energy challenge. While South Africa needs to end power shortages and keep electricity prices affordable for everyone, it also needs to limit its carbon dioxide (CO₂) emissions. The brief argues that the sugar industry can go a long way towards contributing to the national energy supply.

South Africa's Electricity Supply Landscape

Eskom is the national power utility supplier, generating approximately 95 per cent of the electricity used in South Africa and approximately 45 per cent of the electricity used in Africa.¹⁰ The utility generates, transmits and distributes electricity to industrial, mining, commercial, agricultural and residential customers and redistributors.¹¹

Fossil fuels (coal, oil and gas) currently account for more than 92 per cent of South Africa's energy sources. A large nuclear station near Cape Town provides about five per cent of capacity. A further five per cent is provided by hydroelectric and pumped storage schemes. Eskom has a current nominal installed capacity of 44 175 MW. Projections have shown that South Africa needs over 40 000 MW of new generation capacity by 2025¹³. The fight against global warming has increased the emphasis on, and efforts to pursue

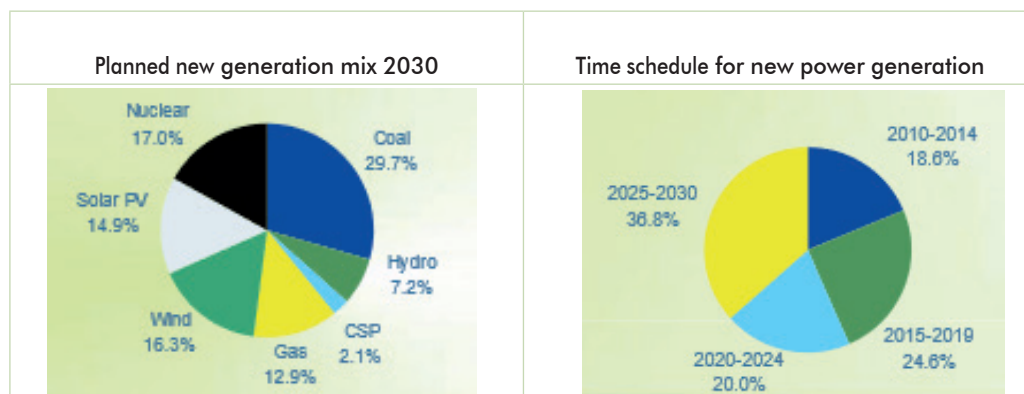
the use of, renewable and clean energy sources as alternatives to the more polluting fossil energy sources.

The Department of Energy has committed to diversifying its energy mix through the introduction of renewable energy at a large scale. The planned new generation, as indicated in Figure 2, shows a 17 per cent nuclear share by 2030 as well as more supply from wind and solar at 16 per cent and nearly 15 per cent, respectively. The share of fossil fuels should reduce to about 57 per cent. The target timeframes show significant progress to be achieved by 2024. However, there is silence on the contribution of biomass as a technology option, as indicated on the planned energy generation mix in Figure 2. This brief argues that while electricity procurement through IPPs continues to gain momentum and is being aligned with the government's objective to grow the economy, significantly more can be tapped on from biomass. Cogeneration through IPPs has opened a new window of great potential in the drive towards an effective energy mix. Power generation from sugarcane fibre has ushered in a new era of opportunity for the sugar industry.

South African Sugar Industry and its role in Energy Production

The South African sugar industry is one of the world's best producers of high-quality sugar, producing an average of 2,5 million tonnes of sugar per annum.¹⁵ The industry combines the agricultural activities of growing sugarcane with industrial factory production of raw and refined sugar. The industry makes a significant contribution to the national economy.¹⁶ Sugarcane is supplied to 14 mills, where it is processed into sugar. Bagasse and molasses are also produced in the process. Bagasse is the fibrous biomass that

Figure 2: South Africa's projected energy generation mix



Source: ¹⁴DoE, 2014

Table 1: South Africa's sugar production levels

Year	Cane crushed	Domestic consumption	Export
1994/1995	14,2	1,2	0,3
1995/1996	15,2	1,2	0,3
1996/1997	19,0	1,1	0,9
1997/1998	20,1	1,2	1,0
1998/1999	20,8	1,2	1,2
1999/2000	19,2	1,2	1,2
2000/2001	21,7	1,1	1,4
2001/2002	21,7	1,1	1,1
2002/2003	20,9	1,1	1,3
2003/2004	18,5	1,2	1,0
2004/2005	17,3	1,2	0,9
2005/2006	19,1	1,1	1,1
2006/2007	18,4	1,2	0,8
2007/2008	17,9	1,3	0,8

Source: Mbohwa, C., 2013

remains after sugarcane stalks have been crushed to extract the juice.

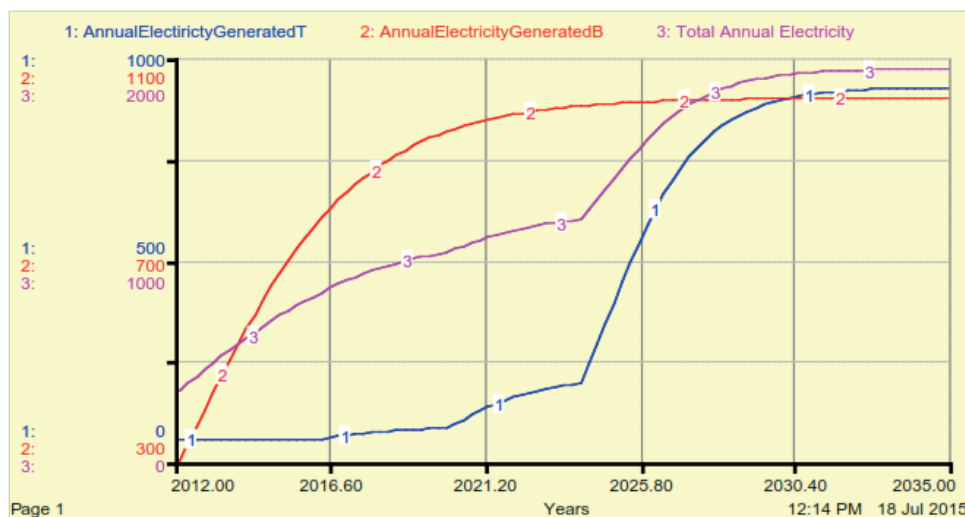
Tongaat Hulett Sugar is the leading sugar-producing company in the country. For every 100 tonnes of sugarcane harvested and milled, it produces 10 tonnes of sugar and 28 tonnes of bagasse.¹⁷ Some of the sugar mills are opting for the cogeneration of electricity from bagasse, but mainly for their own consumption; only a small amount is exported to the national grid. On average, the industry produces more than 19 million tonnes of sugarcane per annum.¹⁸ Current estimates show total electricity production of 742 GWh per annum.¹⁹ The question is, can South Africa's sugar industry produce more electricity and export this to the national grid to reduce the energy demand deficit which Eskom struggles to meet? This brief suggests that the sugar industry can produce more electricity and supply it to the grid. Table 1 shows the sugar production levels for South Africa for the past 14 seasons.

The above statistics provide a clear indication of feedstock provision potential which can be used for electricity generation. The use of bagasse has the potential to improve the amount of electricity generated in the country, reduce greenhouse gases and create employment opportunities. This can be achieved through cogeneration with the sugar industry. Cogeneration is the simultaneous generation of electricity and useful thermal energy from a common fuel or other energy source. Heating and cooling output may operate concurrently or alternately, depending on need and system design. Cogeneration improves energy efficiency from 30 to 95 per cent, and the latest

technology has enabled a reduction in carbon emission.²⁰ Energy efficiency or conservation refers to the process of reducing the amount of energy that is wasted. Cogeneration is therefore an energy conservation technology that produces two types of energy at a single plant.

The first attempt to simulate the country's overall electricity production using spatial systems dynamics has provided interesting insights that are key to driving more investment in bio-electricity generation. The model was developed for Mauritius in an attempt to address the complexity around bioelectricity production and provide ways of optimising electricity generation from industrial sugarcane ecosystems. The model was then extrapolated to demonstrate the potential for South Africa. Figure 3 illustrates the potential total electricity generation from combined bagasse and trash in South Africa. The results indicate that this could be nearly 1950 GWh per annum – far more than double the current production estimates. This implies that excess electricity consumed at the sugarcane plant can be exported to the national grid. The results corroborate Mbohwa's analysis confirming that replication of technology used in Mauritius can increase power output for South Africa to 1378 GWh.²¹ At a micro-scale, Tongaat Hulett currently produces 52 MW at its four South African mills, and this can be increased to between 320 MW and 360 MW. The company plans to bid for its first 80 MW power station, given the inherent benefits envisaged. This brief therefore contends that the sugar industry can certainly go a long way towards contributing to the energy supply.

Figure 3: Simulated bagasse/trash electricity production for South Africa



Source: Author

The energy value of sugarcane production systems hinges on a number of factors. In order to optimise the electricity value from sugarcane-derived feedstock, efficient technology is required. In this regard, condensation extraction technology can lead to a significant increase in power output, to the level of competing with traditional fossil fuel-driven plants.²² The success of cogeneration schemes in industrial sugarcane ecosystems depends on maximising the energy output and minimising the energy expenditure in the sugar production process.²³ High-pressure boiler technologies have proven to be useful in optimising electricity value in sugarcane production systems. In addition, energy efficiency is directed towards reducing power inputs in all areas of sugar and power production in factory operations in order to maximise the available power to be exported.

Another key factor is the cost of electricity production. Electricity costs in cogeneration mode range from \$0,04 to \$0,09/kWh. Electricity cost from new gasification plants is around \$0,10 to \$0,13 per kWh.²⁴ Until recently, South Africa had a price per unit of electricity which was far below the world average, and this negatively affected investment in cogeneration plants. The National Energy Regulator of South Africa (NERSA) has now increased the feed-in tariff to R1,18 per kWh.²⁵ This has resulted in interest in cogeneration within the sugar industry. Most notable is a proposal by Tongaat Hulett to install a cogeneration plant at its Felixton mill that is expected to export 38 MW to the national grid in season and 17 MW out of season. In addition, feasibility studies are underway for cogeneration plants at their Amatikulu and Darnall mills.²⁶ The capital cost of converting one sugar mill

and making it energy-efficient is approximately R4 billion. The company plans to bid for its first 80 MW power station,²⁷ given the inherent benefits envisaged. With this evidence, this brief underscores the need for independent power producers in the sugar industry to invest more in electricity production.

A comparative analysis of electricity generation in different countries from sugarcane-derived feedstock shows the great potential of higher power output from relatively efficient technologies. As shown in Table 2, a total of 742 GWh of electricity is currently being produced per year in the sugar industry in South Africa, and most of this is for the mills' own consumption.

There is no significant difference between South Africa and Brazil at the moment in terms of electricity output. Mauritius is performing better per tonne of cane crushed. The replication of the technology used in Mauritius can increase the power output for South Africa to 1378 GWh, a conservative power output compared to the simulated electricity output shown in Figure 3. The condensation extraction technology can lead to a significant increase in power output, enabling it to compete with traditional fossil plants.³⁴

Social and Environmental benefits from sugarcane-derived electricity

If South Africa were to follow the Brazilian model over the next 20 years it would provide between 13 and 25 per cent of the required carbon footprint reduction needed to meet the target which South Africa has committed to.³⁵ This brief thus argues that South Africa needs to invest in cogeneration

Table 2: Electricity cogeneration potential of South African sugar industry

Type of technology	Power output/tonne of cane (kWh)	Cost of technology per installed Kw (US\$)	Amount of electricity generated (GWh)
Current technology in South Africa ²⁸	30	-	742
Current technology in Brazil ²⁹	40	500–600	848
Current technology in Mauritius ³⁰	65	-	1 378
Condensation extraction with cogeneration (under construction) ³¹	150	600–800	3 180
BIG-GT (biomass integrated gasifier gas turbine) ³²	517	2 500	10 960

Source: Mbowe³³

in the sugar industry by independent power producers.

The technology option provides an opportunity for employment creation. One new job is typically being created for every 3,5 hectares of additional sugarcane planted.³⁶ A cost benefit analysis and macro-economic impact analysis by Connigarth economists has shown that electricity generation from sugarcane bagasse can increase the country's GDP by R1 366 million per annum and create about 3 643 job opportunities in the national economy, of which 2 483 would be in the KwaZulu-Natal Province.³⁷

Salient considerations: Hope for the sugar industry

Fluctuations in international sugar price

The world sugar price fluctuates regularly. This brief argues that the drop in the average world sugar price should not cause the sugar industry to panic, given the great potential of deriving energy and other by-products from the industrial sugarcane ecosystem. In other words, the more sugarcane the industry can produce, the better the supply of feedstock for energy generation, which can increase the amount of electricity exported to the grid. While the sugar industry might cease to rely overly much on sales of sugar, it can earn more revenue from energy sales, boosting business processes and performance. This may also increase the competitiveness of the sugar industry. Given that energy is one of the major operating costs for sugar companies, reduced energy consumption means reduced costs for the company, improving its profit margin and helping to protect it against price volatility.

The price volatility in the industry has led to a decline in sugarcane production. This brief argues that the industry should retain, and even increase, current levels of investment in sugarcane

production. If excess sugar cannot be sold or used for food purposes, the sugar can be converted into a blend of fuel and ethanol – an equally important by-product in addressing energy security, with related carbon emission reduction benefits.

Competing priorities: Food vs energy

Deriving electricity from sugarcane is an optimised way of producing both energy and food without one compromising the other. The promotion of sugarcane production implies an increased production of feedstock (bagasse and trash), which is essential for electricity generation. This dispels the notion of competing priorities for land and water resources.

Ethanol production

This is widely promoted as an octane-enhancing clean-burning petrol additive. No investment has been envisaged yet in South Africa in a bio-ethanol plant to process sugarcane feedstock. Yet for every 100 tonnes of cane crushed, four tonnes of molasses are obtained. Subsequently, one litre of ethanol is produced from every four kilogrammes of molasses.³⁸ Given this theoretical assumption, more than 220 million litres of ethanol can be produced from sugarcane molasses only. This is a high figure compared to South Africa's fuel requirements. If that is the case, the sugar industry can go a long way towards addressing South Africa's energy challenge.

Conclusion

South Africa's sugar industry has the potential to contribute towards the supply of bio-energy for electricity generation from bagasse and trash. Essentially, cogeneration of electricity appears to be economically and financially viable. It can benefit mill owners, cane suppliers and the rural population. The sugar industry can indeed make

a significant contribution towards reducing the energy crisis experienced in the country. The production of electricity from sugar bagasse is very lucrative and should be encouraged. The use of bagasse can improve the amount of electricity generated in the country, reduce greenhouse gases and create employment opportunities. Electricity procurement through IPPs continues to gain momentum and is being aligned with the government's objective of growing the economy. Above all, cogeneration through IPPs has opened a new window of great potential in the drive towards an effective energy mix. This provides a challenge to the sugar industry to optimise the electricity or energy value derived from sugarcane production systems.

Recommendations

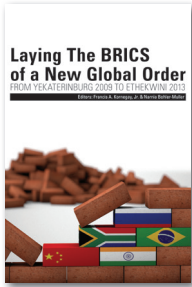
- Energy pricing: The current price of electricity generation from bagasse can greatly influence the viability of the industry. At first glance, coal-derived electricity seems to be much cheaper than electricity derived from biomass feedstock. However, this does not take into account the effects that coal-fired power stations have on the environment. Therefore, the government should consider investing more in bagasse electricity generation, which is a more sustainable energy source.
- The creation of an enabling environment for the Renewable Energy Independent Power Producer Procurement Programme (RE IPPPP) and the promotion of this programme will lessen the energy supply burden experienced by the national utility agent ESKOM.
- Improving energy efficiency in sugar mills is key. Some of the technological considerations could include, but are not limited to: improving steam conditions, making use of lower-grade vapour for heating purposes, improving boiler efficiencies, and replacing steam-driven mill drivers with electric DC motors.³⁹
- Human capital development: Given the limited number of skilled personnel in the energy sector, there is a need for enhanced capacity building in the areas of energy efficiency, energy management, and modelling resource optimisation.
- Research and development: More investment is needed in the areas of research, development and technology innovation, highlighting the cost benefits as well as macro-economic benefits of sugarcane production systems.

- South Africa can learn from best practices in countries such as Mauritius and Brazil and capitalise on the advantages and opportunities offered by the industry.

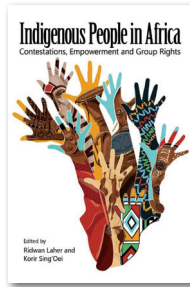
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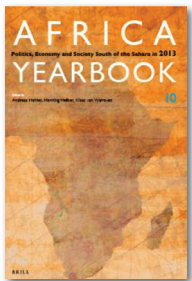
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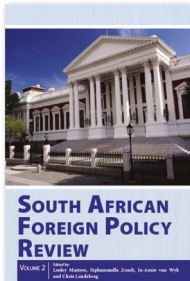
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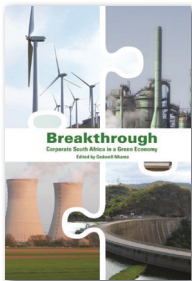
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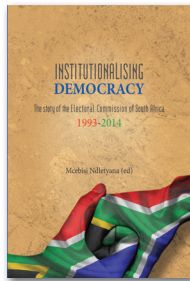
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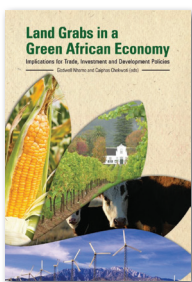


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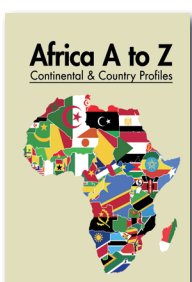


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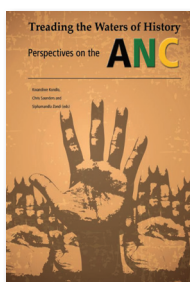


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